Raising Islands

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis.

This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

In an era of dawning anthropogenic climate change, people of atoll nations face grievous threats to their future. Rising sea levels, warming oceans, and changing weather patterns conspire with economic isolation, rapidly growing populations, and the loss of traditional livelihoods to perpetuate conditions of dependence and wardship which threaten the very existence of their island homes. This project examines an atoll nation of the equatorial Pacific, the Republic of the Marshall Islands (RMI) - a vast marine landscape consisting of 29 atolls enclosing thousands of kilometres of submerged reefs, azure lagoons, and tiny islets of sand and verdant vegetation. This outward appearance of pristine tropical paradise belies a tragic history of nuclear weapons and ballistic missile testing at the hands of the US military. Despite the sustained and concerted efforts of Marshallese politicians and intellectuals resulting in the establishment of the RMI as an independent sovereign state in 1986, the US maintains a military base on the largest atoll, Kwajalein. The upheavals caused by years of weapons testing have resulted in a fragile situation on a tiny islet adjacent to the base, Ebeye. Known by the unfortunate epithet "the slum of the Pacific" Ebeye is a narrow strip of coral sand and concrete which is now home to an estimated 15,000 people, who are drawn by the promise of jobs on the military base or who have been evicted from their ancestral land to make way for the testing of missiles, which continues to this day.

While islanders and their world have been consistently framed in rhetoric which stresses vulnerability, smallness and unsustainability, this project contests the limited scope of the regimes of power in Oceania by considering how the independent, grassroots actions of local groups

of islanders have achieved surprising and dramatic results in defiance of the policies and planners at the top. The atoll environment is one of the most challenging 'human ecology' scenarios on earth; despite this, the Marshallese people have occupied these atolls for millenia. This successful and continuous colonization, which presents enormous difficulties - in terms of depauperate soils, lack of reliable fresh water supplies, exposure to storm and tidal events, and very limited land area - was made possible by the development and application of carefully considered landscape manipulations in concert with technologies and traditional skills which enabled atoll people to fully exploit their marine surroundings.

In developing a design proposal for the contemporary condition, this thesis examines the persistent ways in which the islands and people are framed by outsiders. This project engages with the social, political and natural history of the atolls: common tropes are challenged by the actions and agency of a people who have dealt with imperialist outsiders in sophisticated and conscious ways. It explores the traditional cultural practices which enabled the ancestors of the Marshallese people to flourish, and suggests that it is at the level of actions by ordinary people that the most fertile potentials lie, and are in fact already being played out. What forms of urbanism might be appropriate in this environment? How can islanders effectively manage their landscape and engage with the natural processes - as their ancestors once did to a remarkable degree? By pairing traditional techniques with modern technologies, a proposal is synthesized which could empower the contemporary Marshallese to transform their landscape and develop sustainable livelihoods in this extreme and dynamic environmental condition: to build a future which offers the best aspects of both traditional and contemporary ways of life.

Acknowledgements

I would like to thank my committee - John McMinn, Lola Sheppard and Janna Levitt - for their interest and support in the development of this thesis.

Dedication

To my friends in Toronto,
with whom I've shared dreams of other worlds;

and to Dea,
for all your love and support.

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Notes on Style & Intent

This is a rather unusual document, and I would like to offer a few notes which will help the reader to orient themselves and navigate through it.

First of all, this is a story written from beyond the horizon, a story told about a landscape, history and culture of a place to which I have no claim to authority or authenticity. I am Canadian, not Marshallese; I have never been to the Marshall Islands, and have in fact never met anyone from the islands. Furthermore, the thesis deals in great detail with landscapes and ecosystems with which I have little practical experience: atolls and coral reefs. In terms of personal experience, few would be less qualified than I am: besides a few hours spent at Honolulu airport, and 2 years living in Sydney, Australia (which is hardly the definitive 'islander' experience) I've never set foot in the Pacific Islands. I have dived and snorkelled on coral reefs in northern Australia and in Mexico, but not extensively, and not for many years.

This thesis follows in a long tradition of stories told about the Pacific by outsiders which have tended to eclipse local understandings in dialogues about the islands and people. This immediately raises questions about cultural determinacy, the ability or even the *rights* of an outsider to appropriate and retell a history to which he or she does not belong. The great bulk of written histories we have available to us have been written by Westerners, some sensitive to an islander perspective, some not.[1] As careful as I have tried to be in my reading and telling of this story, this is not *my* history. I would only hope that it is evident in my appropriation of the histories and concerns of Marshall Islanders that this is done with as much balance and nuance as the information I had available me would allow, and that the exercise is carried out in good faith with the best of intentions.

I would, secondly, point out that the thesis is written with a 'continental' audience in mind: I assume that few people who might encounter this

1 For a thoughtful and insightful discussion of the tradition within Pacific Studies scholarship of histories told by "outlanders" and the implications, see Borofsky. "An Invitation," pp1-30.

work will have any particular familiarity either with Oceania in general, or with the Marshall Islands in particular. As such, the thesis tries to fulfill a role to which it is not particularly well suited - that of providing the necessary background milieu against which it should be considered. It is a bit like trying to present the entire history of Europe so that an audience completely unfamiliar with that history will be able to understand a very particular proposal being suggested for one out-of-the-way corner. In short, an impossible task. So I would suggest that the history, maps, and images I have provided be read as narrative rather than as a comprehensive history: I do not wish or intend to claim to be an authority on these histories. I have tried to suggest this in the style with which the story is related, which is to say, largely through narrative, maps and images. I have provided an appendix which contains a section of maps which describe many aspects of contemporary Oceania; for those unfamiliar with the region I would suggest that this may be a good place to begin.

I have no way of knowing how relevant these narratives would be from an islander perspective. For one thing, most of my reference material is itself written by outsiders - albeit outsiders with a great deal more contact with the islands than I have had. I have endeavoured to provide as rich a 'picturing' or 'imaging' of the Marshall Islands as I was capable, presenting multiple viewpoints within which to understand the particular social, political and even geological constucts which have informed the design proposal which concludes the work. At the same time however, the reader should note that the selectivity of the stories I have provided reflects the narrative nature of the work: it is a 'designed fiction' which supports a proposition. I attempt to address the ways that the role and agency of the designer is problematized when dealing with distant and disembodied subjects in the epilogue.

I might briefly recommend to the reader some of the key texts which informed me in my attempts to understand and write about a complex and largely invisible history. First and foremost I recommend to anyone reading this to begin by looking at an essay by a man named Epeli Hau'ofa, called "Our Sea of Islands." The essay is short, and though Hau'ofa simplifies the problems faced by Oceania a great deal,[2] it is a very inspiring piece that motivated much of my subsequent research. The body of scholarly work which falls under the umbrella of 'Pacific Islands Studies' - dominated by work coming out of Hawai'i, Fiji, Australia and New Zealand, but increasingly representative of the multitude of cultural perspectives in the Pacific region - offers a richness and complexity which might surprise those unfamiliar with it, as I certainly was. I have greatly enjoyed reading about the history and cultures of Oceania, and recommend the work of authors such as

2 As criticized, for example, by Jolly in several essays, including "On the Edge? Deserts, Oceans, Islands," and "Imagining Oceania: Indigenous and Foreign Representations of a Sea of Islands."

Robert Borofsky, Ben Finney, Joseph R. Genz, David Hanlon, Francis X. Hezel, Margaret Jolly, Patrick Kirch, Glenn Petersen, Paul Rainbird, Marshall Sahlins, Jack Tobin, Haunani-Kay Trask, and many others.

In writing my own version of Marshallese history, I was influenced and reliant to a great extent on a couple of excellent dissertations. The first is Greg Dvoraks' *Seeds from Afar - Flowers from the Reef: Re-membering the Coral and Concrete of Kwajalein Atoll*, which is a remarkable achievement by an author who's unique background enables him to navigate not only the Marshallese / American dialectic, but also the Japanese perspective.[3] The other essential pieces I rely on to inform my story are *Negotiating the Borders of Empire: An Ethnography of Access on Kwajalein Atoll, Marshall Islands* by Sandra Crismon and *Imagining the Marshalls: Chiefs, Tradition, and the State on the Fringes of U.S. Empire* by Julianne Walsh. All three of these works in their own specific focus deal with an often misunderstood or misrepresented history, and it was through contact with these authors that I became determined to engage with multiple sides of the story.

For those interested in more information about cultural and ethnographic history in the Marshall Islands, the Digital Micronesia website written and run by Dirk H.R. Spennemann out of Charles Stuart University in Australia is an invaluable (if somewhat difficult to navigate) resource.[4] It contains information about a whole host of subjects, from traditional settlement patterns, early colonial history, landscape, traditional foods and plants, etc. This, paired with a website called *Plants & Environments of the Marshall Islands*[5] by Dr. Mark Merlin out of the University of Hawai'i helped me to get my bearings with regard to the nature of the landscape with which I proposed to work.

I would like to apologize in advance for any errors I have made with regard to my use of the Marshallese language in the thesis. I do not speak this language, and so it represents another aspect of the Marshallese world I really have no authority to appropriate. I have attempted to include Marshallese words where they describe things or ideas which do not have an easy English analogue. For example, the word for Marshallese chiefs - Iroij. To replace "iroij" with English "chief" or "chieftain" risks aligning the iroij with western stereotypes of chiefs, and furthermore misses out on describing the particular characteristics embodied by "iroij" which is a more specific term than the vague anglicization. This tactic should be fairly clear as you read through the thesis - I have chosen to include Marshallese words where appropriate but also where they are sufficiently often repeated as to be coherent to a reader who is similarly unfamiliar with the language. For

3 It is available by request from him via his website: <http://www.gregdvorak.com/>.
4 See <http://marshall.csu.edu.au>.
5 See <http://www.hawaii.edu/cpis/MI/Home.html>.

guidelines on how to pronounce these words, you might consult Peter Rudiak-Gould's *Practical Marshallese*, which is very accessible. I was mispronouncing Ebeye[6] for a year before I found this book.

Finally, I would warn the reader that the thesis contains an unusual amount of historical analysis for an architecture thesis: one might begin to wonder as you navigate through the first three sections whether all of this is necessary. I would repond that it is a story I was motivated to tell because I found it to be remarkably tragic, uplifting, and also totally at odds with what I expected when I set out: I became determined to treat the Marshall Islands as a subject with as much sincerity and breadth of research as I could muster in service of shattering the preconceptions with which I had myself approached this story. As an architectural project, this thesis could be half the length, no doubt. I only hope you find the story as fascinating as I did, and are motivated by it to read more.

* * *

6 The site of the thesis proposal. My initial assumption that it would be pronounced "Ee-bay" was corrected when i first came across the excellent film *Home on the Range*, by Adam Horowitz (which I would highly recommend to anyone who is interested in hearing the sounds of the islands - language, music).

"The idea that the countries of Polynesia and Micronesia are too small, too poor, and too isolated to develop any meaningful degree of autonomy is an econom[ically] and geograph[ically] deterministic view of a very narrow kind, that overlooks cultur[al] history and the contemporary process of what may be called 'world enlargement,' that is carried out by tens of thousands of ordinary Pacific Islanders right across the ocean from east to west and north to south, under the very noses of the academic and consultancy experts, regional and international development agencies, bureaucratic planners, and their advisors, and customs and immigration officials, making nonsense of all national and economic boundaries, borders that have been defined only recently, crisscrossing an ocean that had been boundless for ages before Captain Cook's apotheosis.

If this very narrow, deterministic perspective is not questioned and checked, it could contribute importantly to an eventual consignment of groups of human beings to a perpetual state of wardship wherein they and their surrounding lands and seas will be at the mercy of the manipulators of the global economy and World Orders of one kind or another. Belittlement in whatever guise, if internalized for long, and transmitted across generations, could lead to moral paralysis and hence to apathy and the kind of fatalism that we can see among our fellow human beings who have been herded and confined to reservations. People in some of our islands are in danger of being confined to mental reservations, if not already to physical ones. I am thinking here of people in the Marshall Islands, who have been victims of USA atomic and missile tests."[1]

- EPELI HAU'OFA

1 Hau'ofa. "Our Sea of Islands" (1993): p6.

Falling stars and broken hearts.
LGM-118A Peacekeeper missile system being tested at the Kwajalein Atoll in the Marshall Islands.

The sun sets in a hurry in this part of the world, dropping like an over-ripe, red Pandanus fruit into the lagoon. The hulk of a World War II-era troop carrier cuts a dark wake through the gleaming water. Closer to shore sailing yachts and motor boats tug gently on bobbing white floats. The sun dissolves into the horizon, lingering for a moment in the hazy twilight, a flicker of green fire signalling the termination of its descent. On the beach, all is cast in pink and mauve, eyes raised to catch the viridian eclipse returning now to smiling faces, raised glasses and raucous cheer.

The crowd – some 40 young to middle-aged men and women, mostly white, with flushed faces and tanned skin – sit at the edge of the beach among tiki torches and bright blue tablespreads cluttered with plates of seafood, wineglasses and plastic bottles of water. Fires blaze in oil drums below swaying palm fronds; beyond the beach, the sounds of a televised baseball game emerge from the open windows of a large thatched-roof building, its interior lit with fluorescent lights. Two women – with chestnut skin and jet black hair, dressed in navy blue slacks – discretely snatch empty plates from tables as a man in a chef's hat conveys steaming platters from a wheeled cart.

Dinner is finished; the sky beyond rows of marching aubergine cumulonimbus fades through crimson into darkness. Tropical stars emerge, Aldebaran and the Pleiades shimmering in the humid night above the occasional flashes of a distant storm on the northwest horizon. But it is not a silent vigil for the remaining diners, who have rearranged their plastic chairs into rows, facing west. They have been joined by small groups of children and teens, who sit on blankets spread out on the sand, attended by dark-skinned women in bright floral dresses. Above the palms, a colossal antenna looms – grinding as it pivots in the darkness – lit by flashing beacons from below. Another mysterious sight: a fulgent, geodesic moon snaps to life among the trees, as a

siren, signalling something, briefly blares.

All at once the voices fall silent, only the remote coughing of an engine and the faint sound of the surf is audible. Then, high in the clouds to the north – just visible – a brief pulsing flash. Again darkness, and then in the next moment, the outline of a towering cloud is lit from within, its fringes a white luminence. Three balls of light emerge into an eerie mise-en-scène: lagoon and cloudy backdrop forming a titanic theatre for the celestial spectacle. Each glowing orb passes silently through the clouds, momentarily visible before slipping once more into the night. Then, one by one, the strange lights fall into the ocean and are extinguished.

* * *

This is Kwajalein atoll.[2] The beach overlooks the largest lagoon on earth,[3] in a nation of atolls called the Marshall Islands, out in the centre of the western Pacific ocean.[4] This island is also called Kwajalein, although it usually known colloquially as simply "Kwaj;"[5] it is the largest of almost 100 strips of sand and verdant vegetation which surround the calm waters of the lagoon. A tiny horseshoe of land,[6] it is crowded with a riot of radar domes, warehouses and satellite dishes: for this remote island is the Mission Control Centre of one of the most powerful and sophisticated radar[7] and telemetry installations on earth: United States Army Kwajalein Atoll.[8]

About half of Kwaj is occupied by the concrete and asphalt of a busy airfield, which supplies the base and the rest of the atoll, and connects Kwajalein with the Marshallese capital on another atoll - Majuro - some 400km distant. The rest of the island (no more than 1-2 metres above the surrounding water, except for an artificial mound at the western end of the island nicknamed "Mount Olympus"[9]) is occupied by a tidy village of concrete barracks, swimming pools, and a nine-hole golf course, all set amid spacious green lawns and rows of coconut

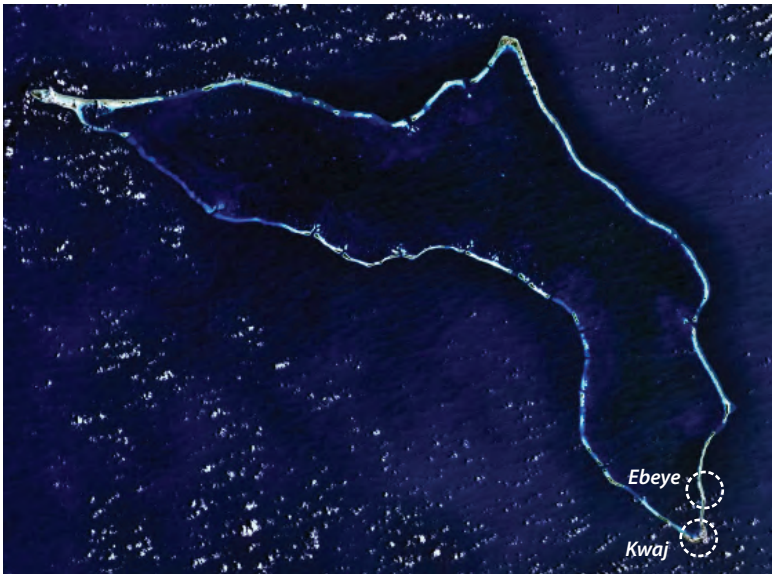
Note on Marshallese orthography and pronunciation:

Throughout this thesis, Marshallese words are used where appropriate. For information on pronunciation and orthography, see Rudiak-Gould. *Practical Marshallese* (2004).

In the case of Kwajalein, the American pronunciation is most common: roughly "Kwa-ja-lyn." In Marshallese orthography, it is spelled Kuwajleen, pronunciation roughly "Ku-wadsh-eh-lehn." Dvorak. (2007): Introduction.

Herein "Kwaj" refers specifically to Kwajalein *Island* only, the primary component of the American military base; "Kwajalein" refers to the atoll itself, including the lagoon and all islands which surround it; "USAKA" refers to the collection of installations spread across 11 islands which the US army leases from the Marshall Islands.

2 See sidebar.
3 See Fig. 0.2 opposite.
4 The Marshall Islands, officially the Republic of the Marshall Islands (herein referred to as the RMI), consists of 29 individual atolls and 5 islands spread over an ocean area of approximately 1,000,000km² (2,000,000km² Exclusive Economic Zone, or EEZ), approximately 4000km WSW of Honolulu and 4000km SE of Tokyo, north of the equator and west of the international date line.
5 See sidebar.
6 Kwaj is about 5km long and 400-1000 metres wide, with an area of 3.14km².
7 Wilkes, Frank, & Hayes. (1991): p7.
8 Accronyms abound in this militarized paradise: USAKA is home to the Ronald Reagan Ballistic Missile Defense Test Site - or RTS - a Major Range Test Facility Base (MRTFB) which is a component of the United States Army Space and Missile Defense Command (USASMDC). RRBMDTS. (2005).
9 The *ca.*12m high man-made "Mount Olympus" is a missile launch structure - a relic of the Nike / Zeus anti-Ballistic Missile project from the late 1960's and early 1970's.



Kwajalein
Kwajalein Atoll - NASA NLT Landsat 7 (Visible Color) Satellite Image. Kwajalein lagoon is an irregularly shaped triangle, some 130 kilometres from tip to tip, more than 40km wide for much of its length, 30-80 metres deep, with an area of about 2170km². The total area of all 93 islands surrounding the lagoon is only 16.4km².

FIG. 0.1

Oceania

Oceania - the Pacific

Ocean Area: 179,700,000 km^2;
The Pacific Ocean contains approximately 25,000 islands; 16 Pacific Island nations, with a total land area of 8,536,716km^2 (not including Australia: 849,866km^2).
The population of Oceania is approximately 36 million, of which 14 million live in the 15 Pacific Island nations not including mainland Australia.

LEGEND

Cultural Regime

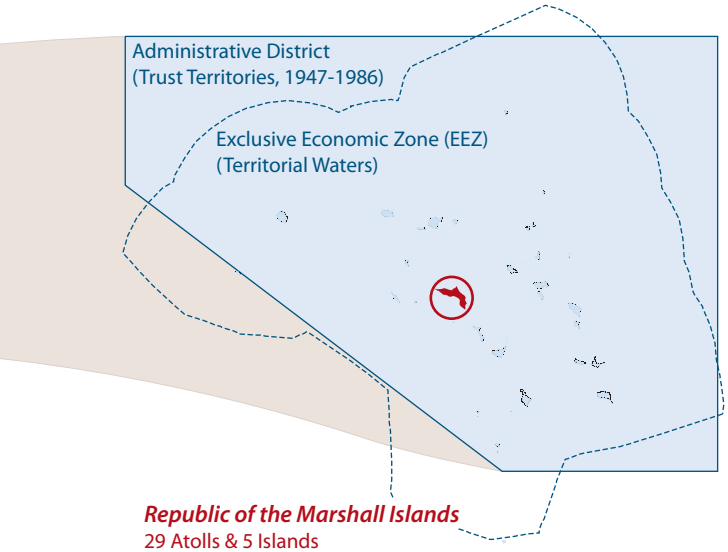
Melanesia

Micronesia

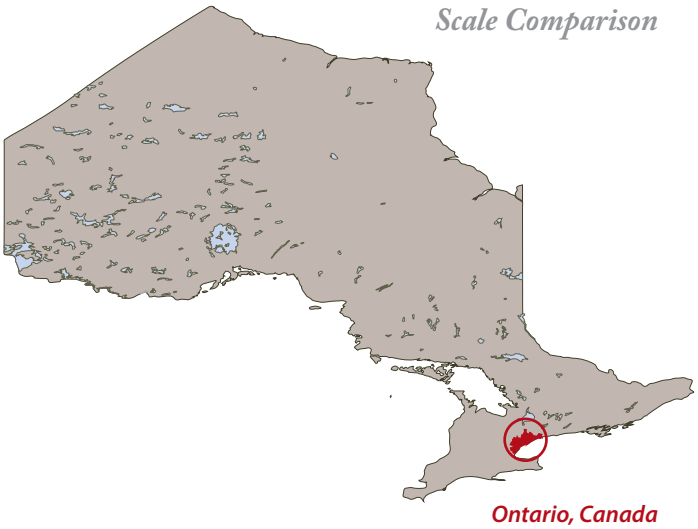
Polynesia

FIG. 0.2

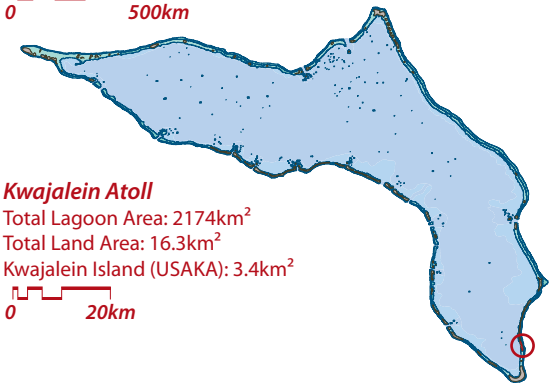
Scale Comparison



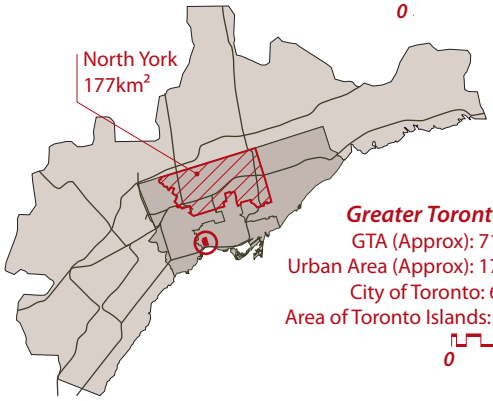
Republic of the Marshall Islands
29 Atolls & 5 Islands
Area of EEZ: 1,990,530km²
Total Lagoon Area: 11,673km²
Total Land Area: 181km²
0 500km



Ontario, Canada
Total Provincial Area: 1,076,395km²
Area of Water (Lakes & Rivers): 158,654km²
Area of North York: 177km²
0 500km

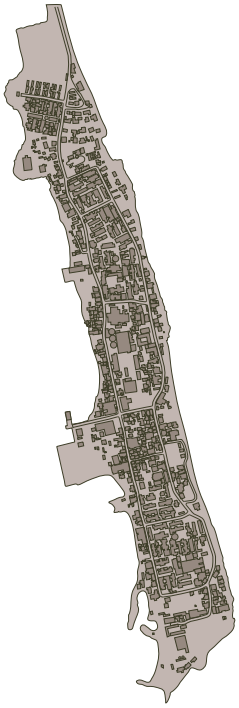


Kwajalein Atoll
Total Lagoon Area: 2174km²
Total Land Area: 16.3km²
Kwajalein Island (USAKA): 3.4km²
0 20km

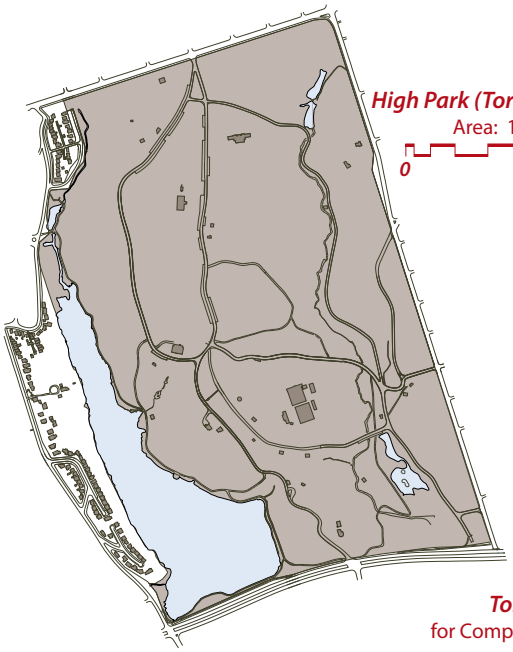


Greater Toronto Area
GTA (Approx): 7125km²
Urban Area (Approx): 1750km²
City of Toronto: 630km²
Area of Toronto Islands: 2.3km²
0 20km

Ebeye
Total Land Area: 0.3km²
Population: <15,000
0 500m



Ebeye, Kwajalein atoll
The Marshall Islands



High Park (Toronto)
Area: 1.6km²
0 500m

Toronto
for Comparison

FIG. 0.3

Kwaj & Ebeye

palms: a kind of tropical New Jersey suburb. Today, this village is home to some 2500 Americans - mostly civilian contractors and their families - who perform a variety of jobs related to base operations, sometimes living here for years, raising their families in a tropical idyll with the amenities of a "country club."[10] Despite this, and the lack of visible fencing and hard borders that are found on most American military bases on foreign soil, access is tightly restricted to base personnel on official business.[11]

The scene which opens this section portrays the atmospheric re-entry of de-activated warheads (Re-Entry Vehicles, RV's) delivered here by intercontinental ballistic missiles. They are launched from a military base in California[12] and soar 1500km out into space in a gentle parabolic trajectory towards the target 10,000km away across the Pacific.[13] Kwajalein sits at the other end of 'gravity's rainbow,' where the RV's re-enter the atmosphere - dropping in a fiery plunge towards Kwajalein lagoon at 25,000km/hr. The raison d'être for USAKA is to capture that final minute of re-entry.

> "For a weapon to be a weapon of deterence, it needs to be proven that, in fact, it will work. We want to know that it's as accurate as possible, so that when a decision is made by the President of the United States, he can be assured that exactly what he has asked for, he can have."[14]

USAKA is the 'down-range' component of the United States most extensive missile testing range[15] - a corridor between California and the western Pacific which includes not only Kwajalein, but facilities on multiple tiny islands in the central Pacific, as well as ocean areas covering thousands of square kilometres where debris from the tests fall into the ocean. As the RV's plunge to earth, the radars track every aspect of their descent, measuring accuracy, velocity, timing and trajectory. USAKA employs multiple types of radar which enable rocket engineers to track every aspect of the flight - from the moment the missile breaks the radar 'horizon' 4000km away until splashdown - at resolutions of centimetre accuracy.[16] USAKA is also used to develop and test anti-ballistic missile technologies.[17] As the RV's approach, missiles are deployed from a launch facility on one of the islands to intercept and destroy them in the upper atmosphere. All told, including

10 Crismon. (2005): p228.
11 Dvorak. (2007): p10.
12 Vandenberg Air Force Base, not far from Santa Barbara
13 Wilkes, Frank, & Hayes. (1991): p3.
14 Lt. Col. Harold Buhl, RTS Commander. Corcoran. (2009).
15 The Western Test Range (WTR).
16 Wilkes, Frank, & Hayes. (1991): p3. The RV's do not carry active nuclear warheads; they do, however, carry a payload of depleted uranium, which ensures that they behave exactly as a real warhead would; in addition, they carry sensors which relay their trajectory information to tracking stations on the ground.
17 Ibid. ABM, or Strategic Defense Initiative (SDI) - more commonly referred to as "Star Wars" technologies.

Kwajalein, Vandenberg, and all the intermediate installations, each test involves hundreds of people, billions of dollars of equipment, and up to 185,000km^2 of sea and air space.[18]

The Army does not own this atoll - they lease it. For the privilege of conducting their intercontinental, exoatmospheric tests here, they pay $15 million dollars a year to the owners, who have been evicted from their land for the past 50 years.[19] A short distance across the *reef shelf* (the flat coralline rim of the lagoon which lies below sea level in the inter-tidal zone) about 4km as the frigatebird flies, there is another island, where many of these landowners live, along with their many descendants and relatives: Ebeye.[20]

A starker contrast with the tidy grass and concrete of Kwaj can scarcely be imagined. Kwaj may be tiny, but Ebeye - 200 metres wide and about 1200 metres long, or about 0.3km^2 - is *miniscule.* And it is very, very crowded. The best recent estimates suggest that at least 15,000 Marshallese people live on Ebeye.[21] This is an almost unimaginable number, especially considering that most of the housing here is single-storey: predominantly a hodge-podge of tin and concrete-block shacks in various states of disrepair that have earned Ebeye the unfortunate moniker of "the slum of the Pacific."[22]

Multiple families are crowded into cramped quarters, with 10-20 people sharing single rooms.[23] One end of the island is occupied by a garbage dump, spilling over into the lagoon and surrounding the ramshackle trailers and make-shift homes which abut it. Running water is frequently unavailable,[24] forcing many residents to carry water home from central storage tanks. Power supply[25] is similarly intermittent. Raw sewage is pumped directly into the lagoon, polluting the beaches where many of the people bathe and wash cloths.[26] In short, Ebeye is a mess, its inhabitants living in destitution just a short distance from the wealth and privilege of the American base. They suffer from a range

18 Ibid., p18.
19 RMI/USA. (2003).
20 Pronounced "Ee-bye."
21 Although the official RMI census number is 12,000, Dvorak estimates 13,000. (2007): p288. There has not been an official census undertaken since 1999. The US Army Corps of Engineers Report (2010) estimated a population as high as 15,000.
22 Dvorak. (2007): p277.
23 ASPA. (2001): p174.
24 RMIOCS. (2008): pp10-13. And water is expensive, relying primarily on a central reverse-osmosis (RO) plant which converts saltwater to fresh.
25 Ibid., pp6-9. Provided entirely by a massive diesel generator.
26 Ibid., pp14-15. Despite the existence of a sewage treatment plant, currently unused and fallen into a state of disrepair.

of health problems related to the crowded, unsanitary conditions,[27] and are also at risk from radiation from the powerful radar.[28] When the highest tides come in, much of the island floods: garbage from the dump washes into their houses and sewage mixes with salt-water in the streets.

They are here - *without question* - because of the base.[29] Every day, beginning before dawn, the rumble of boat engines signal the start of another work day. 1800 Ebeye residents board the ferry[30] to make the 20 minute journey across the lagoon to jobs on the base. They work as groundskeepers, dock workers and maintenance workers, keeping the base supplied and shipshape. But they also work more intimately with the American families, cooking their food, cleaning their homes, and taking care of their children. The money they earn on the base[31] supports their families back on Ebeye, which over the years have grown into several generations of dependents. They are not allowed to live on Kwaj. Every night they return to Ebeye, the drone of the ferry an ever-present and mournful reminder to Marshallese and Americans alike that there is another world just across the reef.[32]

* * *

27 California Newsreel. (2008). The tuberculosis rate is 220 per 100,000, some 55 times the US average; Ebeye has also been the site of numerous epidemics over the years, including Polio, Typhoid and Measles, the most recent being a major Cholera outbreak in 2001; chronic problems include skin diseases, dysentery, diabetes, malnutrition and suicide, which reached an all-time high here in 2003. Crismon. (2005): p304.
28 Dvorak. (2007): p261.
29 Despite the protestations of the military administration. See Corcoran. (2009).
30 Actually the troop carrier described in the narrative; they do not board the ferry at once, but must wake early to obtain a seat; others wait as the carrier makes multiple return trips.
31 Today, $5US/hr for their efforts. See Corcoran. (2009).
32 Dvorak. (2007): p277.

This thesis is fundamentally an investigation into 'ways of seeing.' It is a sounding into the cartographies and official histories which have described and endeavoured to control the islands of the Pacific, in search of narratives and mythologies which challenge the accepted paradigms put forth by continental minds. Oceania - the island states of Polynesia, Micronesia, and Melanesia - are routinely described by what they lack: land, resources, connectivity, and potential for development. The people of Oceania have entered the twenty-first century mired in debt and dependence; the landscapes and people have been scarred by the events of WWII and the Cold War; they are encumbered with Western stereotypes concerning cultures and landscapes; the lands and reefs seem to be awash in dawning environmental catastrophes; and they have been continuously occupied by the speculations and geopolitical machinations of distant superpowers and corporations - all of which have conspired to limit visions of their future. Coming to terms with contemporary Oceania is an earnest mission. Among these island landscapes exist some of the most precarious human-ecology scenarios on earth. Islands - and in particular, atolls - are the front line in what will surely be a confrontation in this century with anthropogenic effects on the climate and environment at a worldwide scale. The bathymetries of the changes to come are only now beginning to reveal themselves.

Through an inquiry into the history, culture and landscape of the Marshall Islands - with a specific focus on Kwajalein atoll - this thesis seeks to uncover the very real ways in which islanders have energetically and efficaciously acted to construct their own futures. Central to this thesis is the idea that throughout Marshallese history, a 'continentally' biased 'way of seeing' has conditioned the way in which outsiders have pictured and framed these islands. The conditions found 'on-the-ground' seem to demonstrate as self-evident the hopelessness of effecting change; but our imaging of these conditions is founded in conventional mechanisms of assessment imported from the large, continental nations of the west. The atolls are consistently scripted - by academics, bureaucrats, and by islanders themselves - in a rhetoric which stresses smallness, isolation, weakness and vulnerability. Because of this smallness there is a tendency to try to essentialize and classify, to treat the Marshall Islands and other nations of the insular Pacific as ideal laboratories or "convenient microcosms" for larger global crises.[33] But this format for conceptualizing Oceania is a geographically, economically and culturally deterministic view which, masquerading as legitimate history or scientific assessment, has resulted in the confinement and belittlement of a people who do not imagine their world in such microscopic terms.

33 Baldacchino. (2011): p237.

> "There is a gulf of difference between viewing the Pacific as 'islands in a far sea' and as 'a sea of islands.' The first emphasises dry surfaces in a vast ocean far from the centres of power. When you focus this way you stress the smallness and remoteness of the islands. The second is a more holistic perspective in which things are seen in the totality of their relationships."[34]

A challenge to the orthodox paradigm need not be rooted in nostalgia for an impossible past. It is challenged everyday by the complex assemblages of informal transactions, bonds of kinship, extra-territorial travel and remittances which actually define the day-to-day lives and concerns of island peoples. The Marshallese have already adopted and transformed many aspects of the life offered up to them by the modern world, adapting and making it their own. The goal of this thesis is to suggest that despite the threats posed, this process will continue to be the most valuable resource the Marshallese people have at their disposal. The investigation uncovers a remarkable degree of resilience, ingenuity, and capacity for experimentation on the part of the Marshall Islanders, and these traits are not relegated to the distant past.

In developing the design proposal which forms the conclusion to the thesis, the chapters which follow are concerned with several important questions. Part one introduces the Marshall Islands and examines the persistent ways in which the islands and people are framed by outsiders. How accurate is a picture of the Marshallese as helpless victims at the hands of a ruthless American imperialism? Or conversely, as a hapless and backward people who have become 'professional victims' content to live off of the handouts of their American beneficiaries? Through a re-telling of Marshallese history, these common tropes are challenged by the actions and agency of a people who have dealt with their western (and eastern) colonizers in sophisticated and concious ways. From wholesale and deliberate landscape transformations of the 19th century, to the 'breadfruit revolution' of the 1970's, to the contemporary situation of leveraging US coercion against insular opportunism, Marshallese agency has been instrumental in extracting advantage from uneven partnerships with distant metropolitan powers throughout their history.

34 Hau'ofa. (1993): p7.

Part two inverts the act of picturing, and attempts to develop for the reader insights into the Marshallese view of the west. What is the Marshallese attitude towards the United States? In what ways have individuals acted to resist US aggression, and in what ways have the Marshallese been effectively coerced? How suitable are the typical imagings of the islands and people: for example, a description of Ebeye as a kind of hell on earth? If stories told from 'beyond the horizon' often have little relevance to the day-to-day reality as lived by ordinary people, what evidence exists of local, grass-roots action which has the potential to extricate the Marshallese from a future of dependence?

Part Three departs from the Marshall atolls to ask: what is the use of utopias? The chapter approaches this question by examining the work of a man named Wolf Hilbertz - an architect and marine scientist - and the relation between his pragmatic grass-roots work with coral reefs and impoverished coastal peoples, and the theoretical and political underpinnings which drove the development of this work. Hilbertz' story provides an interesting foil to examine the ways in which the future of the Marshall Islands - which is clouded by narratives of predestination: environmental doom, continuing American dominance, and economic stagnation - may in fact offer up unexpected potentials which have been hinted at in the historical analysis presented thus far. To what extent is the islanders future threatened by unavoidable conditions, and to what degree is the adoption of western methods - of western forms of urbanism, economic production, transportation, consumption - really to blame?

The final chapter introduces a design proposal which builds upon the theoretical and historical analyses of the first three. Of particular concern are two parallel but distinct paradigms which must be addressed to develop an efficacious and relevant response to the situation at hand. The first involves the technical issues which might enable a form of inhabitation in the atoll environment which is resilient to dynamic climatic changes, and works *with* rather than against the existing landscape condition. What forms of urbanism might be appropriate in this environment? How can islanders effectively manage their landscape and engage with the natural processes - as their ancestors once did to a remarkable degree? To this end, there are a number of emerging technologies which may prove beneficial in the near future, but there is also a wealth of appropriate knowledge

and techniques embodied by traditional cultural practices (with regard to landscape, transportation, and social organization). What kinds of hybrid solutions might be proposed which draw from both modern and traditional technologies?

The second, and arguably equally - if not more - essential consideration are the dreams, desires, adaptability and capacity to innovate of ordinary people. Critiques of faltering economies and social problems among the island nations of the Pacific often lament the 'Americanization' or 'Westernization' of islander culture, and lay the blame for the failures of development initiatives on the complacency fostered by the handouts and compensation packages of external aid. And yet, many aspects of traditional culture endure: the contemporary social structures in the Marshall Islands reflect an enduring commitment to the value of traditional leaders, practices of land tenure, and bonds of kinship. While the urban Marshallese have - by necessity in some cases - adopted western foods and a wage-earning form of livelihood, traditional foods and subsistence formats of production endure simultaneously. It is not simply a choice between the modern (western) and the traditional, but rather a question of which aspects of modern life have real value in Marshallese eyes. What do the Marshallese people imagine for the future in the islands? Do they want jobs? Or might a comprehensive and varied array of livelihood options more fully address what local people wish to bequeath to their children?

Any proposal, to have validity, must engage with at least some of these questions. The dreams, adaptability and capacity to innovate possessed by ordinary people do not figure very prominently on our maps and graphs; these are extremely potent forces, and a chronic failure to understand and acknowledge these forces goes a long way towards explaining the failures of so many development initiatives, foreign-direct investment proposals, and the like.

* * *

"Here we are, fifty years after Bravo, and the people forcibly removed from their homes for the atomic tests... have yet to return home. The question of exposure as it affects other atolls of the Marshall's has yet to be fully addressed. Many claims are still being prepared. Adjudicated claims have not been paid in full as agreed upon by the United States. Medical and monitoring programs, promised by those who exposed us, have been severely curtailed or abandoned... Bravo is not over. The people of Kwajalein, who sacrificed their home and society for America's nuclear ambitions, still live in squalid conditions on Ebeye, unable to live in peace and comfort in their own homeland. They have been subjected to many of the same treatment the islands of the tests suffered: displacement, loss of traditional skills, social disruption, and the contamination of their lands and seas. We became dependent on the US because the US claimed the power to govern us. We did not ask for it, but when it happened we came to understand the choices we had. After decades of living with the good and the bad under American rule, we decided that the greater good would be to cast our lot with the US under the Compact of Free Association.

Today we are America's allies in the war on terrorism. We are America's allies in the development of the missile systems. We are allies in the United Nations - and vote with you when all your other allies abandon the US on issues of great importance. We do that of our own free will, without the exercise of extra-ordinary US powers under the Compact. For all these reasons, I can say we appreciate and understand America. We understand what Fourth of July means to Americans. We understand what Ford's theater, and December 7, 1941 mean to America. We understand what November 22, 1963 means to America. We understand what September 11 will always mean to America.

What we are here today to ask is that America understand us as well as we understand it. For our people, for the Marshall Islands, March 1, 1954 is the defining moment in world history."[1]

- JAMES MATAYOSHI
Mayor of Rongelap Atoll

1 Matayoshi. *Yokwe Online* (2004).

Operation Crossroads
The moment of detonation. Crossroads Baker explodes in Bikini lagoon, 1947.

The sea was calm, and in the east the first rays of the morning sun cast an amber hue on banks of cumulus. The ocean was a deep purple, gentle swells lapping at the wooden hull of a vessel with taut lines stretching into the gloom behind. The weight of trawling nets pulled against the thrust of the engine, causing a slight asynchronicity between the rolling of the deck and undulating surface of the sea. The boat did not plow through the swells so much as surf them, held suspended on the leeward crest of each wave by the weight of the catch. Calls of gulls and fulmars swarming the lines indicated the nearby presence of land in an otherwise featureless sea.

A sudden lull in the breeze caused the lone man on deck to raise his eyes to the west, where they were met with a startling sight: a sudden flash on the horizon, so bright he had to cover his eyes and look away. When he looked back, the flash had been replaced by a great glowing hemisphere, which slowly rose as the sun does, the moisture-laden morning air painted in hues of orange and deep crimson red.

"Yabai!"[2] *- another man's voice, shrill.*

The young man, bewildered, looked from one shoulder to the other, from east to west, the gentle orange light of the eastern sunrise now dim in comparison to the red fire which seemed to have spread over the entire western quarter, a glowing orb rising and expanding from its centre. Strange sparkles of light filled the sky, tendrils of fire flickering with a solar luminance. More voices below-decks, rousing slumber, as one by one men emerged into the morning to stand transfixed before the mysterious cosmic event. Soon the entire crew stood watching in quiet wonder as this second sun rose before their eyes. It grew brighter once more, the molten crimson surface fracturing to reveal a rising brilliance below. As the ball of fire ascended, the clouds around it seemed to melt, liquescent plastic before the inferno, slivers of darker matter peeling away from the surface and sliding down and out into the newly formed void. The conflagration continued upwards in a surreal silence, spreading and flattening below an expanding ceiling of white vapour. The shattered hemisphere beneath the white plume grew darker and broke apart slowly, a molten column hefting the snowy toroid from its centre. The sky

2 TRANS. "Oh shit!" JAP.

above was distorted, rent by semi-circular rings which gave the impression that the whole of the heavens was about to collapse to the earth. Layer upon layer of ethereal gossamer was pushed up and distorted against an invisible barrier at its crown. All at once, as the plume expanded and grew horizontally, lit from within and by the now pale light of the true sun at their backs, the atmosphere evaporated and a complete image was revealed to all. The comprehension of what they were witnessing was burned into their retinas: a vertical red column capped with an ever-expanding mushroom cap.

"Pikadon,"[3] someone whispered into the morning.

A wind shift brought a sudden gust of air from the east, whistling in the rigging and whisking froth from the crests of waves, making the turbulence tangible to the eyes. The horizon shimmered, a shadowy apparition approaching over the deep blackness of the sea before them, fringes licked with an orange flame and the air above rippling like a desert mirage. The frightful image of the mushroom cloud was compressed and doubled, stacked upon itself, the light arcing over approaching thermoclines, two, three, then four stacked columns of vapour crushed into the crystal refraction of the air. Sea spray around the boat swirled, changed direction again, rushing back into the faces of 23 terrified men. A sharp, attenuated clap of pressure was attended with a tremendous blast of warm wind. The vessel keeled over, its port gunwales almost touching a now confused sea, gentle parabolic swells replaced with a turbulent interference pattern before the unnatural onslaught of tepid violence. The men grasped what they could, some losing their footing and falling to the red-painted boards of the deck. A deep bass trembling followed, the sound of a hundred thunders, and the cool wetness of morning moisture was instantly replaced with an electric dryness that tasted faintly of ozone. Hemp lines strained at pulleys, the net twisted by the shift in the vessels course and waves out of the west. Unspoken orders set the men to work, frantically winding winches and hauling in the lines. The engine was cut and they pulled and stacked the nets, the lead line with its bobbing cork floats followed by the drag line with its lead shot.

Morning blossomed, the incandescence in the west fading to a dull red, a sculpture cast in hot iron cooling in the air. The sea became calm again. With the net pulled in to its throat, the engines roared to life and the boat swung around to the north. The massive white plume spread high in the jet stream, an ovoid cloud towering up and over the vessel, spreading out beyond to the south and east obscuring the rising sun in hazy whiteness. The men settled into the routine of sorting through the catch, pike-poling bonito and shark behind the gills and heaving them into the hold, tossing hagfish and herring back to the swarming seabirds, pausing occasionally in their toil to confirm the continued ominous presence on the horizon. Colourful corks piled up to starboard, the light of the sun growing dim behind thickening mists overhead. The sea was now glass-calm, slate-grey, the sky the colour of a

3 TRANS. literally "Flash-boom!" JAP., a word coined to describe the bombs the Americans ignited over Hiroshima and Nagasaki.

Castle Bravo
Bravo erupts into the upper atmosphere, March 1, 1954. The device utilized a solid-state enriched lithium fuel for the second fission reaction, which was ignited by the enormous pressure created by the primary reaction and the bombardment of the enriched lithium crystal with high energy neutrons. The device was expected to yield 4 megatons; however, the addition of unenriched lithium produced an unexpected 'tritium bonus,' significantly magnifying the power of the blast. Bravo would be the most powerful nuclear device ever detonated by the United States. Sublette. "Operation Castle 1954" (2007).

Ground Zero, Bikini Atoll
Bravo crater, northwest corner of the atoll: 2 kilometres across and cut more than 100 metres into the reef flat.

winter morning on the sea of Japan, so unlike its usual tropical brilliance.

A veil had descended over the horizon, the sun barely discernible as a faintly brighter smudge in the lambent clouds. "Yuki! Mite!"[4] The shroud of mists fell silently. The great twisted tree of the blast faded and was gone, and they floated alone in a silent dream. In the waters beyond the bow were held suspended tiny white flowers, the mist resolving itself into a million falling snowflakes. The snow was gentle at first, a few tiny flakes drifting down from the heavens to rest on the sea, on the glossy paint of the transom, in the outstretched hands of bewildered men. The flakes fell faster than real snow, and seemed preternaturally large, falling petals of sakura.[5] Pieces of many shapes and sizes materialized in the hazy light: tiny motes of dust, sheets of charred paper curling in the air, and filaments like falling cobwebs. Catching it in their hands, the men felt that the material was not cold or wet but dry and warm, like the ashes from a fire.

Soon the air was filled with a flurry so dense that the sound of it settling on the deck became audible. They retreated to the cover of the wheelhouse, bootsteps crunching as they crossed amidships to the threshold. As they tried to shake the stuff from overalls and brush it from shoulders they found that it left a chalky residue on cloth and skin alike that could not easily be removed. The entire crew crowded the wheelhouse, watching with a growing dread the unnatural storm that had engulfed the ship. Several of them had flecks of white in their hair and on their shoulders and arms. An acrid scent permeated the air.

* * *

The vessel in the story was the *Dai-go Fukuryū Maru* - the "The Fifth Lucky Dragon" - a 140 ton Japanese long-line tuna boat. On March 1st, 1954, the vessel was trawling for tuna 30 kilometres to the north of Rongelap atoll in the Marshall Islands.[6] The explosion the 23 crew members witnessed that morning was the detonation of a nuclear device code-named the "Bravo" shot, which exploded on a jetty at the northwest corner of Bikini atoll in the Marshall Islands, as part of the "Castle" series of nuclear tests carried out by the US navy. Bravo produced an explosive yield 250% more powerful than the American scientists who set off the blast had anticipated. It exploded with a force equivalent to 15 megatons of TNT, or more than 1000 times more powerful than the bomb which had devastated Hiroshima 9 years earlier. It would be the most powerful nuclear device that the United States would ever detonate.[7] So enormous was this explosion that it was fully visible from Kwajalein atoll, some 400 kilometres distant where buildings housing the former inhabitants of Bikini "shook as if there

4 TRANS. "Snow! Look!" JAP.
5 TRANS. "Cherry Blossoms" JAP.
6 Dvorak. (2007): p347.
7 Sublette. "Operation Castle 1954" (2007).

had been an earthquake."[8]

An hour and a half after the blast, a gritty white ash blanketed the decks of the Fukuryū Maru.[9] The unnatural flurry continued for two hours; it was clear to the crew that the blizzard of ash was fallout from a nuclear explosion: they had heard the stories of *Hibakushi*[10] and they were terrified that they would be poisoned by radiation. They described an ocean as far as the eye could see covered in a frothy blanket of grey sludge; 5-10cm coated the ship. With no other choice, they swept the ash into bags with bare hands and threw it overboard.

During the return voyage to Japan, the crew fell ill, wracked with headaches and nausea; eyes and skin burned and broke out in rashes and many were bedridden with fevers. But by the time they made it back to Japan, many of these symptoms had cleared up, and 12,000 pounds of fish they brought back was sold, headed to *sashimi* markets all over Japan. But the symptoms soon returned, and the captain and seven other crew members were diagnosed with severe radiation poisoning.[11] Panic ensued; as Japan's government frantically tried to track down the irradiated fish, the market in Geiger counters exploded. The ship and crew of the Fukuryū Maru was placed in quarantine. Aikichi Kuboyama, the radio operator, would die of his injuries seven months after his return, and 13 more men would have their lives cut short in the following years. Kuboyama left these last words: "I pray that I am the last victim of an atomic or hydrogen bomb."[12] All incoming fishing vessels were checked for radiation, both in Japan, and soon on the United States west coast, as the news of the disaster caused an international uproar. The US at first tried to cover up the incident, but fearful of a strong anti-American sentiment in the Japanese media, the United States government negotiated a settlement in which the US paid reparations to the amount of $2 million to the Japanese people.[13]

The incident blew the lid off of the secrecy with which US operations in Micronesia had been cloaked. In Japan, the disaster re-awakened the traumas of Hiroshima and Nagasaki; the American government was forced to admit that testing of nuclear arms had continued even after the horrors visited upon the Japanese people 9 years earlier. Japanese

8 Tomaki Juda, quoted from Dvorak. (2007): p346.
9 Niedenthal. (2004): p270.
10 Survivors of Hiroshima and Nagasaki.
11 Dvorak. (2007): p348.
12 Japan Times. (2009). The tuna market collapsed, the Tsukiji fish market in Tokyo flooded with merchandise that a terrified public would not eat.
13 See: Wikipedia: "Daigo Fukuryu Maru," and Dvorak. (2007): p349.

fisheries in Micronesia had become an atomic proving ground.[14]

"Mike Who?"

Even today, it is difficult to talk about the Marshall Islands without mentioning the nuclear weapons testing which took place here following World War II: Castle Bravo is for the Marshallese the "defining moment in world history."[15] But it is also for many outsiders the only point of reference. Ask non-islanders what they know about the Marshall's, or Micronesia, and you may get a reply similar to the one given by an American congressman, asked for his opinion on the future political status of the then US controlled Trust Territories of Micronesia, who responded: "Mike Who?"[16] By contrast, such was the fascination, awe, and provocative mystery the nuclear era inspired in the public, that the site of these world-shaking blasts was immortalized in the name of a skimpy, two-piece bathing suit.[17]

The term 'Micronesia' describes a geographic region which contains many cultural, geologic, and historic contrasts. Like the Marshall Islands - one of 7 nations and territories which are usually understood to comprise it - Micronesia is in many ways an invention: a construct of the continental appraisals of Empire from beyond the horizon, rather than a real entity that existed prior to the occupations of Europeans, Japanese or Americans. The region describes some 2300+ islands spread across more than 7 million square kilometres of ocean.[18] A few large volcanic high islands and raised coral islands punctuate a seascape dominated by atolls. Unlike Polynesia, which, although containing a plethora of cultural traditions, is genetically and linguistically rather homogeneous, (see Fig. 0.9) the diversity of Micronesian history makes simple categorization impossible. Just as the sands which make up the 'land' on the many coral atolls throughout the region are constantly shifting, the boundaries of language, affiliation and kinship are similarly fluid. For the most part, Micronesia "existed only in the minds of

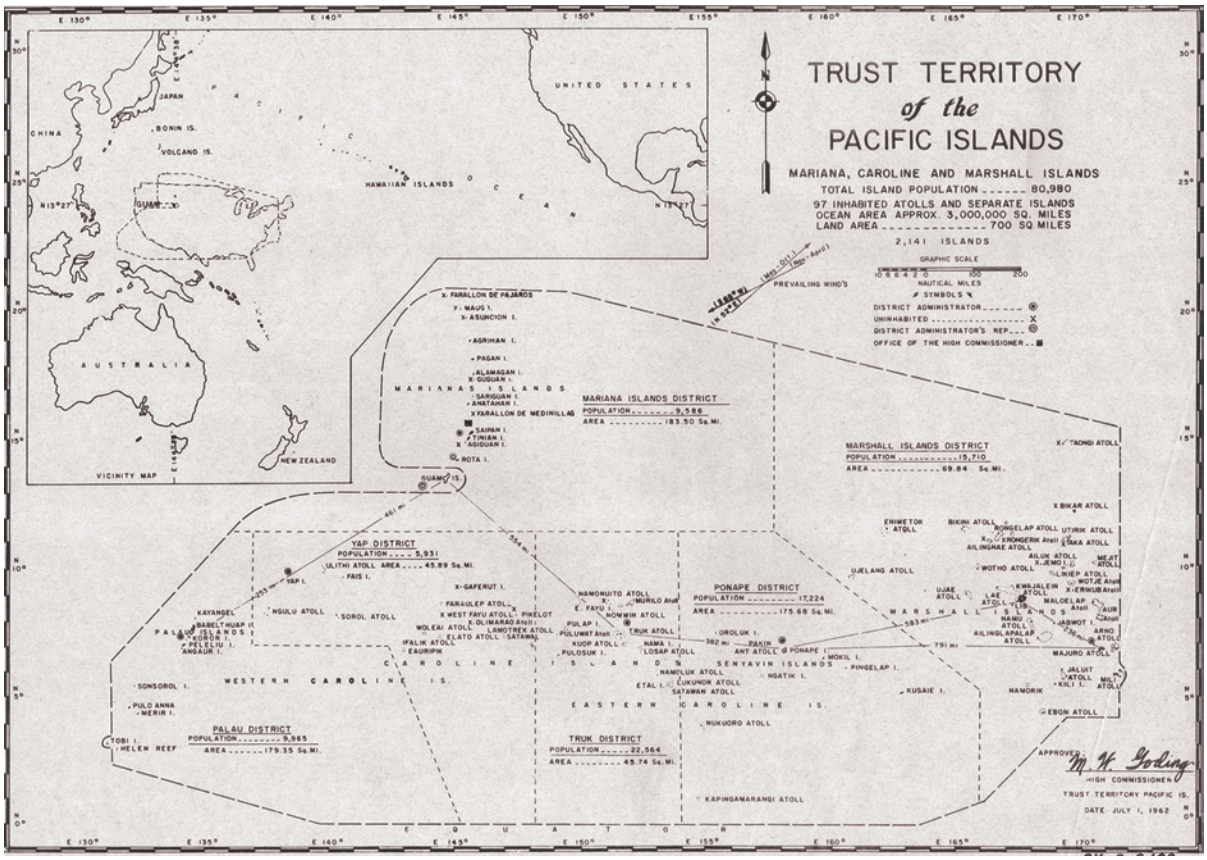
14 Dvorak. (2007): pp342-350. Anxiety embodied in this realization is demonstrated in Hondo Ishiro's film *Gojira* (which would become familiar on American shores two years later in its edited, dubbed form: *Godzilla*) released just six months after the incident, in November of 1954. In the film, a sleeping monster is awakened from its slumber by strange scientific testing, and heads directly to the Japanese home islands where it wreaks havoc on Japan's cities. In the original, many clues hint that Gojira's place of origin is none other than the Marshall islands; Gojira attacks a fishing trawler near the beginning of the film, and there are references to *genshi maguro* (atomic tuna), a term which had become ubiquitous in Japan during the summer of 1954. The story of the Fukuryū Maru would also inspire a movement against nuclear weapons among Tokyo housewives which would sow the seeds for later organized anti-nuclear movements in Japan and across the Pacific. Japan Times. (2009).

15 Matayoshi. *Yokwe Online* (2004).

16 See "Micronesia: Trials of Trusteeship," in *Time Magazine*, Vol. 77 (23 June 1961): excerpted from Rainbird. (2004): p37.

17 Described in both Dvorak. (2007): p345, and Crismon. (2005): p158.

18 An area larger than the continental US - but with a combined land area smaller than Rhode Island. See Rainbird. (2004): p38.



United States Trust Territory of the Pacific Islands
A historical map of the Trust Territory *ca.*1962. The Marshall Islands are on the right; Micronesia is administered in four separate districts, from left to right: Palau; Yap; Truk; Panape. The Marianas are to the north of Guam, an unincorporated United States territory.

people from the outside who have sought to create an administrative entity for purposes of control and rule."[19] The ancestors of the Micronesians moved within a world free of the boundaries of state or border; great navigators, their journeys traced out trading networks which stretched far afield - and their languages and traditions reflect this.

Isolated island worlds have often been conceptualized as microcosms of the earth, sealed human environments which form ideal laboratories for the study of larger, more complex processes of the continental world.[20] But this tendancy to essentialize[21] ignores the very real social reality of a people whose "world has often been a large one allowing movement by judicious use of winds and currents that would often mean extended stays on islands that were not their homes: but, they were at home with the sea."[22] History is similarly full of anecdotal evidence of enduring contact between Micronesians and the cultures which surrounded their oceanic world: sometimes accidental, storm-blown castaways from as far afield as the Phillipines or Papua New Guinea;[23] more often purposeful voyages of war and trade which connected the Marshallese with the high island empires of Kosrae, Truk and Pohnpei and with the peoples of the Gilberts to the south, with whom they regularly traded and intermarried. Oral traditions also describe acts of conquest, such as a story from *ca.*1860, where a group of about 50 canoes were dispatched from Majuro to conquer Kapingamarangi - some 2000 kilometres away.[24]

> When Europeans arrived on the scene, with their histories of imperial expansion, their technologies of domination, and their lusts for superordination, they did not encounter peoples who were unfamiliar with the possibilities of empire. Rather, they found populations who were not only committed traders but already possessed fairly sophisticated concepts concerning the

19 Hanlon. (1989): p1.
20 See for example Diamond. (2004), and Bahn, Flenley. (1992). These 'microcosmic' theories have been criticiqued by Kirch, Baldachinno, and Rainbird, among others.
21 Borrowed from island biogeography, where generalizing with regard to species isolation and evolution, diversity, etc., is justified. But this correlation does not translate simply to island peoples, who maintained more complex relationships with distant resources and cultures, seldom isolated completely or for long.
22 Rainbird. (2004): pp1-4. To illustrate this, Rainbird offers the story of Caroline Islanders who would regularly sail over 1000 kilometres across the Phillipine Sea to collect a special type of mother-of-pearl. Similarly, the Marshallese of the northern atolls had a tradition of visiting *Eneen-Kio,* (TRANS. "the island of the *Kio* flower" MAR.) now known as Wake Island - a tiny speck of land some 3.5km^2 in the middle of the northwest Pacific, some 1000 kilometres to the north of Bikini and Enewetak. They travelled to this remote, arid atoll to collect the eggs and feathers of birds, especially the wing-bones of albatross which were used in traditional tattooing. Here they also collected the rare Kio flower, probably a rare orange variety of the creeping Beach Morning Glory, *Ipomoea grandiflora*. See Spennemann. "The wreck of the Libelle and other early European Visitors to Wake Island, Central Pacific," *Digital Micronesia* (2010).
23 Ibid. pp4-6.
24 Spennemann. (2005): pp40-42.

> possibilities of overlordship, well-developed committments to making use of it, and skills and tactics for resisting it.[25]

The sea which flows among this multitude of islands is as much a connecting sea as it is an isolating one, a smooth space upon which the boundaries of consequence were primarily social rather than physical, and fluid rather than fixed. Micronesia was a human landscape of *fusion* - not in the sense of sameness, but in the sense of a heterogenic multitude of unique identities which are constantly in flux, the result of a "milieu of communication and contact across seaways and across putative language groupings."[26]

Atollscape

The modern Marshall Islands consist of 29 atolls[27] and five islands, which make up a total area of dry land of about 180 km^2, dispersed across almost 2,000,000 km^2 of ocean.[28] The atolls form a pair of parallel archipelagos - the *Ratak* and *Ralik*[29] chains - necklaces of pearls cast a thousand kilometres across an azure sea. The atolls range from tiny fringing reefs around sand islands (Mejit, Kili), to large reef structures which completely encircle a shallow lagoon (Taongi, Uterik), to enormous Kwajalein, a partially submerged reef which encircles the largest lagoon on earth, 120km long and more than 40km wide in some places (see Fig. 1.1). The Ratak and Ralik chains are relics of ancient volcanic arcs.[30] Beneath the waves, submerged seamounts form an undersea mountain range rising 6000 metres from the mid-Pacific abyssal plains. But the vulcanism that created this atollscape has long been dormant; the basaltic rocks which underlie the atolls are suspected to range from 75 - 170 million years old.[31] Volcanic hotspots which once fuelled this mountain-building were extinguished or moved on, and during the eons which followed, the immense weight and pressure of the overlying ocean caused the earths crust to slowly sink. Fringing reefs grew up around these undersea mountains, which still punctured the surface of the sea, but eventually erosion and subsidence erased all evidence of them, leaving only a ring of coral which continued to grow as the basalt beneath slowly sank.[32] The coralline rocks and sediments which now exist at the surface sit atop millions of years of coral growth, sometimes more than a kilometre thick[33] (see Figs. A1.6, A1.7 in

25 Petersen. (2009): p26.
26 Rainbird. (2004): p9.
27 Comprising over 1200 individual islets.
28 Which is to say, an land area the size of Brooklyn dispersed over an area about equal to the size of Mexico.
29 Spennemann. (2005): p25. Ratak: the "sunrise or eastern" and Ralik: the "sunset - the western."
30 Similar to the more familiar ones which make up the Hawai'ian and Marianas archipelagos.
31 Earthref.org. (2011).
32 See Nunn. (2010): pp349-353, and IOC. (1987).
33 Sponsel. (2009): pp408-440.

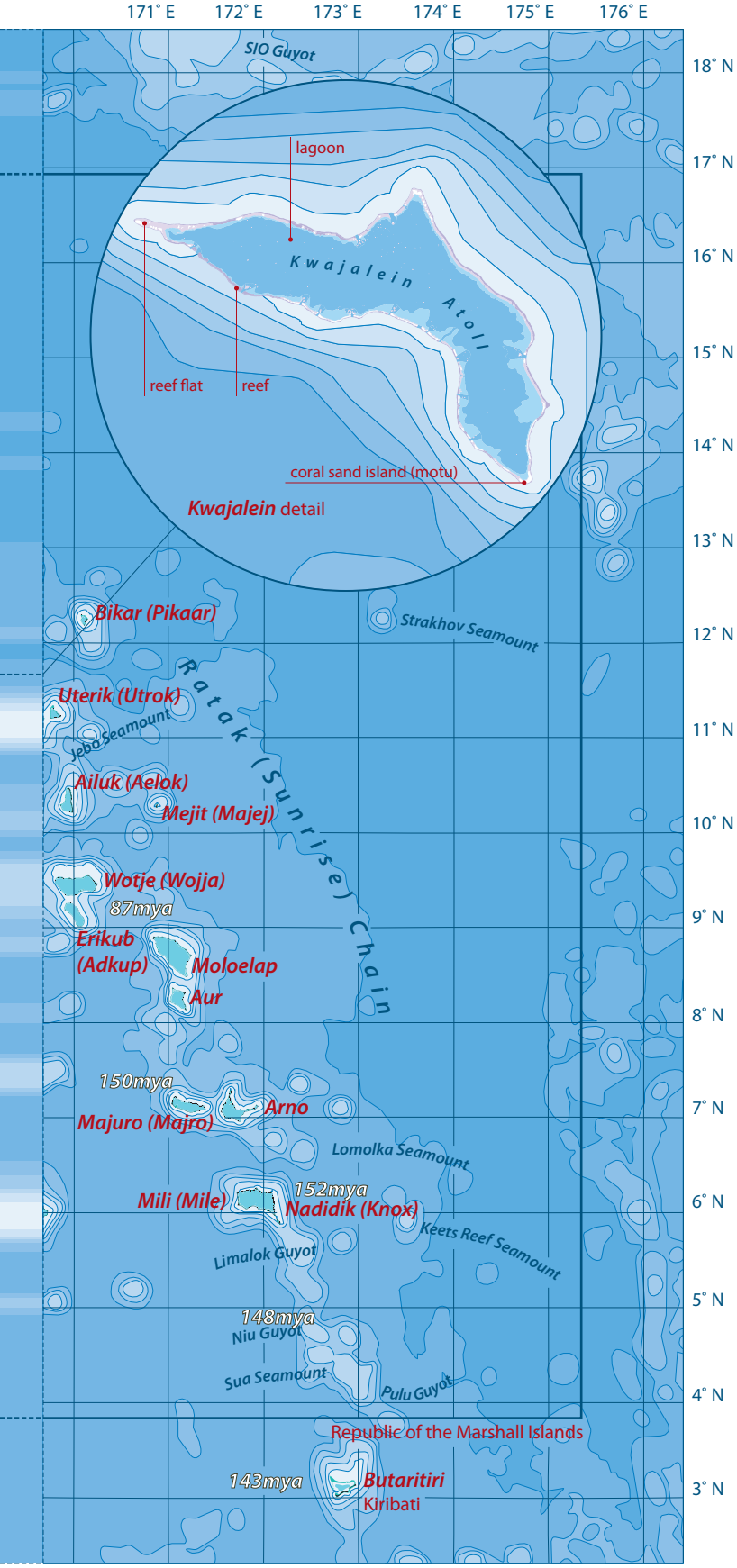
The Headhunter and the Hula Girl
(left) A tattooed man of the Ratak chain, drawn by Adalbert von Chamisso, *ca*. 1818. (right) 'Portrait of Poetua, 1777': the daughter of Orio, a chief of Raiatea, painted by John Webber during Cooks' 3rd voyage. The serenity of the scene belies the fact that at the time she was being held captive. This is perhaps the first in a tradition of paintings which would idealize and sexualize the European idea of Polynesia.

From the earliest European interactions with islanders, perceptions of race and development conditioned relationships. Explorers such as Cook recognized and commented upon affinities with Polynesians and admired them as an advanced and noble people. In contrast, the 'black, wooly headed natives' of Melanesia and Micronesia inspired fear and derision. D'Urville's superficial categorization of the Pacific into Polynesia, Melanesia and Micronesia - which utterly fails to apprehend the diversity of the latter two regions - nevertheless persists today. Polynesians, though culturally diverse, are linguistically and genetically essentially one group; Melanesians and Micronesians, on the other hand, are far more heterogeneous, the extant groups emerging from a much longer period of interaction among disparate cultural and genetic lineages. See Jolly. (2007) for a comprehensive discussion.


157° E
158° E
159° E
160° E
161° E
162° E
163° E
164° E
165° E
166° E
167° E
168° E
169° E
North Pacific Ocean
Dixie Jane Seamount
Karin Seamount
165mya
86mya
North Wod-En Guyot
Zubov Seamount
Seascan Seamount
173mya
Aean-Kan Guyot
Neen-Koiaak Guyot
South Wod-En Guyot
Lomtal Guyot
Ioah Seamount
102mya
Lewa Guyot
Bokak (Taongi)
Lobbadede Guyot
Ratak Guyot
Ita
Mai Tai Guyot
Bwewa-Kan Seamount
Lakoto-Nornor Seamount
South Laanmojanjan Seamount
Laanmojanjan Seamount
Lojabon-Bar Seamount
Lawun-Pikar Seamount
Peto-En Seamount
Lo-Wuliej Seamount
Look Seamount
140mya
Lami Seamount
Ruwituntun Guyot
Sylvania Tablemount
Bikini (Pikinni)
Lojemeja Seamount
Rongerik (Rondik)
Lainjin Seamount
76mya
Likelep Guyot
Enewetak (Anewetak)
Ailinginae (Ailōnginae)
Rongelap (Ronlap)
Toke (Tōka)
Lajutokwa Guyot
Lo-En Guyot
Lewonjoui Guyot
Lotab Seamount
76mya
168mya
Jemo
Wotho (Wōttol)
Lalibjet Seamount
Ujelang (Ujla, Wūjlan)
Likiep (Wojja)
80mya
Ujlan Guyot
Kwajalein (Kuwajleen)
Kwajalein Guyot
165mya
Lae
160mya
Ujae
163mya
Ralik (Sunset) Chain
Lib (Ellep)
Namu
Jabat
Ailinglaplap
Jebro Seamount
Pakin
FSM
Ant
FSM
Pohnpei
Federated States of Micronesia
Mokil
FSM
Maanjidep Seamount
Jaluit (Jalwoj)
Pingelap
FSM
Namorik (Namdik)
Kili (Kole)
Kosrai
Federated States of Micronesia
Ebon (Epoon)
North
0
240km

FIG. 1.1

Marshall Islands Atollscape



LEGEND

Bathymetry

Seamount Age

Undersea Features

- Sublittoral Lagoon 0-80m
- Epipelagic 0-200m
- Mesopelagic 200-1000m
- Bathypelagic 1000-2000m
- 2000-3000m
- 3000-4000m
- Abyssal Pelagic 4000-5000m
- >5000m

Features

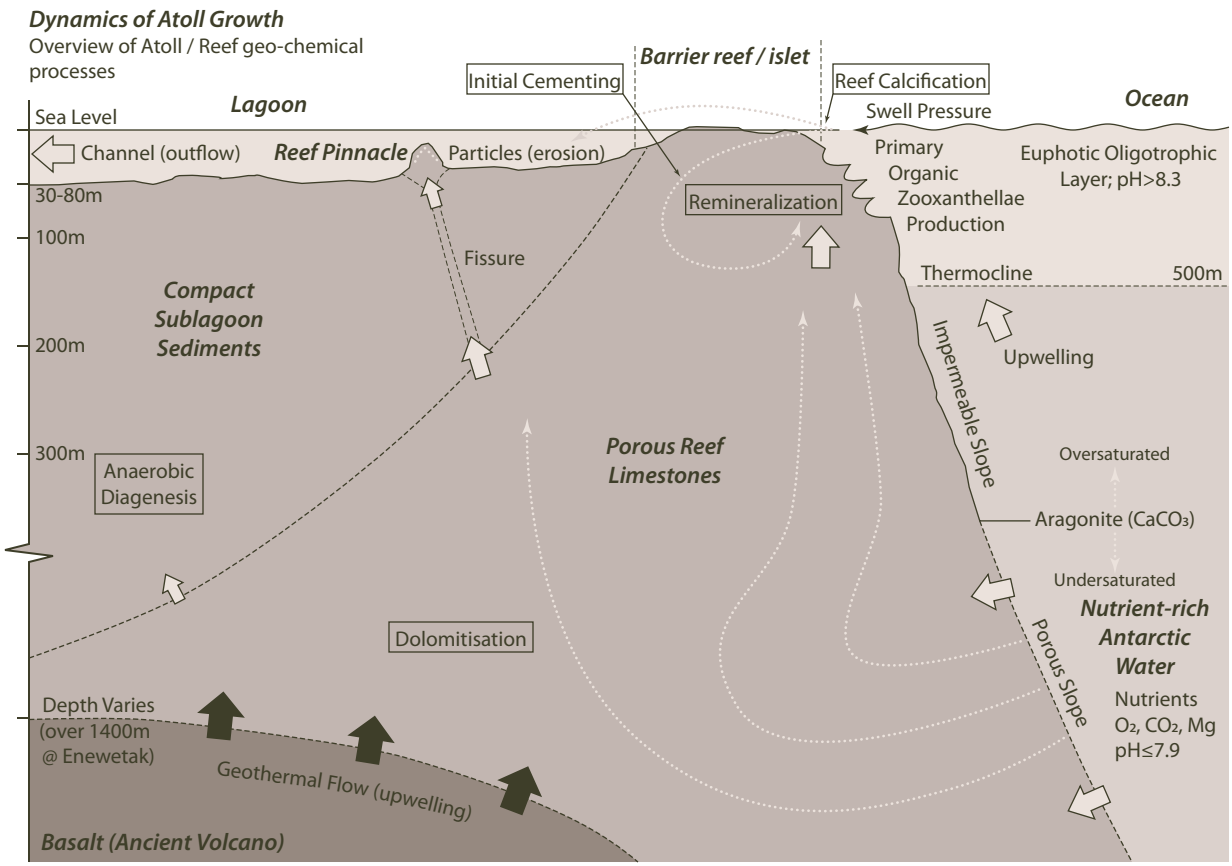
Atoll Name (Alt.)

- Seamount / Guyot
- Atoll Structures

FIG. 1.2

Atoll Geochemical Processes

1+



Overview of Geochemical Process of Atoll Formation
This diagram illustrates one theory of reef development, which answers Darwins Paradox (the apparent impossibility of balancing input and output of nutritive elements which control the coral polyp metabolism) and the enigma of atoll phosphates (massive quantities of subsurficial phosphates on tropical islands which do not appear to have, nor have ever had, large seabird populations sufficient to create them). Deep, nutrient rich water is absorbed into porous submarine mountainsides and transferred to the surface by means of geothermal endo-upwelling: differentials of temperature and chemistry induce enormous volumes of nutrient rich water to transfer up through the sub-surface mountain structure of an atoll. The morphology of the atoll drives this endo-upwelling: wave and tidal action on the reefs constantly flushes the system, drawing more water to the surface. Rougerie. (1998).

Appendix I).

Though the healthy coral ecosystems of the Marshall atolls teem with life, the crystal clear blue waters of the Micronesian ocean are one of the most nutrient deficient on earth. This blue "means desert for ocean, just as yellow-ochre does for the sand of the continental deserts."[34] The atoll structures of the Marshalls alone cover some 12,000km^2, and grow at a prolific rate (at up to 10kg of organic matter fixed per m^2/year, they are one of the most prolific ecosystems on earth) providing shelter and sustenance for an incredible diversity of marine fauna in the midst of an oceanic desert.[35] It is the mountain-structures that underlie these reefs which are largely responsible for their abundance: the nutrient rich water of the deep mesopelagic ocean is absorbed into the porous lower slopes of the mountain, and is then slowly transported towards the surface by a variety of processes, including geothermal upwelling. Thus the living reef, the underlying mountain, the morphology of the lagoon, and the temperature and nutrient gradients of the ocean all exist in a tenuous balance which requires an intricate web of relationships for its fitness (see Fig. 1.2).

> "Coral colonizes: Polyps voyage the ocean currents, joining with other coral communities atop sub-aquatic volcanoes that rise miles above the sea floor to break the surface. Their migrations are based on the flows of the sea, and their settlements are serendipitous. They join with previous settlers, bringing their own histories to the reef, re-territorializing and adapting, forming a complex geneology that connects islands together and forms new ones, reshaping and making sense out of the endless blue of ocean."[36]

The Marshall atolls were colonized by seafaring settlers sometime between 500 and 1500BC, but if those peoples left behind more physical evidence of their lives and culture than a few middens, the scattered coral-gravel yards of ancient homesteads, and evidence of gardening features and fishtraps, it has not been found.[37] The archaic inhabitants may have come from the west, via the Marianas islands at a very early date; it is also possible that they arrived from the south via

34 Rougerie. (1998): p165. Nutrient deficient in terms of dissolved phosphates, nitrates, and silicates.
35 Ibid., p166. The engine of this incredible production is the symbiotic relationship between the tiny coral polyps and micro-algaes called zooxanthellae. The oligotrophic surface layers (the Euphotic zone) in fact overlies an enormous reservoir of nutrient richness. "The surface layer (9-150m), heated by the sun, floats over the deeper waters and is separated from them by a thick density barrier which extends between 150 and 500m, the depth from which the Intermediary Antarctic Water is found. The ocean is therefore in two layers: a warm, oligotrophic surface layer, clearly separated from the deep layer, which is both cold and rich in nutrients."
36 Dvorak. (2005): p63.
37 Spennemann. "Archeological Sites." (1998). There is some debate about where they came from - the origins and affiliations of the ancient Marshall's are complicated and have been little studied.

the Gilbert Islands[38] or arrived in multiple waves from many sources. What is known is that over the course of probably more than 3500 years, this marine landscape has been continuously inhabited by a group of people who developed unique ethnobotanical, cultural, and technological systems to deal with the depauperate atollscape (see Fig. A1.4 in Appendix I).

Atolls are one of the most challenging environments ever colonized by mankind. A testament to this fact are the numerous archeological sites left behind by Polynesians in similar landscapes among the Rawaki and Line Islands, which were uninhabited at the time of European arrival: despite the formidable technology and ingenuity with which the Polynesians settled the rest of the Pacific, they either chose to abandon or failed to survive there. The islands are seldom more than a metre or two above sea level, and are composed entirely of sand and gravel derived from the living reefs which ring the atoll and grow in the lagoons. The sediment which make up these sand islands - or *motu*[39] - is generated by the erosive power of waves crashing on the reefs, but also the significant biological erosion created by corallivorous fishes and invertibrates[40] which feed on the living corals and excrete coralline sands into the water column. These sediments are driven by waves and currents up onto the flat reef shelf, and eventually into the lagoon.[41] In effect, atolls are enormous natural sediment traps.

There is no ground water; beneath the sand, the porous bedrock is saturated with salt-water. Rainfall which soaks into the sand percolates down until it reaches this saline layer, where - because of its lower density - it floats. Enough rainwater can build up in this way to form what is called a "Ghyben-Herzberg" lens - a body of freshwater soaked into the island sediment which presses down on the saline layer below it, forming an inverted lens (note location on Fig. 1.3). At the interface, tidal action and wave pressure slowly mix the fresh and saline layers; only on large, wide islands with regular rainfall to "recharge" the lens is a reliable drinking water source provided in this way.[42]

While protein sources are readily available on the reef shelf and marine environment - seabirds, shellfish, fish and turtles - the cultivation of starches and fruits required extensive human manipulation, creating anthropogenic ecosystems which could support a range of introduced plant and animal species. The landscapes the early settlers encountered would have been forests and scrub-land which grew precariously on these shifting sands. There is no really solid 'ground' in the sense that all of the land consists of a relatively thin layer of sand and rubble consolidated by a hardy scattering of plant species salt-tolerant enough

38 -now known as Kiribati.
39 A Polynesian word which has entered into the common parlance of geologists.
40 Parrotfish and crown-of-thorns starfish, for example.
41 Nunn. (2010): pp353-354.
42 For discussion, see Bailey, Jensen, and Olsen. (2010).

Traditional Settlement

Wato (Traditional Land Allotment)
Landholding of one household or family group, a wato traverses the islet from oceanic to lagoonal shore, and includes the adjacent marine resources.

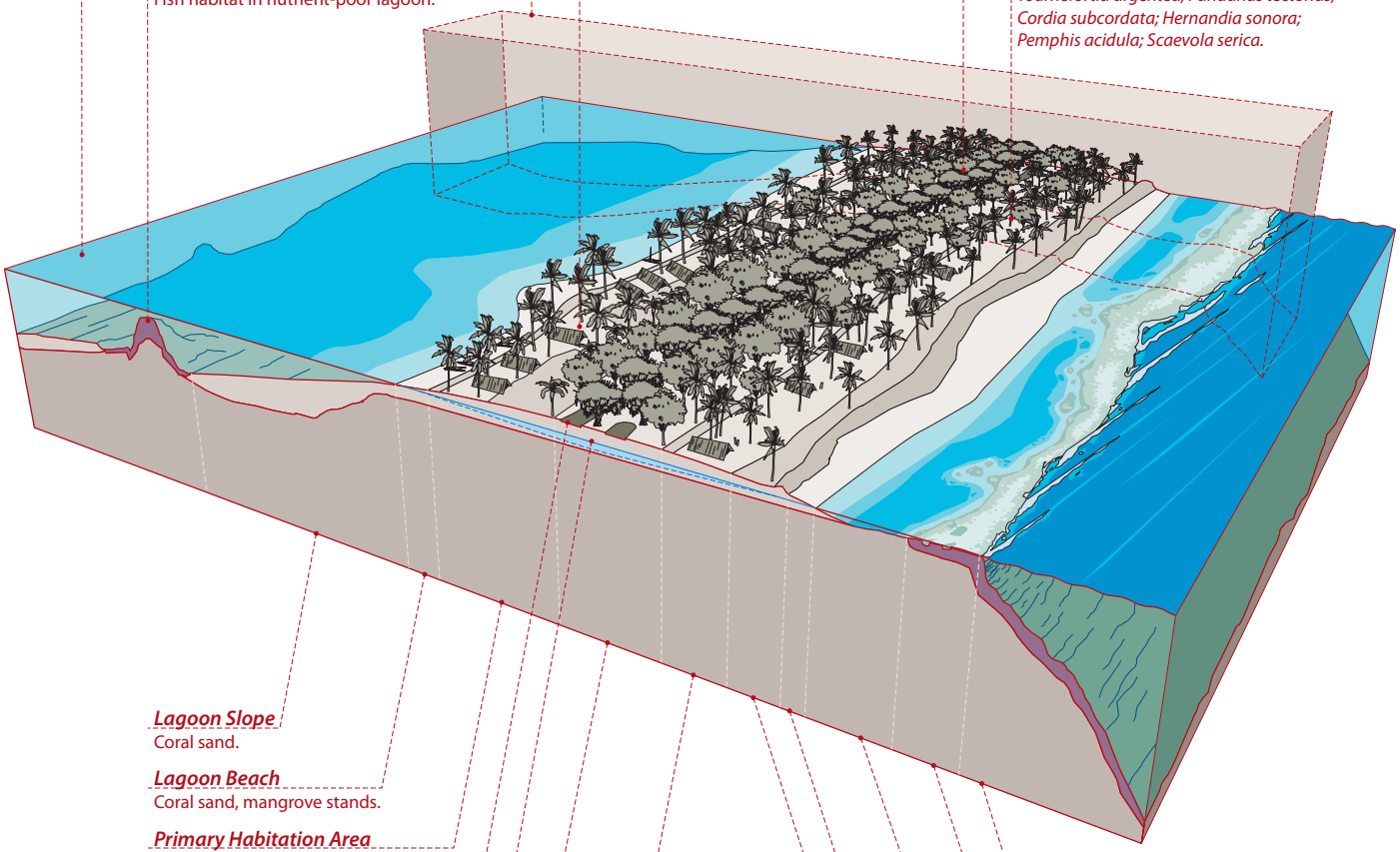
Lagoon Flats
Coral sand and gravel, 40-80m depth.

Reef Pinnacle
Fish habitat in nutrient-poor lagoon.

Inhabitation Zones
Fruit and succulents cultivated in man-made microclimate: *Cocos nucifera; Artocarpus altilus; Artocarpus mariannensis; Musa sapientum; Tacca leontopetaloides; Crinum bakeri.*

Breadfruit Forest
Intense aquatic taro cultivation, protected by Breadfruit and Pandanus: *Artocarpus altilus; Cyrtosperma chamissionis; Alocasia maccrohiza; Pandanus tectorius; Bruguiera gymnorrhiza.*

Oceanic Broadleaf
Salt tolerant plants & shrubs only: *Cocos nucifera; Guettardia speciosa; Tournefortia argentea; Pandanus tectorius; Cordia subcordata; Hernandia sonora; Pemphis acidula; Scaevola serica.*



Lagoon Slope
Coral sand.

Lagoon Beach
Coral sand, mangrove stands.

Primary Habitation Area
Coral gravel yards surround traditional huts; ornamental and utility plants.

Taro Pit
In the islet centre, where the freshwater lens is thickest, artificial pits would be created to grow taro.

Fresh-water Lens
Brackish water permeates the limestone bedrock of the atolls; a narrow lens of fresh water floats atop the brackish water.

Breadfruit Forest
Moist, loamy soil; excavated taro / mangrove pits in the understorey.

Secondary Habitation Area
Oceanic broadleaf shrubs and coconut palms; gravelly soil.

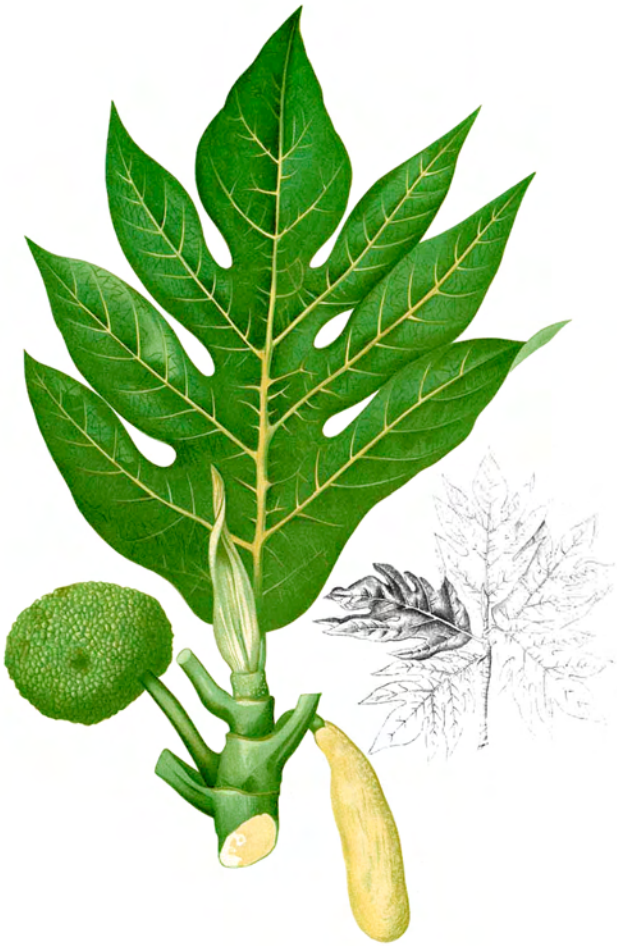
Reef Slope
Living corals to 50m depth; coral rock slope to approx 1400m.

Algal Ridge / Reef Crest
Living corals & surf break zone.

Reef Flats
Largely exposed at low tide, composed of solid coral rock, with some deeper pools and rubble; fish traps were carved into the coral, allowing unattended fishing.

Ocean Beach
Primary fishing / shellfish collection.

Ocean Strand
Boulder / cobble soil behind distinct strand wall; few plants besides palms.



Breadfruit - Mā
The most important traditional foodcrop - *Artocarpus incisus*.

to survive. The island environment is constantly in flux, periodically inundated by storm-driven tides, torn apart by cyclonic winds, or even completely washed away by cataclysmic waves which leave nothing behind but the bare coral shelf. Though the contemporary imagining of a south-seas paradise is dominated by swaying palm trees, these palm forests are largely the result of human intervention.[43]

Early settlers brought with them a whole host of resources (in the form of introduced plant & animal species), technologies (farming, forestry, hunting and fishing techniques) and cultural practices (social systems such as land tenure, taboos, traditional laws, and the cultural practices surrounding the maintenance of the canoe voyaging tradition) which enabled them to flourish. They radically transformed the landscape, modifying the flora to suit their needs and provide food and shelter. The Marshallese subsistence system (described in Fig. 1.3) relied upon the introduction and cultivation of four primary plant species which were deployed in a system of mixed tree-gardening or agroforestry. The natural forest was replaced with a managed forest of dense, salt tolerant varieties of Pandanus tree (*Pandanus tectorius ssp.*) as a kind of hedge or screen to protect the interior atoll from wind-driven salt and spray. Pandanus (TRANS. Bōb MAR.) is a medium sized tree which was a vital crop in its own right: it grows a large, fibrous fruit which was eaten fresh or stored as a fermented paste, which could be kept for many months; the fibrous fronds of the bōb were utilized to weave clothing, thatch for housing and baskets, as well as the sails of canoes.[44] In the interior of the islands, partially protected by Pandanus and other vegetation of the ocean-strand, the people managed dense forests of the most vital food-crop: *Artocarpus altilus*, or breadfruit (TRANS. Mā MAR.). The mā trees, which like the bōb were cultivated into many varieties, produce a large, starchy fruit in copious quantities. Breadfruit formed the staple of the Marshallese diet, and would have been consumed with every meal; furthermore, like the fruit of the bōb, Marshallese developed techniques to preserve it, storing specially prepared mā in baskets to be used in times of food shortage. In the most sheltered areas of the largest islands, pits (TRANS. Pat MAR.) were excavated. They were surrounded with more pandanus, and a type of mangrove also brought here by design, *Bruguiera gymnorrhiza* (TRANS. Joñ MAR.), which prevented the infiltration of salt air and was an important source of rot resistant wood for canoes and houses. These pits were intensively cultivated with plantings of semi-aquatic taro varieties such as *Cyrtosperma chamissonis* (TRANS. Iaraj MAR.) and

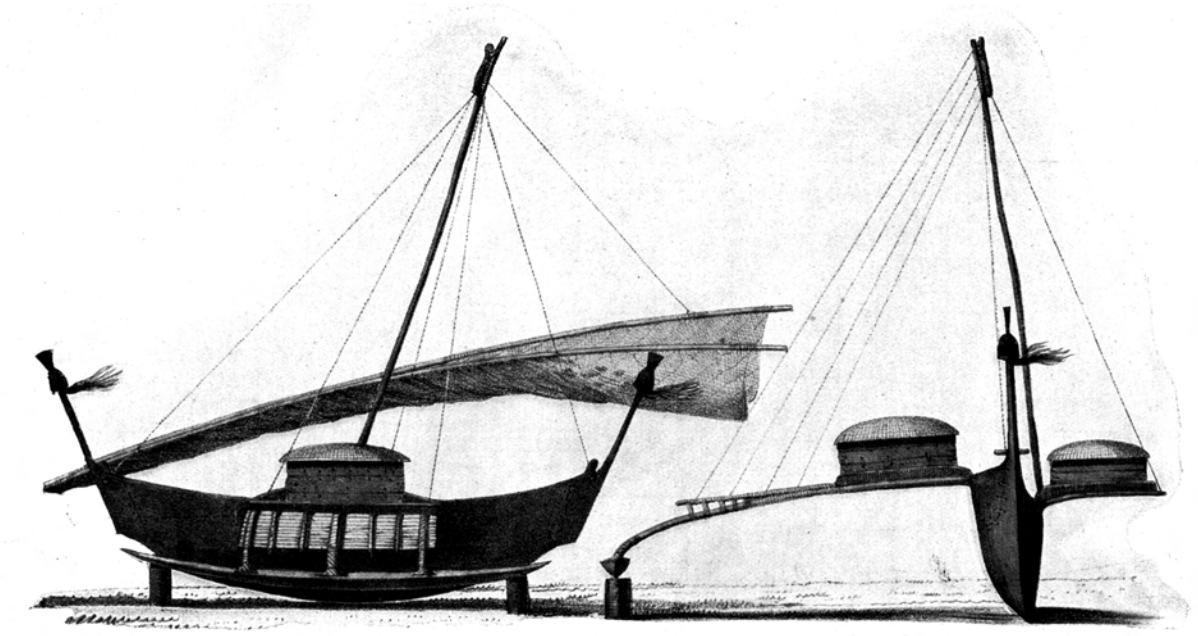
43 Hathaway et al. (2011): pp13-17. The atolls would originally have been covered in forests of *Pisonia grandis* and scrublands dominated by species of *Scaevola* (Beach Naupaka) and *Tournefortia* (Tree Heliotropes) which provide very little in the way of harvestable food sources.
44 Merlin. (2011). While bōb may have existed here before human arrival, it would have differed from the more than 100 varieties which the Marshallese cultivated through preferrential propagation over countless generations, optimizing it to produce larger fruit, better fronds for weaving, and adapting it to various climates.

Colocasia esculenta (TRANS. Kōtak MAR.), which required standing fresh-water in a moist, humid environment. To prevent salt-water intrusion from below, the pits were lined with organic matter such as pandanus fronds, and the taro crop was grown on raised miniature islands in the mucky pit.[45] And of course, the ubiquitous coconut palm, *Cocos nucifera* (TRANS. Ni MAR.) was cultivated on all islands, along lagoon shores and amid the breadfruit forests. It probably has more uses than any other plant in the world, with more than 300 traditional and modern applications recorded.[46] The atoll dwellers built houses of wood and thatch along the sheltered lagoon shore, among coconut, pandanus, and various fruit trees such as bananas and papaya, and supplemented the food sources of the landscape they created with the bounty of the seas which surrounded it.[47]

The Navel of the World

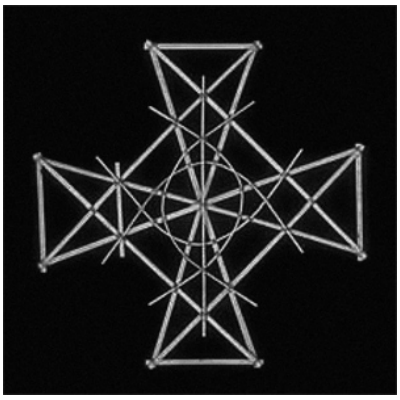
The importance of the canoe to the endurance and resilience of traditional Marshallese society cannot be overstated. As Josepha Maddison, a cultural activist in Majuro remarks: "There's no Marshall Islands without the canoe."[48] The Marshallese were well known for expertise in long-distance sailing voyages and a system for open ocean navigation which relied primarily on their ability to discern recognizable patterns of waves around islands.[49] This form of navigation is not unique to the Marshallese, in the sense that other Micronesian and Polynesian navigators were certainly aware of wave effects and used them in combination with other navigational tactics to find islands at sea (in the same way, Marshallese navigators were not solely reliant on wave patterns). However, the Marshall islands are uniquely suited to a navigation paradigm based on wave interactions, and the Marshallese developed this to a level of sophistication which is unparalleled. The practice of wave navigation is a response to archipelagic morphology: linear chains of atolls and seamounts which are oriented perpendicularly to dominant wind and swell regimes. The wind-driven swells created by the northeast trade wind - the dominant swell regime - have a deep and regular pulse, unhindered over a 7000km reach.[50] The navigators orient themselves by feeling the interactions between different swell regimes - which manifest as exaggerated peaks and troughs, known as wave-nodes - and by checking the direction of swells with celestial objects, visible islands or wind directions. In addition to surface swells are powerful sub-surface currents: the

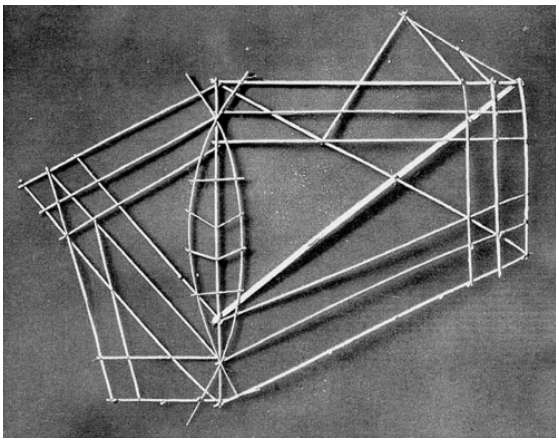
45 Ibid.
46 Ibid.
47 Manner. (2008): pp64-68.
48 Miller, R. (2010): p42.
49 Genz; et al. (2009). An excellent overview of the skills and techniques of traditional Marshallese navigators is provided by this article.
50 Ibid. Canoe navigators recognized as many as eight distinct swell patterns at sea, emerging from every direction of the compass. These swell patterns are seasonal; while the northeast swell, known as the *Rilib*, is the most reliable, a southeasterly or even southerly swell dominates during the tropical summer.



Segelschiff der Radaker (von seitwärts und von vorn) *Gezeichnet und lithogr. von Choris*

The Marshallese Canoe
Traditional Marshallese *tipnol* canoe: a lithograph by Louis Choris, who visited the Marshall's with the von Kotsebue expedition in 1816. The Marshallese constructed several sizes and types of canoes: the *walap* was a huge long distance voyaging canoe, up to 30m in length and capable of carrying as many as 50 people; the *tipnol* was a common mid-size canoe, capable of inter-atoll voyaging over open water and ocean fishing, carrying up to 12 people; and the *korkor*, a small rowing/sailing canoe for 2-3 people, used solely for transportation and fishing in the calmer lagoon waters. See Spennemann. (2005): p32.





Marshallese Stick Charts
Wapepe (top): an idealized wave pattern chart used for teaching the principles of wave navigation. *Meddo* (middle): a more specific diagram depicting expected swell patterns between two islands, often showing external reference points in relation to a wave node or cardinal swells. *Rebbelib* (bottom): the most familiar chart to western eyes emphasizes wave patterns with reference to islands; scale is less important than illustrating major features - a directional rather than dimensional concept of space. The *Rebbelib* also betrays regional knowledge on the part of the navigator who created them; detail deminishes with familiarity on these charts. See Spennemann. *Essays on the Marshallese Past* (1998).

Marshall's are spread out in the path of the north Equatorial Current and the Equatorial Counter current, which also cause wave effects in their interactions, creating steep waves where they follow against the wind, and flatter waves with the wind.[51]

These oceanic phenomena interact with the strings of islands in predictable ways, reflecting off of the windward reefs and refracting around to lap on leeward shores. Where the swell fronts pass between islands, they bend and intersect with one another and with themselves; these interactions form detectable phenomena - 'seamarks' which the navigator follows to find land (refer Fig. 1.6). Seamarks encompass both wave phenomena - wave-nodes, calm areas, and breaking swells - and natural phenomena, such as marine mammals and fish, seabirds, (especially the non-pelagic species which return to land every evening to roost) bioluminescent planktons, etc.[52]

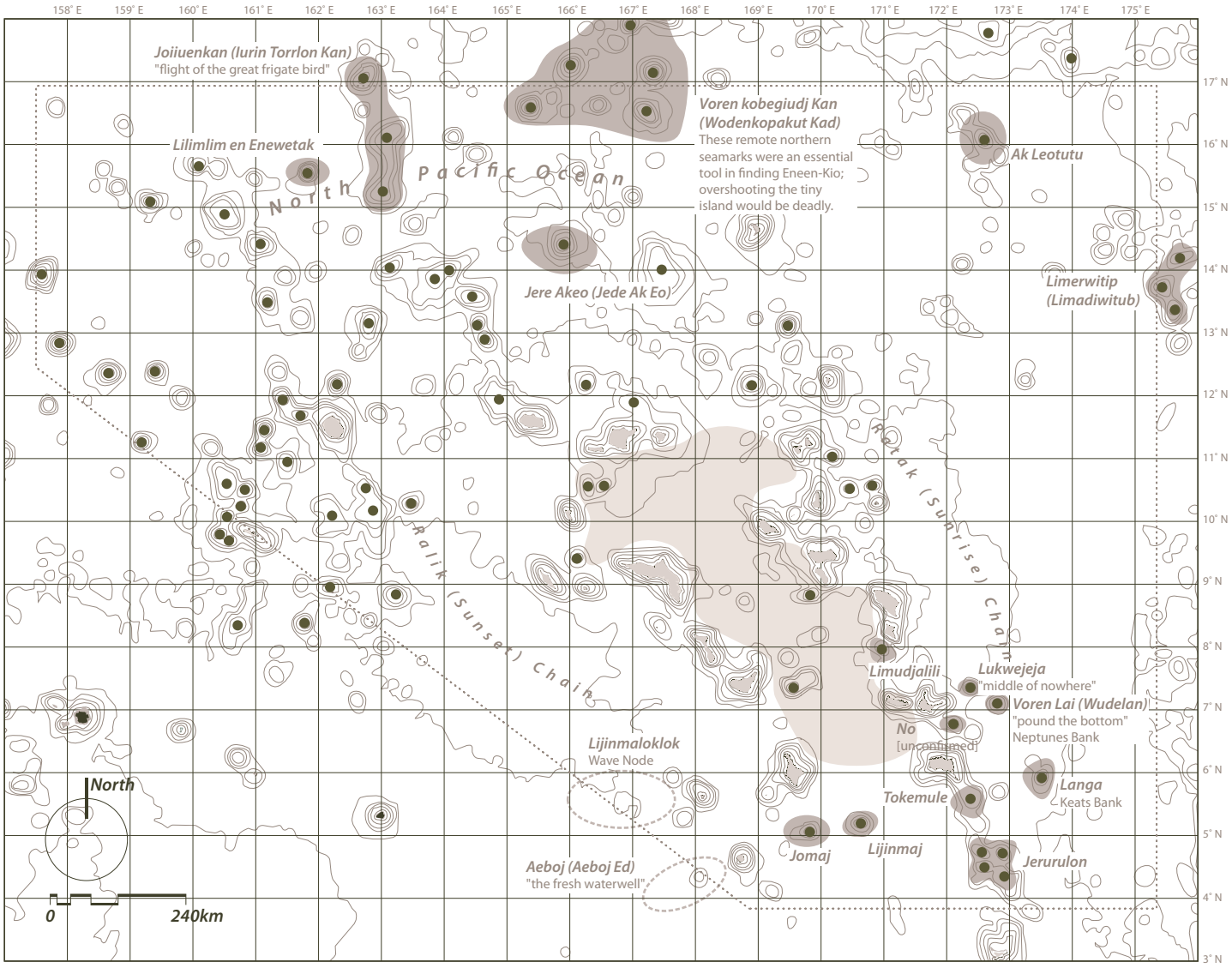
Navigators codified their knowledge, constructing elaborate, tactile "maps" out of coconut mid-ribs and shells. These 'stick charts' (see Fig. 1.7) come in many varieties, but can be described as a form of indigenous mapping which pre-dates European contact in the islands. While some of these objects resemble conventional maps, with a sort of armature or grid supporting a network of white shells representing islands, others are totally abstract, idealized representations of the way wave patterns interact with one another. The maps embody two principle insights into the navigational worldview of the Marshallese which differ quite dramatically from that of the western traditions of cartography. First, the primary object of these maps (ie the features which they represent) are not solid landforms, but rather oceanic phenomena, or 'navigation signs' (TRANS. Kōkḷaḷ MAR.): the wave-nodes (TRANS. Booj MAR., literally "knots"), seamarks, and areas of upwelling that form landmarks in an otherwise featureless ocean (see Fig. 1.4).[53] They would not have been used in the same way as the maps of Europeans, carried along and checked periodically for reference. As Wade Davis writes:

> "The skills of the traditional navigator are not unlike those of a scientist; one learns through direct experience and the testing of hypotheses, with information drawn from all branches of the

51 Goodenough, Thomas. (1987): pp9-10. This article provides a more detailed account of how Micronesian navigators operate in practice, and attempts to test the abstractions of their tradition against real phenomena.
52 Spennemann. (2005): pp37-39. What is perhaps even more remarkable is that not only could Marshallese navigators discern wave patterns with sufficient sensitivity to enable inter-atoll voyages, their navigational lore contained references to many open-ocean wave nodes. These phenomena are created by the upwellings of deep ocean currents which occur due to the interference of submerged bathymetric features: shallow reefs, but possibly even seamounts with summit depths well below the sea surface. Such is the force of these upwellings that they modify surface wave phenomena to a degree detectable to expert navigators.
53 Genz, et al. (2009): p238.

FIG. 1.4

Navigation & Seamounts



LEGEND

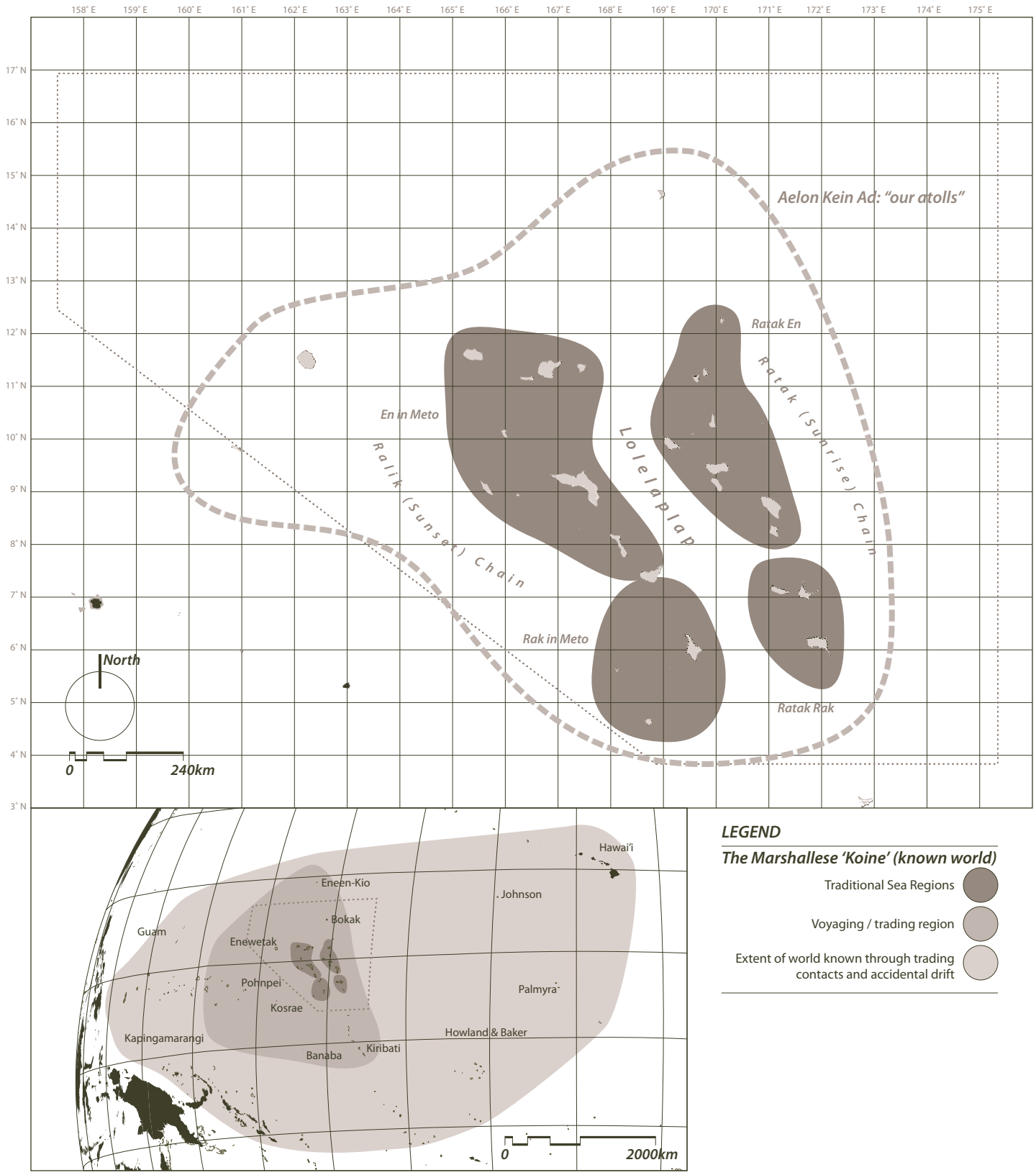
Seamarks & Seamounts

Seamount <2000m Depth

Known Navigation Seamarks

Lolelaplap (sea enclosed by the atolls)

The Marshallese 'Koine'

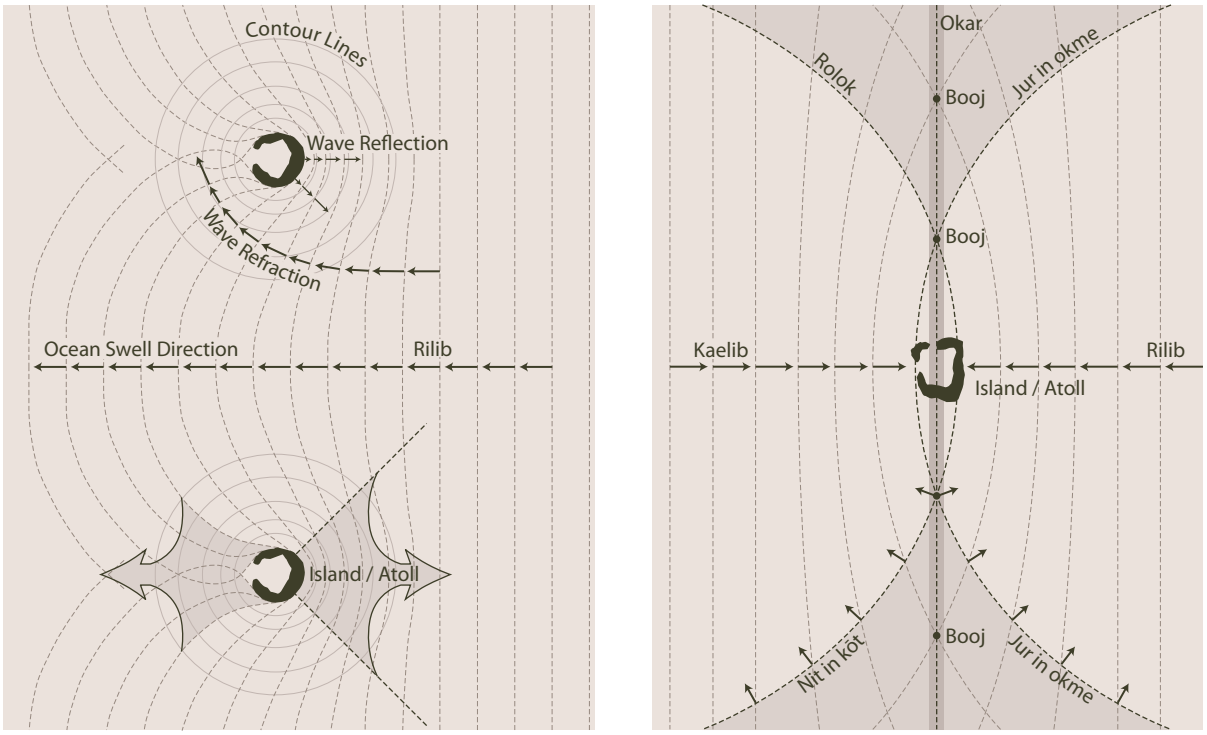


> natural sciences, astronomy, animal behaviour, meteorology, and oceanography. Temper this with a lifelong training of impossibly intense commitment and discipline, all to be rewarded with the highest level of prestige in a culture where status counted for everything. All the intellectual brilliance of humanity, in other words, together with the full potential of human desire and ambitions, was applied to the challenge of the sea."[54]

The navigator was trained from birth with knowledge and practical skills which were carefully guarded, passed down among families and clans. To say that he 'memorized' these maps would be an understatement; he had a whole host of phenomenological knowledge upon which to draw, which he spent his entire life learning. The *Wappepe* and *Meddo* 'maps' are no more than mnemonic devices which were used as teaching aids - to visualize abstract phenomena which were seldom so clearly illustrated in nature.[55]

The more 'map-like' form of chart, the *Rebbelip*, which shows more than just the conceptual journey between two islands, elucidates a second, more crucial point. These charts describe an imaginary of the ocean which is fundamentally *directional* rather than *dimensional*. Shells may indicate the presence of islands (often including much if not all of the Marshallese archipelago) but it is nevertheless the phenomena of the ocean, and the directions these phenomena describe in relation to each island, which is the subject of the chart. Imagine, for a moment, a European navigator, plotting his course across the vastness of the Pacific on a map in front of him. The security he feels in this endeavour is predicated on the belief that the map before his eyes provides a model - in small scale - of the world around him. The islands, shoals and graticules of the map are fixed and secure in the same way that the real islands, shoals and dimensions of the ocean across which he sails are fixed and secure. His feeling of security is reaffirmed every time an island appears on the horizon, exactly where his map and instrument readings tells him it should be. The world is fixed, and the navigator is in motion among fixed, real objects. By contrast, the Micronesian wayfinder flips this relationship around, and imagines his canoe to be fixed in place, with the world in motion around him. As the world moves around the canoe, so too the directional relationships change. The wayfinder holds in his memory an entire catalogue for these relationships, such that at any stage upon his 'journey,' he is able

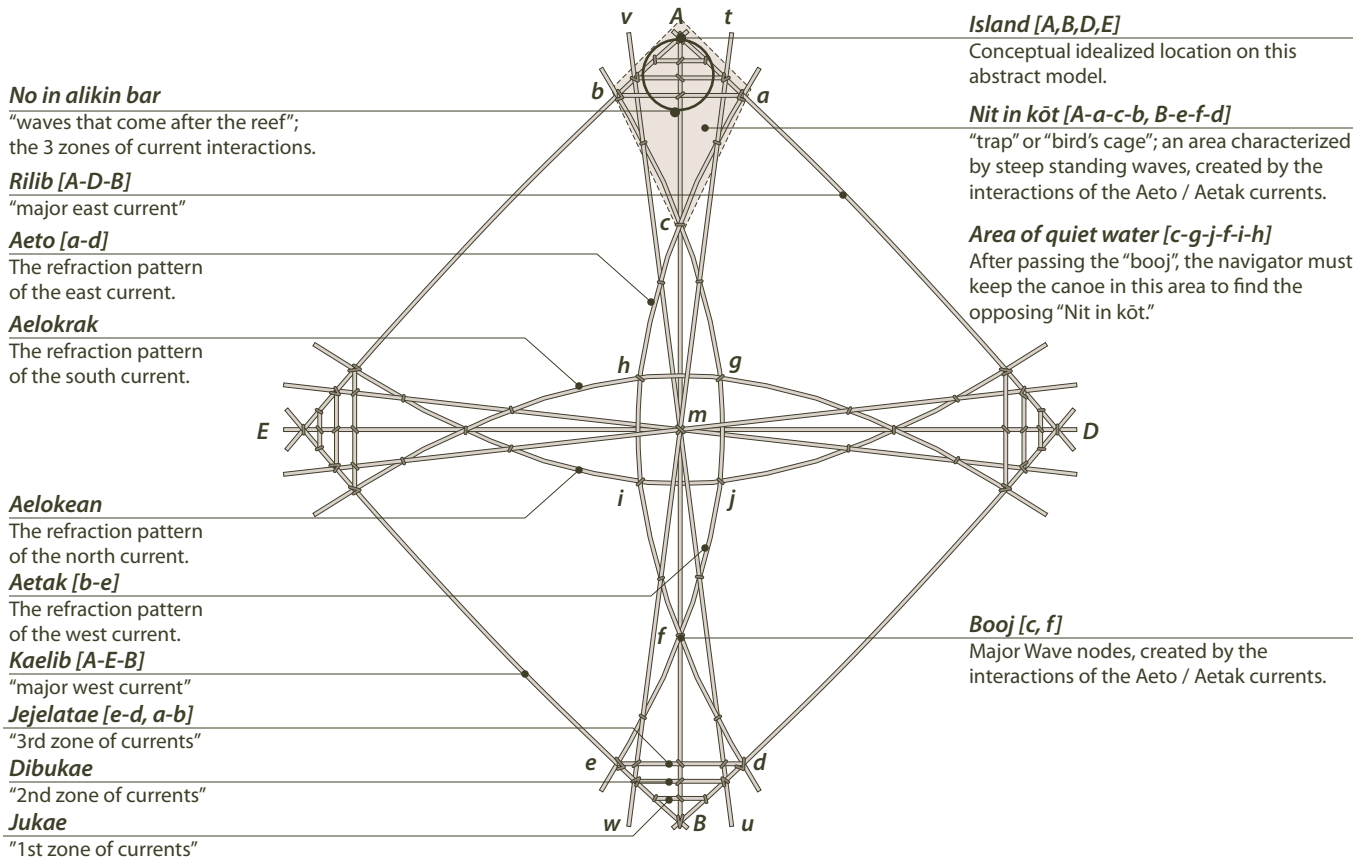
54 Davis. (2009): pp52-53. He is talking directly about ancient Polynesians, but this is equally applicable to Marshallese navigators.
55 Genz, et al. (2009): p236-40. They depict the interaction of opposing ocean swells between islands, the intersections of the various curving pieces of palm describing specific quadrants along a path between two islands where the waves can be expected to behave in a particular way. *Kōkḷaḷ* extending out from an island can be detected by a navigator from 40 kilometres or more; he orients his canoe by noting the change from one wave form to another. In essence, the interference between the refracting swells create *booj* which form a line of conceptual "roots" (TRANS. Okar or Dilep MAR.): the wayfinder follows these signs to find his course.



Wave Refractions around Islands & Atolls
The basic principles of wave refraction and reflection between islands. The left-hand diagram shows the basic refraction / reflection pattern of a single wave-front encountering a pair of islands. The waves refract around behind the islands, creating an area of longer periods between them and shorter periods in their lee. Simultaneously, wavefronts on the windward side of the islands interact with reflections. The diagram on the right shows the interaction of two opposing wavefronts hitting the same island. As they refract around the island, they pile up and cancel each other out, creating alternating areas of calm and intense and erratic wave activity - the *zz* that the wayfinder follows. See Spennemann. *Essays on the Marshallese Past* (1998).

FIG. 1.7

Wappepe



***Wappepe* illustrated**
A diagrammatic representation of the Wappepe chart, illustrating the meaning of the various components. See Spennemann. *Essays on the Marshallese Past* (1998).

to conceptualize the set of *directionalities* which define the proximity of islands or seamarks which are moving towards or away from his fixed centre.[56]

This is an ingenious system to find reference in the smooth spaces of the ocean without maps or instruments, but it also implies something more profound. For the European navigator - even aboard his robust vessel - the ocean is a terror, a great empty void to be crossed. Should his ship encounter a storm, he will batten down the hatches and be blown about. When the storm subsides, he will find himself staring at his map, not knowing where he is. In contrast, the wayfinder will simply take down his sail and wait. When the storm subsides, he will look again to the stars and the waves and construct a picture of the world around him. Even if he finds himself in a position whose directional relationships do not correspond with any he knows in his memory, he will follow the trail of wave refractions, cloud patterns, or the flight of birds to find an island. For him, the ocean is no empty void, but a landscape criss-crossed by the telltale signature of many living, natural and celestial phenomena. In this way, the Micronesian wayfinder conceptualizes the ocean not as an emptiness, but as a multitude, full of islands. This 'way of seeing' informed all aspects of islander life: the isolation and paucity of resources embodied by the atoll world belies an enormous bounty utilized by islanders, who supplemented the meager production of a single island with the far-ranging harvest made possible by ocean navigation.

Mobility / Obligation

The traditional practices of land-tenure (ownership of resources, inheritance, and identity) are predicated upon the same macro-scale picturing of the world. To mitigate against the tenuousness of an existence dependant on the vagaries of rainfall, tropical storms, the migrations of marine fauna, and the aggressions of outsiders, the Marshallese developed a social system that bonded groups of people across wide ranges of space in webs of obligation and responsibility. Land was divided up into allotments called *wāto*: strips of land which extended laterally across inhabited islands, from the crest of the fore-reef and into the lagoon as far as the owner could stand to fish.[57] Wāto were held by local chiefs (TRANS. Iroij [plural - irooj is the singular] MAR.) who were responsible for the commoners who lived upon and worked the land. It is incorrect to imagine that the iroij 'own' these parcels of land in the sense it is usually used in the west; in practice,

56 Goodenough, Thomas. (1987). It is difficult to express how mentally complicated this operation is; suffice it to say that the navigator memorizes the directions of stars, other islands, and wave phenomena from *any known reference* point in his world. This is why the *Rebbelip's* seldom look the same - each one is constructed with a specific reference point as its centre, and each set of relationships is unique, as it is also filtered by the knowledge and needs of its creator.
57 Spennemann. (2006): p52.

clans and individuals shared links to the same piece of land, in a kind of shared custodianship. "It is not that one owns the land, but rather that one is *owned* by that land, that one belongs to it and passes it on to the next generation appropriately."[58] Society was matrilineal and matrilocal[59] which tended to promote constant intersectoral migration; furthermore, iroij land-holdings were seldom limited to one island or even atoll. Typical chiefs would maintain iroij rights (from which they would receive annual tributes) for one or several islands, but might have resource rights to dozens of locations spread across multiple atolls. In practice this meant that Marshallese society was highly resilient in the event of storms or draughts. Historical records abound of shortages causing migrations of islanders taking advantage of inter-atoll obligations, sometimes to move an entire population from one atoll to another (see Fig. 1.8 for an overview of traditional connectivity networks).[60]

> "These contacts and reciprocal obligations were not random throughout the Marshall Islands. Any connectivity was derived from the productivity of the atoll, the proximity of the atolls to each other, and the sailing conditions encountered."[61]

In addition to inter-sectoral migrations in times of emergency, the traditional Marshallese moved seasonally - to take advantage of crops or hunting opportunities, or to avoid typhoons or droughts in certain areas. Typhoons are probably the greatest threat to life in the atolls. While fully developed cyclonic storms are considered rare,[62] the surrounding area is a major spawning ground for storms which later develop into major typhoons as they move west towards Asia; as such, most Marshallese islands are periodically subject to minor typhoon events, and 'direct hits' of major storms have occurred numerous times in history, with occasionally devastating effects. Even minor storms can be deadly, as low-islands are easily over-washed, inundating fragile crops of taro and breadfruit which blacken and die as a result.[63] As a result of these dangers, people maintained semi-nomadic lives, living together on protected, large leeward islands during the season of typhoons, and then moving out for seasonal harvests.[64]

58 Dvorak. (2007): p97. Emphasis added.
59 Spennemann. (2006): p51.
60 Ibid., p54.
61 Ibid., p55.
62 Spennemann. "Non-traditional..." (1998).
63 Ibid. Refer to description of 1905 typhoon event.
64 Ibid. It is troubling that these seasonally inhabited areas (typically in the eastern or southeastern areas on most atolls, as typhoons tend to form and move from southeast to northwest in the region) which were considered 'uninhabited' by European speculation, would become the densely-packed urban areas of the present era. Both Ebeye and Delap-Uliga-Djarrit (henceforth D-U-D) on Majuro (the major urban centres) are located in positions which place their residents in severe danger in the event of a direct strike by a major typhoon.

Though the modern Marshall atolls are amalgamated into a single entity, like the larger construct of Micronesia the pre-colonial Marshallese had neither a fixed term for the atolls as a whole, nor an idea of themselves as a nation or unified group. They called the atolls simply *Aelon Kein Ad*, "our atolls" and might have referred to themselves as *Armij Aelon Kein*, "people of these islands" (referring to inhabitants of any of the islands generally), *Ri-Ratak*, or *Ri-Ralik* (referring to people of the Ratak and Ralik chains respectively.[65] However, the world of which they were aware (TRANS. Koine MAR. - see Fig. 1.5) stretched well beyond the horizon, informed both by their own voyaging and conquests as well as intentional and accidental visits from other areas which surrounded them.[66]

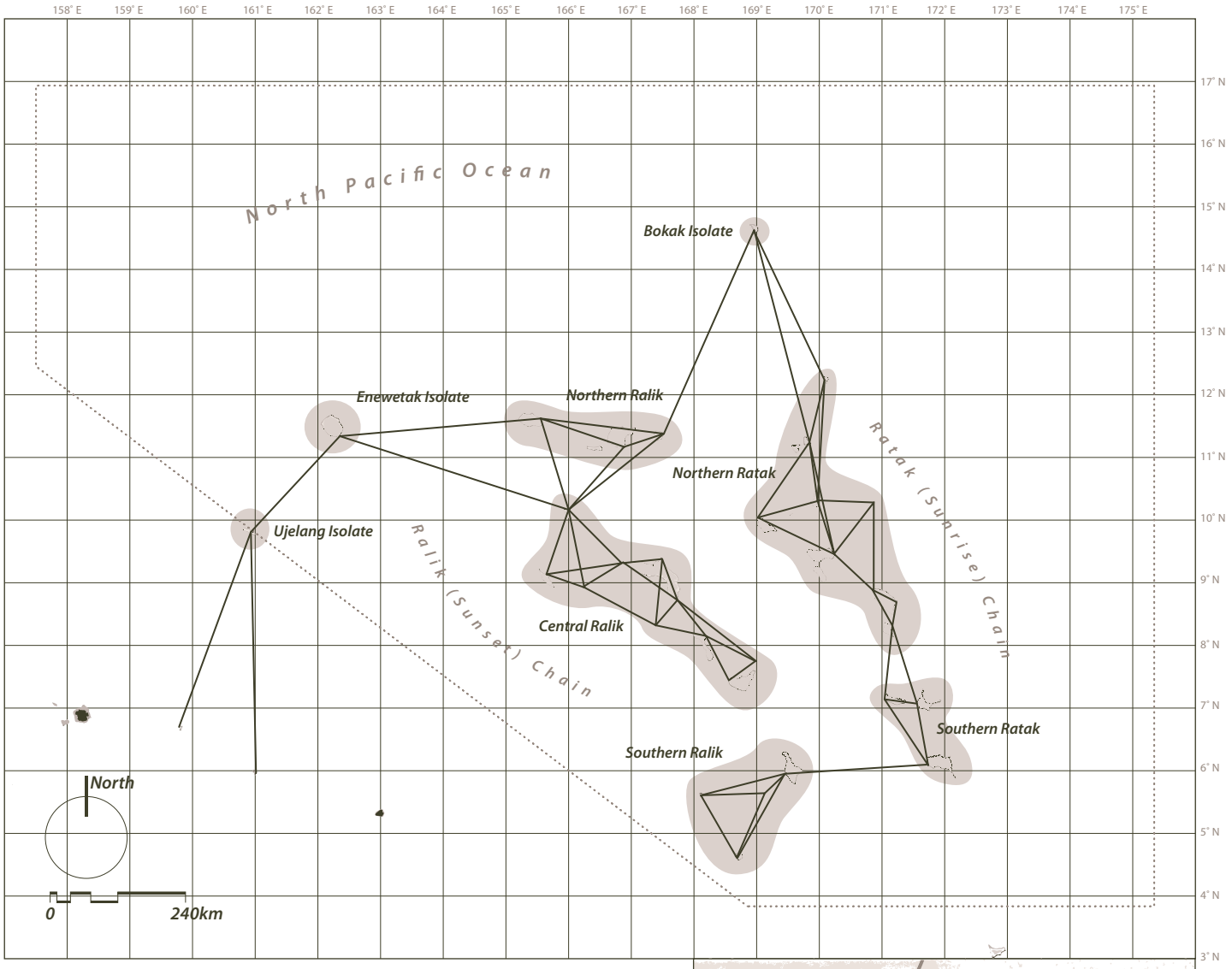
The atolls were first encountered by Europeans in the 16th century, as from time to time Spanish ships made landfall during their attempts to cross the *Mar Pacifico* from west coast of North America to trade outposts in southeast Asia.[67] But the Spanish did not colonize islands that were considered resource poor and were furthermore inhabited by people who were reknowned for their fierce hostility towards strangers.[68] The islands received their European name more than 250 years later, when British Captain John Marshall, en route to New South Wales with a cargo of convicts, encountered them in 1788.[69] It was not until 1859 that there would be a continuous European presence on the islands, when a German mercantile organization, the Jaluit Company, established trading outposts here. The German interest in the region centred around the exploitation of copra (dried coconut husks). The establishment of the copra industry altered the settlement and vegetation patterns throughout the islands; carefully managed eco-regimes, which had required hundreds of years to reach a mature state, were largely replaced by coconut plantations.[70]

The "German colonial administration (1886-1914) intentionally, directly and indirectly, consolidated the hierarchical structure and the power position of the iroij by imposing a tax on the chiefs - payable in copra - and by prohibiting internecine conflict.[71] With the traditional means of altering the balance of power removed, iroij - who were previously entitled to a share of food production over their land-holdings - now demanded in addition the payment of their share in copra. The Jaluit company - which was also the only buyer - dealt

65 Spennemann. "The Sea..." (2009). Reflecting the patterns of connectivity which tended to unite groups latitudinally - up and down the two parallel archipelagoes, rather than longitudinally between them.
66 Spennemann. (2005): pp37-39. This koine included the Caroline atolls (as far west as Mokil and Nqatik), the Gilberts (and probably Papua New Guinea) to the south, Eneen-kio to the north, and Johnston and possibly Hawai'i to the east.
67 Rainbird. (2004): Introduction.
68 Flood B.; Strong; and Flood, W. (2002): p174.
69 Dvorak. (2007): p7.
70 Spennemann. "Traditional Land Management" (1998).
71 Spennemann. (2006): p52.

FIG. 1.8

Traditional Connectivity



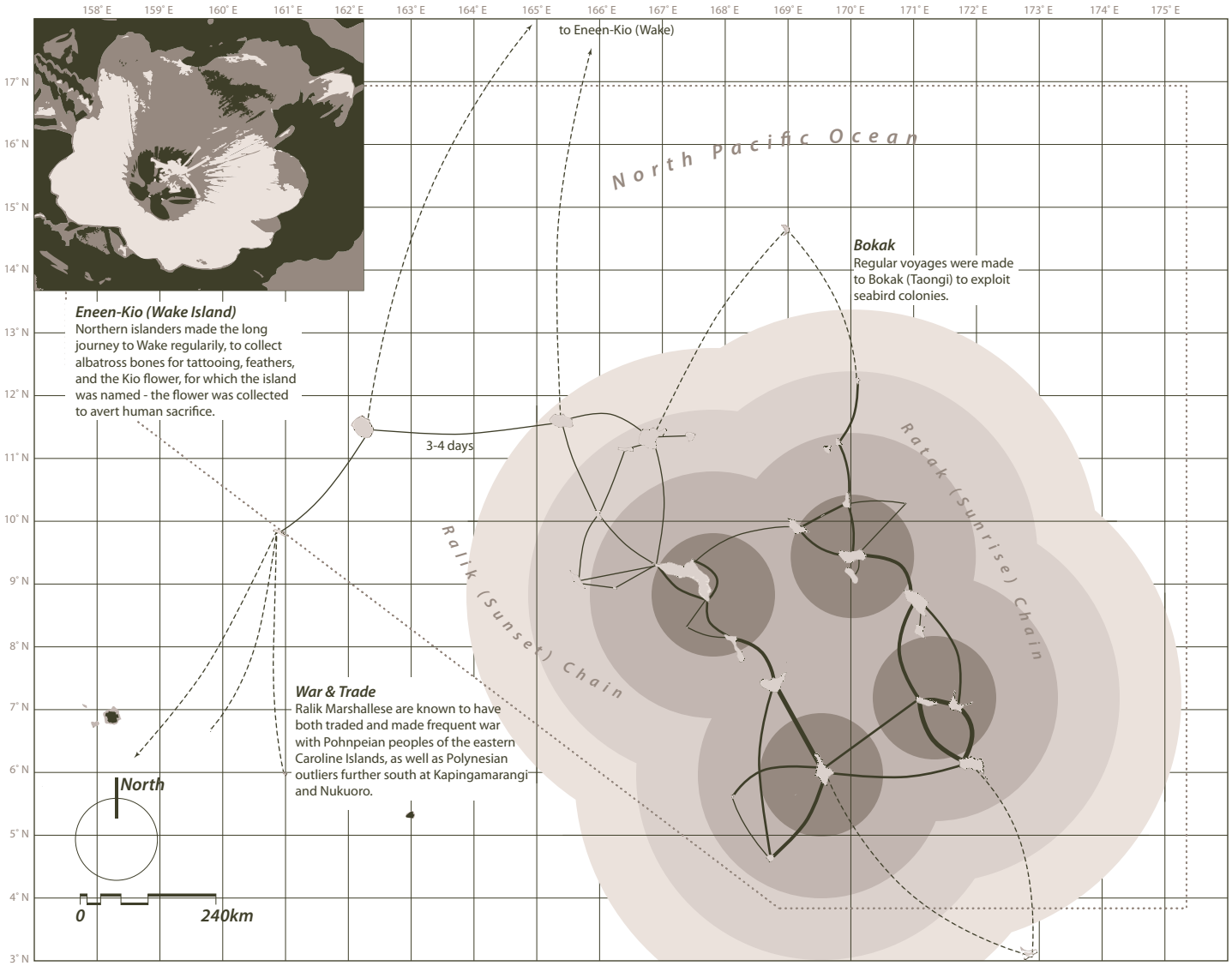
LEGEND

Traditional Connections

3rd Point Proximal Analysis (after Spenneman)

Connectivity Group

Sailing Distances



LEGEND

Travel Time & Sailing Distances

1 day = *up to about 100-125km*
2 days = *up to about 200-250km*
3 days = *up to about 300-375km*
4 days = *up to about 400-500km*
5+ days = *>500km*

Connectivity

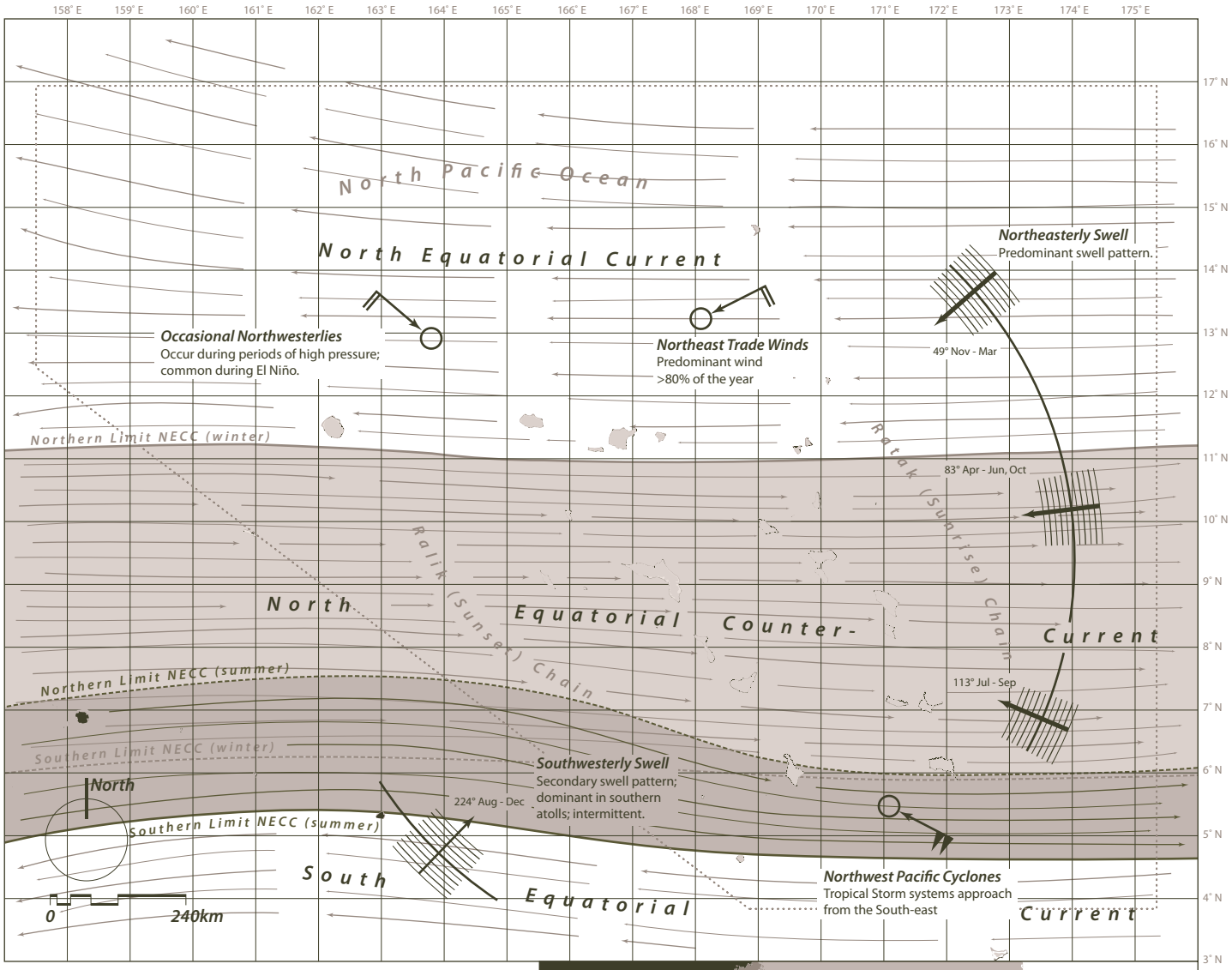
Regular

Thickness of lines = frequency of voyages

Very Infrequent

FIG. 1.10

Marshall Islands Winds & Currents



LEGEND

Winds

Swell Pattern (direction & intensity)

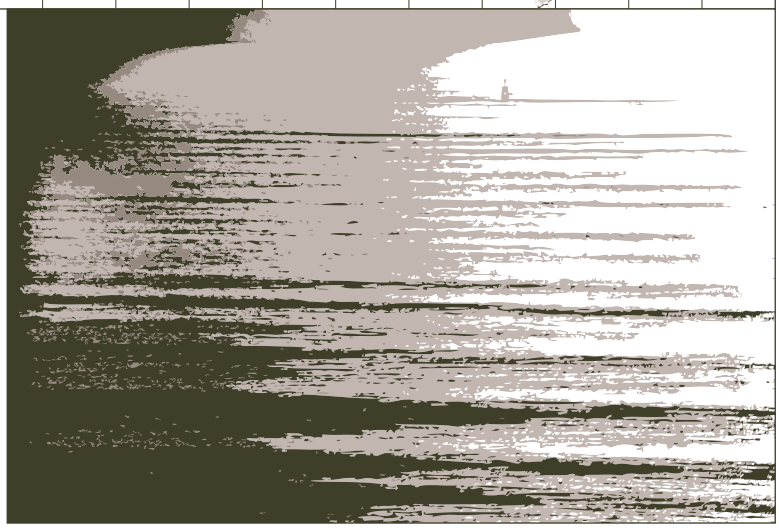
Average Wind Intensity (1 bar=10kts; triangle=50 kts)

Prevailing Wind Direction

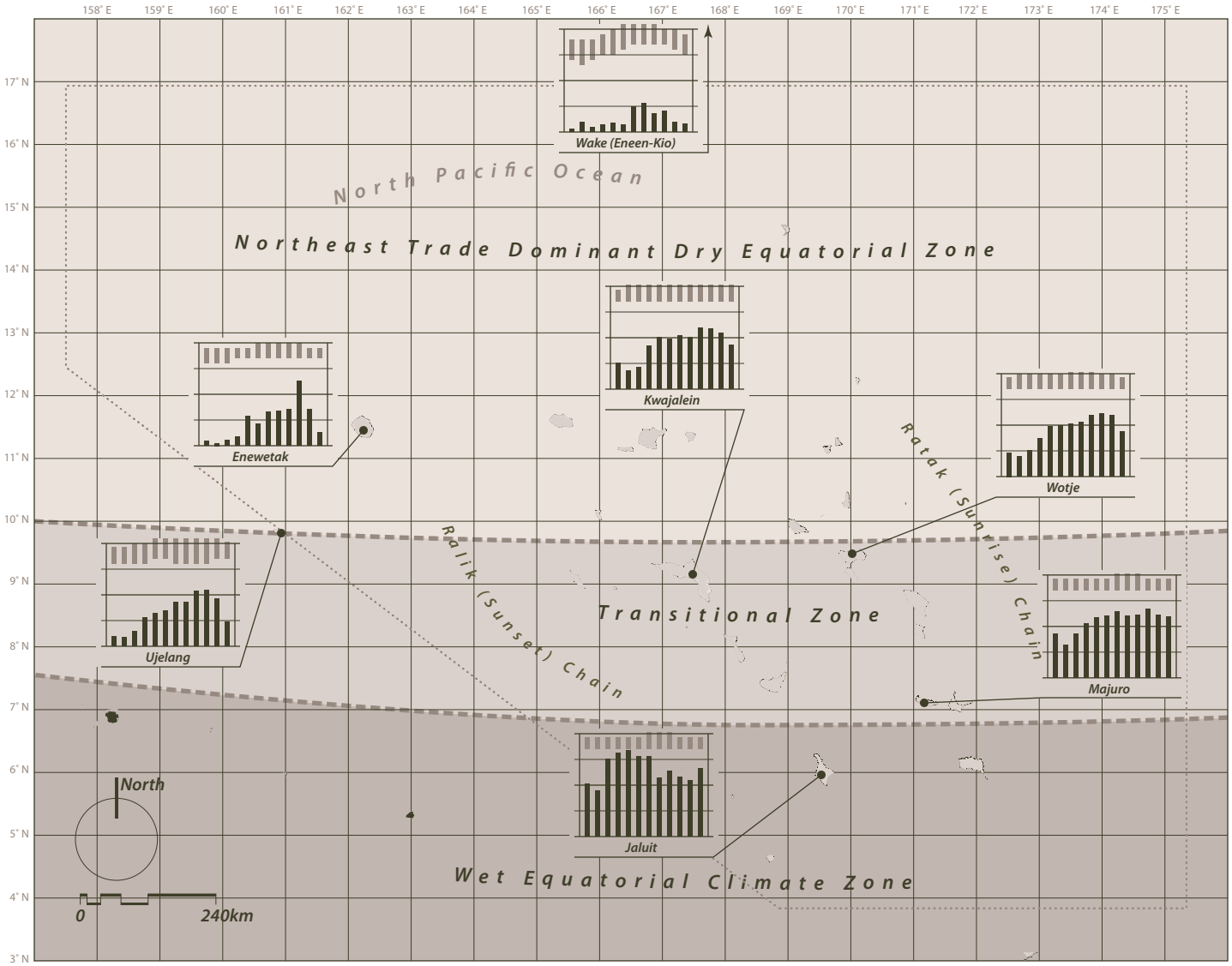
Currents

North Equatorial Counter-current (winter)

North Equatorial Counter-current (summer)



Marshall Islands Climate



LEGEND

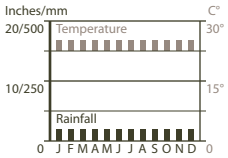
Climate Regimes

Wet Equatorial
(>3810mm / >150 inches per year)

Transitional
(2540-3810mm / 100-150 inches per year)

NE Trade Dominant Dry Equatorial
(<2540mm / <100 inches per year)

Rainfall & Temperature



directly with iroij rather than with villagers on outer islands, further formalising their position of power, and allowing some to become enormously wealthy. The ban on warfare had removed the motivation for the maintenance of inter-atoll sailing canoes, which were replaced by European-style schooners purchased by increasingly wealthy irooj.[72] Thus, except on the remote northern atolls such as Bikini, Rongelap, and Enewetak, the voyaging traditions which had sustained the Marshallese for millenia began to disappear.[73]

Copra production radically altered the ecology and human-carrying capacity of atoll islands (see Fig. 1.12). The traditional forest was dense and humid, and readily retained the moisture delivered by rainfall; in contrast, the sun-loving coconut required widespread clearing, and was planted in a grid, about 10 metres apart. As coconut monocultures replaced the pandanus / breadfruit forest, the combination of solar access and higher evaporation rates, wind-borne soil transport, salt air and erosion from runoff caused islands which previously had reliable fresh-water lenses to dry out. Atolls converted to plantations could no longer support the same population sizes, as water and cultivated food sources became scarce.[74]

Nanyō Guntō

It was with the Japanese, who seized the islands from Germany in 1914, that the modern history of the Marshall's begins. Japan, at the outbreak of World War I in Europe, saw itself as the locus of the 'East,' the inheritor of an empire tradition whose broad duty it was to defend against the colonial and imperial aggressions of the 'West.' Japan duly set about the work of *nanshin* - southward expansion into the Pacific islands. Ports, towns and military bases were established in places like Saipan and Palau – the gateways to Micronesia – and opened up trade and settlement in the disparate archipelagos beyond: Chuuk, Pohnpei, Kosrae, and Jaluit. Appropriation of islands and population groups was justified by a kind of Pan-Asian 'manifest destiny,' a view that the European colonial powers had abandoned their stake in Micronesia, having exploited what they could of the natural resources (chiefly copra and phosphorus for fertilizer) and leaving it to the Japanese to bring the

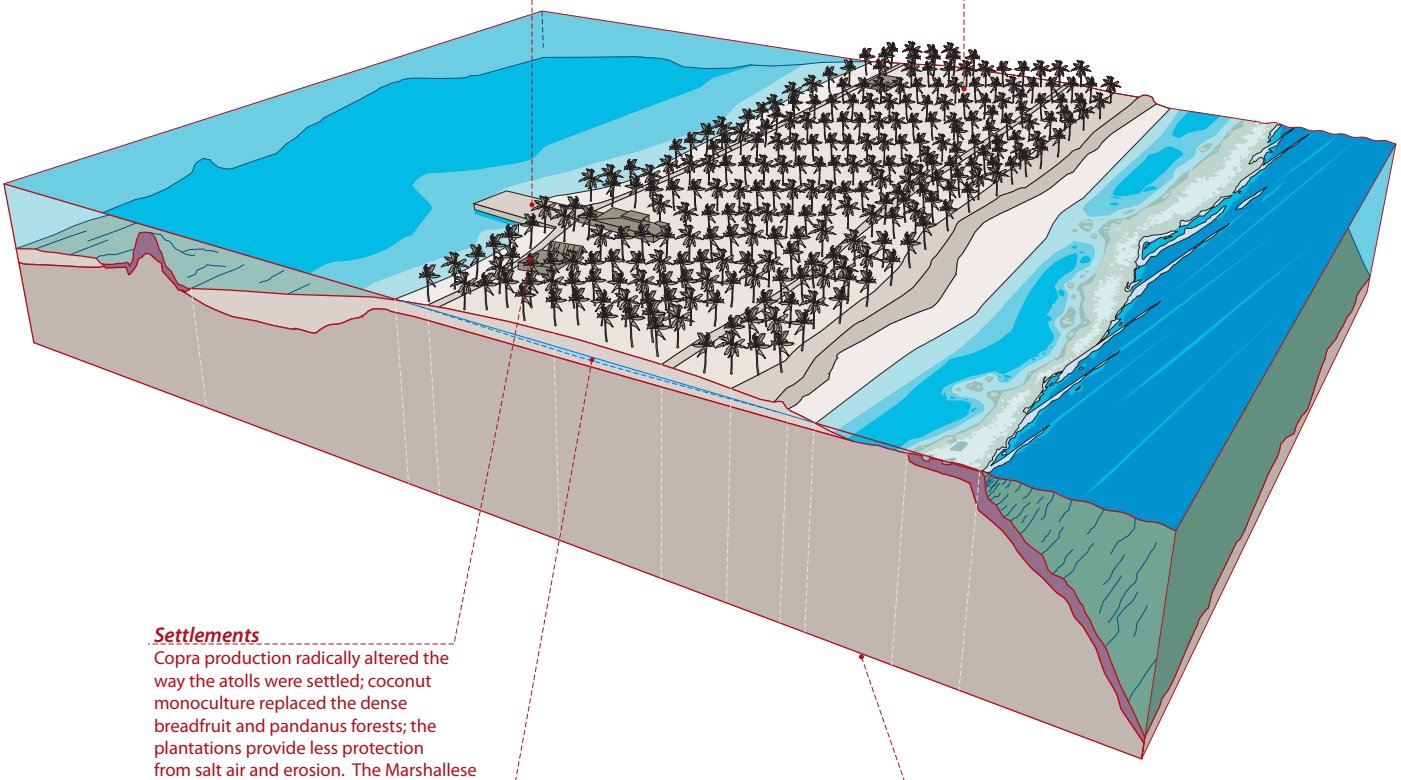
72 Spennemann. (2005): p33. European boats were chosen for their ability to carry larger loads of copra and for the prestige they conveyed upon their owners.
73 Dvorak. (2007): p8. It was during this period that a second major cultural change took place: in the 1850's an influential irooj named Kaibuke granted access to American Protestant missionaries, who built mission schools and began actively discouraging indigenous customs.
74 Spennemann. "Annual Copra Production" (1998-2010). In 1893, the Jaluit company was extracting almost 2000 metric tons of copra annually; this had increased to nearly 4000 tons by the end of the German period in 1914.

Copra Plantation

Wharf
Plantations required construction of large docks for deeper draft European ships; many of which still survive within the RMI.

Dry Islands
As coconut monoculture replaced traditional cultivation, the combination of wind-borne soil transport and salt exposure dried out the islands; fresh water retention is significantly altered.

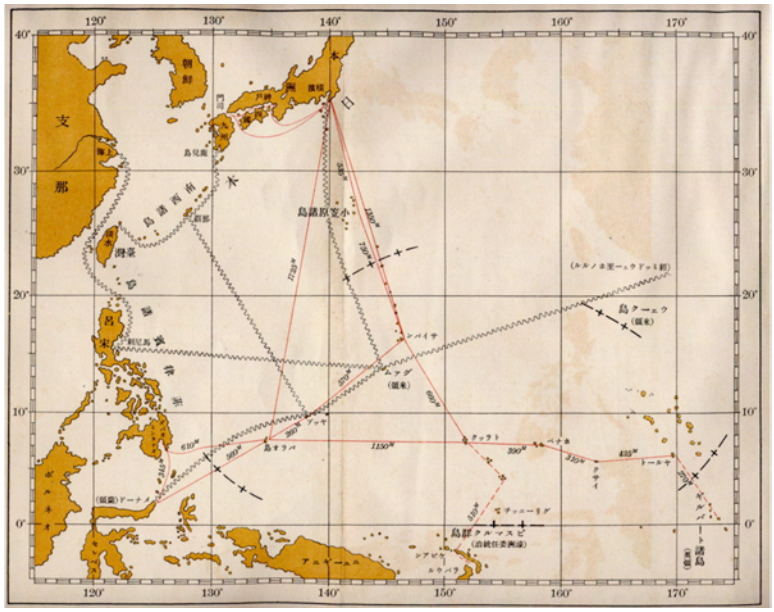
Plantation Economics
Typically coconut trees are planted about 30 feet (9m) apart in a grid, allowing a density of between 100-160 trees per hectare. Depending upon rainfall, each tree will produce between 50 and 80 nuts per year, yielding 600-1600kg per hectare. Sale prices at the supplier end have varied widely, especially in the RMI due to its isolation, but are typically in the range of $0.20 US/kg (in 2008 prices spiked to nearly $0.50/kg) allowing earnings ranging from $120 to as much as $800 US per hectare ($12,000-80,000 US per km^2)



Settlements
Copra production radically altered the way the atolls were settled; coconut monoculture replaced the dense breadfruit and pandanus forests; the plantations provide less protection from salt air and erosion. The Marshallese became reliant on copra earnings to purchase foreign food; rice eventually supplanted breadfruit as the diet staple.

Fresh-water Lens
As coconut plantations replaced traditional planting regimes, the fresh water lens on the island could be threatened by increased run-off, erosion, and higher rates of evaporation.

Reef Flats
Largely exposed at low tide, composed of solid coral rock, with some deeper pools and rubble. As a result of the coconut plantations permeability to wind, plantations often result in increased erosion, and the transport of salt-laden soils to the more protected lagoon habitat of the island.



Nanyō Guntō
The south sea as an extension of the Japanese empire, *ca.*1931. This map shows the major shipping routes (red lines) connecting the Japanese home islands to outposts in Micronesia, as well as a network of undersea communication cables (jagged lines) including one which connects to a large Japanese population in Hawai'i. Micronesia is simultaneously connected to the Japanese empire and the first line of defense, ready to broadcast news of imminent threat from the European holdings in the Pacific beyond. See Dvorak. (2007): pp68-70..

islands into the modern era.[75]

More properly, the Japanese name for the Micronesian portion of the empire was *Nanyō Guntō* (South Seas Islands). Japanese colonialism in the Marshall's was more integrative than the Germans. The primary industry was exploitation of the fisheries; more than 1000 Japanese settled at Jaluit, and the Marshallese and Japanese seem to have peacefully integrated. There was intermarriage between Japanese fishermen and Marshallese women; in fact, a kind of stereotype of the 'chieftains daughter' became a common cultural trope amongst Japanese settlers, mirroring the European sexualization of Tahiti.[76] The Japanese imperial project, though clearly distinguishing Micronesia from the Japanese *Nihon Rettō* (home islands), imagined a fully Japanese future here; by the 1930's, aggressive economic development and immigration programs resulted in the native population being outnumbered by Japanese, Koreans and Okinawans by as much as two to one.[77]

The islanders were at once welcomed into the Japanese cultural imaginary through the medium of schooling and as workers, while at the same time their distinct cultures were invalidated by the Japanese tendency to see the whole of the Nanyō Guntō as a uniform group. Ultimately, as the Japanese empire expanded and tensions in the Asia-Pacific region built up prior to the outbreak of World War II, Oceania came to be seen less and less as a romanticized tropical outpost and more clearly as a strategic maritime barrier that would serve the empire as a first bastion of defence in the event of western aggressions.[78] By 1937, the imperial navy supplanted the civil administration in Palau as the chief administration of the Marshall's, and there was a shift in the agency of Japanese hegemony from a project of modernization and integration to one of militarization. The territory was carefully mapped, and fortifications and an airfield were constructed at Kwajalein. The Japanese now exploited the islanders as conscripted labourers, working alongside Korean villagers (another territory subject to the Japanse 'Co-Prosperity Sphere') to construct bunkers, military buildings, and dynamite the reefs to create landfill materials.[79]

As war raged in the Pacific, Kwajalein played a key role in Japans' early and rapid dominance of the Pacific territories. Eventually, as the war turned in the Americans' favour, the Marshall atolls, and in particular

75 Dvorak. (2007): pp59-69. *Daitōa kyōeiken* (the Greater East Asia Co-Prosperity Sphere) was the name the Japanese gave to their expanding empire; its limits were rather vague, encompassing all of Micronesia, but later expanded conceptually as far as the Phillipines, Taiwan, into mainland China, Vietnam, and even sometimes Australia and India.
76 Jolly. (2007): p521. It is interesting to note how the Japanese attitude to the Marshallese - so different from the Europeans who preceded them - was attended with this sexualization of Marshallese women.
77 Dvorak. (2007): pp9-10. There were perhaps 10,000 Marshallese at the time.
78 Ibid., pp69-73. The *umi no seimeisen* - Japans' "lifeline of the sea."
79 Ibid., pp73-79.

Kwajalein, were the site of several tremendous and bloody battles; Roi, Namur, Kwajalein and Ebeye[80] were completely leveled of buildings and vegetation during the initial US assault in 1944. Having endured a bloody ground battle at Butaratiri and Tarawa in the Gilberts,[81] the US invasion forces changed their tactics, bombarding Kwajalein island for 4 days. It was a massacre: less than 200 of the 5000 Japanese garrisoned here survived. Marshallese losses during the war are not recorded[82] but it is clear that in the fortification before the war and the major battles, communities were uplifted. While the impact of the nuclear tests attracted a great deal more international attention, the dislocations of the Pacific war actually effected a larger group of Marshallese, and changed the way the islands would be inhabited in the post-war period.[83]

Japanese occupation and development was integrative: land appropriation and dislocations did occur, but the Japanese focussed on improvements and modernizations to which the local peoples were included. Marshallese attended Japanese schools, worked in the Japanese fisheries, intermarried, travelled to other Japanese territories for work and education, and even moved to the Japanese home islands.[84] Following American 'liberation' of the Marshall Islands, the United States began a more covert[85] but ultimately more devastating and sinister program of imperial subjugation. The American presence was militarized and territorial from the beginning. It was during this post-war period that new settlement patterns were set in motion, driven both by the land appropriations (American military installations were built at Kwajalein, Enewetak, and Majuro) and by population dislocations brought about by the Japanese war effort and the fighting itself, which had devastated existing communities.[86] It is clear in a reading of the subsequent history that it was imperial interests which dictated the goals and actions of the US: de-facto annexation cloaked in the thinnest veil of noble intentions.[87]

80 -all islets of Kwajalein atoll.
81 Hayward. (1944). This award winning documentary shows the full violence of the assaults on the Gilbertese islands.
82 Crismon. (2005): p207. 200 are estimated to have died in the battle for Kwajalein alone.
83 US Navy. (1947). Within weeks Kwajalein was repurposed as an American naval base, and became the nexus for logistical and ballistic support in the subsequent infamous battles at Saipan, Guam and Iwo Jima.
84 Dvorak. (2007): p383, the story of Bubu.
85 Smith. (1997): pp40-44. To the outside world, at least, the United States consistently maintained that it had no desire to expand its territorial empire in the Pacific.
86 Ibid., p41. Such as at Jaluit; essentially, a pre-war town was erased by shelling, and Marshallese from Jaluit who had come to rely on and live integrated into a colonial economy sought support among their kin on other atolls - or died along with the Japanese. Following the war, and until 1951, the Marshalls were administered directly by the US Navy.
87 Ibid., p42.

D-Day Kwajalein
January 31st, 1944: Kwajalein was leveled by more 15,000 tons of explosives from naval and aerial bombardment - 15 kilotons, roughly equivalent in explosive force to the atomic weapon used at Hiroshima. After the battle, the island was stripped bare. Not a single scrap of vegetation remained.

Vice Admiral W. H. P. Blandy (left)
"The bomb will not start a chain-reaction in the water converting it all to gas and letting the ships on all the oceans drop down to the bottom. It will not blow out the bottom of the sea and let all the water run down the hole. It will not destroy gravity. I am not an atomic playboy, as one of my critics labeled me, exploding these bombs to satisfy my personal whim." Sublette. "Operation Crossroads: 1946" (2007).

The Commander of Joint Task Force One, Operation Crossroads. Painted in 1946 by Charles Bittinger on board his ship the USS Mt. McKinley; the orange painted target fleet is just visible on the horizon.

King Juda of Bikini Island (right)
The leader of the Bikinian people at the time of their exodus, painted by Grant Powers in 1946.

For the Good of All Mankind

In December of 1945, President Truman issued a directive that further testing of nuclear weapons would be necessary "to determine the effect of atomic bombs on American warships."[88] The Marshall Islands were designated the "Pacific Proving Grounds" and the place chosen for the tests was Bikini Atoll – far from major air and sea routes.

> "I realize the tragic significance of the atomic bomb... It is an awful responsibility which has come to us... We thank God that it has come to us, instead of to our enemies; and we pray that He may guide us to use it in His ways and for His purposes."[89]

In 1946, Commodore Ben H. Wyatt, the military governor of the Marshalls, traveled to Bikini. On a Sunday after church, he assembled the Bikinians to ask if they would be willing to leave their atoll temporarily so that the United States could begin testing atomic bombs for "the good of mankind and to end all world wars." King Juda, the leader of the Bikinian people, stood up after much confused and sorrowful deliberation among his people, and announced, "We will go believing that everything is in the hands of God."[90] In preparation for the initial series of nuclear tests to take place at Bikini (codenamed "Operation Crossroads") 167 islanders were removed from their homeland and travelled aboard US Navy landing craft 200 kilometres east to an uninhabited atoll called Rongerik. It is telling that Rongerik was uninhabited; the Marshallese had a detailed oral knowledge of the atolls and the seascapes that surround them. Every island was known, and those which could support long-term settlement were invariably inhabited. Rongerik was traditionally thought to be the home of evil spirits, unsuitable for settlement; but the Bikinians preferred to try their luck with the spirits rather than impose themselves and become subject to the dominion of another irooj.[91]

The Crossroads tests involved the detonation of two "Fat Man" type atomic weapons, codename "Able" and "Baker," which were essentially unmodified from the wartime weapons which devastated Hiroshima and Nagasaki.[92] These were the first 'weapons-effects' tests ever conducted – tests designed to determine the effect of nuclear weapons

88 Niedenthal. (2004): p268.
89 President Truman. (1945): Radio address.
90 Niedenthal. (2004): p268.
91 Ibid., p268. In the spring of 1946, the entire community was relocated, ferried from Bikini to Rongerik in a troop carrier left over from the war. They settled in with 3 weeks of supplies left to them by the US military, and soon discovered that the lagoon was much smaller than Bikini, perhaps too small to support the large group. The coconut palms and breadfruit seemed to produce poorer yields as well, and it was difficult for them to find a reliable source of water.
92 Left-overs from the build-up to "Operation Downfall," in which multiple warheads would have devastated many targets in Japan simultaneously, had the Japanese not capitulated after Nagasaki. A detailed bibliography regarding the bombings of Hiroshima and Nagasaki is provided by Wikipedia: "Atomic bombings of Hiroshima and Nagasaki."

on discrete objects, such as buildings, warships, and animals – as distinguished from the wartime "Trinity" series, which tested the behavior of different weapon designs. Both bombs were detonated in the waters of Bikini. The first – Able – was dropped from a B-29 on July 1st, and the second – Baker – was suspended beneath a target ship 3 weeks later. 71 surplus and captured ships were used as targets, placed in the lagoon at various angles and distances from the detonation: battleships such as USS Saratoga, USS Gilliam, USS Nevada and USS Arkansas, as well as the Japanese battleship Nagato were sent to the bottom of the lagoon. The Baker blast so severely irradiated the lagoon and nearby Bikini island (the main settlement island inhabited by the Bikinian people) that planes could not land there safely for more than a week.[93]

By 1948, the Bikinians were in crisis. A fire had destroyed most of the coconut palms on the island, and the islanders were suffering from malnutrition, poisonous fish, and shortages of water, "literally starving to death."[94] Another relocation was planned, a site chosen for them in the western Marshall's on an isolated atoll known as Ujelang. Young men from the group were flown to Ujelang in November and began preparations, constructing houses and a community area. By the end of December, however, the navy had decided to conduct the next series of tests at yet another atoll, Enewetak, 300 kilometres to the west of Bikini. This atoll was also inhabited; it was decided it would be easier to move the Enewetak people to the Ujelang site and find another location for the Bikinians. In March of 1948, after almost two years of suffering, the Bikinians were finally removed from Rongerik and flown to Kwajalein, where they were temporarily housed in tents next to the US navy airfield.[95] With few options to choose from, King Juda and his advisors decided upon Kili Island, at the southern end of the Ralik chain, for his peoples new home. Again the choice was made to avoid being the subjects of an established irooj. The decision would doom the traditional Bikinian diet and lifestyle: Kili is a tiny, isolated island devoid of a protective lagoon for fishing, and the islanders would depend even more heavily on US aid for survival. After six months on Kwajalein, the community was relocated for the third time in two years.[96] The Bikinians eked out an existence, often close to starvation, essentially abandoned by the military to their fate.

Following Crossroads, the Marshall's, along with the rest of the former Japanese territories in Micronesia, were placed by the United Nations under US control in the form of a 'Strategic Trust Territory' - an ambiguous state of wardship with no clear boundaries defining US

93 Sublette. "Operation Crossroads: 1946" (2007).
94 Niedenthal. (2004): p268.
95 Ibid., p269.
96 The administration of the Trust Territory attempted to resolve further food supply issues by providing the settlers with a 40 foot supply ship, but this would be dashed on Kili's reef in 1951.

control or responsibility to ensure the establishment of Micronesian self-determination. On the contrary; rather than being treated as a foreign people, responsibility for the trusteeship would be transferred from the Navy to the Department of the Interior, pairing the Trust Territories with Indian affairs, and implying a similar relationship to the American state.[97] The Marshallese found themselves united with the linguistically and culturally diverse peoples of Micronesia: in crisis with regard to the incredible destruction the Pacific War had wrought; and in opposition against an obstinate American imperialism, which sweetly and reassuringly masqueraded as humanitarian obligation, while silently conducting its program of relocation and nuclear testing (see Fig. 1.13).[98]

The official mandate of the Trust Territory, to "promote the political, economic, social, and educational advancement of the inhabitants... and their progressive development towards self-government or independence," which "to this end shall...protect the inhabitants against the loss of their lands and resources"[99] seems blatantly at odds with the American policies of the time. The post-war American interest in its newly acquired Micronesian territories was clearly outlined by James Forrestal (then Navy secretary, later to become the first secretary of defense) in 1946:

> "Single island positions cannot be considered strong *bases*. *Selected* islands can, however, together with Guam, form a far-reaching, mutually supporting base network, although each alone would fall short of being an impregnable bastion."[100]

Spawner of Monsters

Over the next 6 years, the navy would detonate 9 atomic weapons on Enewetak, including the first hydrogen bomb, "Ivy Mike," which would completely obliterate an island, Elegulab.[101] Enewetak seemed ideal for conducting atmospheric hydrogen bomb tests: there was nothing 'downwind' for more than 300 kilometres, and its people were even more marginalized by isolation. But for undisclosed reasons, the test location was moved back to Bikini at the beginning of 1954, in preparation for the Castle series – the first test of a 'weaponized' hydrogen bomb.[102] A high altitude weather monitoring station was established at Rongerik; over the course of several weeks, the station took measurements of wind speed and direction at various altitudes from 50,000-100,000 feet; it soon became clear that the detonation of the Bravo device would put several inhabited islands, especially

97 Petersen. (2004): p51.
98 Ibid., p53.
99 United Nations. "Chapter XII: International Trusteeship System" (1945).
100 Forrestal. *New York Times*, September 24, 1946: excerpt from Petersen. (2004): p49.
101 Sublette. "Operation Ivy: 1952" (2007).
102 An air-deliverable device, in contrast to the house-sized device in the Ivy Mike blast.

Rongelap, 170 kilometres east of Bikini, in severe danger of fallout contamination.[103]

> "The night before the shot time, I plotted the most recent winds and discussed them with Kearns, Armstrong, and Captain Molumphy, comparing them to the wind data from 12 hours earlier. The vectors were curving from east to north and the summation lines had moved more easterly. There were Marshallese natives on ... Rongelap ... east of Bikini. I didn't think the pattern would miss them to the north, especially if the winds moved more easterly overnight. Woody and I attended the 10 pm weather briefing and voiced our concern. The Air Force meteorologists poo-pooed our analysis and the decision was made to proceed in the countdown."[104]

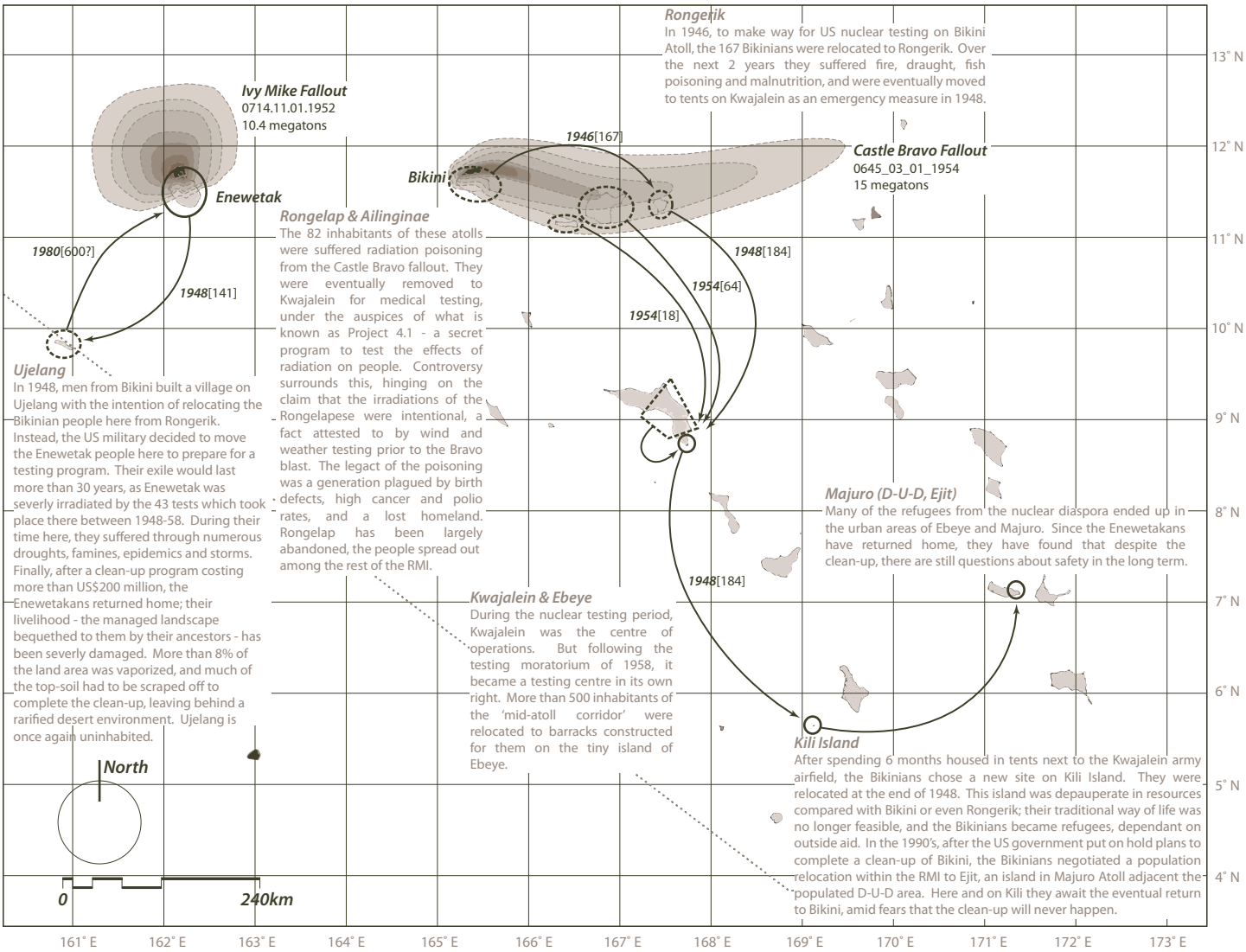
Despite these warnings, the Bravo shot was detonated. In an instant the fireball vapourized a 2 kilometre wide crater in the reef to a depth of almost 100 metres - an inhuman work of performance art. The waters of the atoll were shrugged aside by the force of the blast, the vegetation flattened and incinerated as the fireball grew to 5 kilometres in diameter. Hefted by the buoyancy of its intense heat, the incandescent pillar tore through the troposphere, friction elongating its shape, rising convection currents creating a violent annular vortex. In one minute the mushroom cloud had reached 15 kilometres into the atmosphere; within three it had breached 30 kilometres; after 6 minutes the cloud began to flatten itself out against the upper layers of the stratosphere. 8 minutes after detonation the pyrocumulus had stabilized, latent humidity condensing into a cloud of ash and ice that began its slow fall back to earth.[105]

The closest inhabited atoll to the test was Rongelap, 170 kilometres to the east; despite its proximity, the 64 inhabitants would not be evacuated until March 3rd, nor would people living on nearby Ailinginae and Utrik. The people of Rongelap awoke that morning to the same sinister snowfall witnessed by the crew of the Fukuryū Maru; the story is related by John Anjain:

> "In the morning, the sun rose in the east, and then something

103 Niedenthal. (2004): p270.
104 Lawson. (1996).
105 The cloud was 100 kilometres in diametre, the base of the mushroom above the tropopause, the pillar supporting it 7 kilometres in diameter. Sublette. "Castle Series" (2007). After fifteen minutes, the vapourized calcium carbonate, mixed with massive quantities of nitrous dioxide and charged with radioisotopes, began to blanket the lagoon; personnel observing the blast from a bunker on Eneu island retreated from the control room to a heavily shielded fallout shelter below, from where they had to be rescued 11 hours later. Observation ships 70 kilometres away had to evacuate crews and seal the decks; the weather station on Rongerik, more than 200 kilometres from ground zero, was evacuated the following day as staff measured dangerous radiation levels continuing to rise. Niedenthal. (2004): p270.

Nuclear Diaspora



LEGEND

Nuclear Testing Fallout

Castle Bravo & Ivy Mike Fallout Radius [RADS]

- 100
- 300
- 1000
- 3000
- 10,000
- 30,000
- Ground Zero

Dislocations

Date of Relocation [# people]

Major Resettlement Locations

Abandoned settlements

> very strange happened. It looked like a second sun was rising in the west. We heard noise like thunder. We saw some strange clouds over the horizon... We were very curious about this ash falling from the sky. Some people put it in their mouths and tasted it. People walked on it, and children played with it. Later on, in the early evening, it rained. The rain fell on the roofs of our houses. It washed away the ash. The water mixed with the ash, which fell into our water catchments. Men, women, and children drank that water."[106]

By nightfall, parents were horrified as burns began to appear on themselves and their children. After evacuation, American doctors conducted mysterious tests that terrified them, and they would not be allowed to return to their homes for 3 years.[107] The radiological disaster caused a sensation in the media: first as news arrived from Japan about poisoned sailors on the Fukuryū Maru; and later as the plight of the Rongelap people was publicized. More disturbing was the legacy of the people of Rongelap - high rates of cancer and still-born babies, born without bones and with hideous deformities; they came to be known by the local people as "jellyfish babies," hidden from their mothers lest they go crazy.[108] Despite the monstrous effects of the initial hydrogen weapon, and the fact that it had entirely destroyed the test facility forcing all further Castle shots to be detonated remotely, the United States would test 5 more hydrogen weapons at Bikini and Enewetak in 1954 alone.[109] These atolls would be so severely irradiated that they remain uninhabitable to this day. Between 1954 and 1958, the weapons testing reached a maniacal intensity, as the Atomic Energy Commission raced to keep pace with the Soviets; through these years, almost 60 more nuclear weapons were detonated here.[110]

After the United States ceased atmospheric nuclear testing in 1958, the military shifted its focus to Kwajalein, which was reconfigured as a test target for disarmed intercontinental ballistic missiles (ICBM's), under the guidance of the US Army. Missiles launched from warships or from Vandenberg Air Force Base in California would plunge to earth at Kwajalein, which acquired the nickname amongst military personal "the Giant Catcher's Mitt."[111] In 1964, to accommodate the incoming weaponry, the military once again uprooted communities, this time from 11 settlements spread along the central islands of Kwajalein atoll - designated the "mid-Atoll Corridor" (or MAC).[112] They were resettled on a tiny islet just to the north of the military base on Kwajalein island

106 Doub, B., et al. (1986): p18.
107 Dvorak. (2007): p367.
108 Beacham. (1992).
109 Dvorak. (2007): p367.
110 Sublette. "Gallery of US Nuclear Tests" (2007).
111 Dvorak. (2007): p265.
112 ASPA. (2001): p167.

- Ebeye - and given $25 a month for the inconvenience.[113]

The *ri-Kuwajleen*[114] were placed in an ad hoc labour camp - hastily constructed by the Navy Seabees out of scraps of plywood and other cheap materials.[115] The camp on Ebeye, though built to house about 370 people, accomodated more than 550 from the start. The population soon swelled, as people came to Ebeye from the outer atolls seeking employment and medical care on the base, western goods which were available here, and connectivity via the airfield to Majuro atoll (which was itself becoming an attractive urban centre to outer islanders as the centre of the Trust Territory administration).[116] In 1954, there were about 1000 people living here; by the end of the 60's, this number had grown to about 3500-4000.[117] Estimates vary, but by the early 1980's there was somewhere between 6000-8500 people crammed onto this tiny island.[118] Not only did this result in severe overcrowding, with 14 people or more sharing a single room,[119] but increasingly often made this the site of severe health crises, with unsanitary conditions causing outbreaks of infectious diseases.[120]

As Ebeye slowly stagnated into what would become known as the 'slum' or 'ghetto of the Pacific,'[121] the US poured an enormous amount of money into developing Kwajalein atoll into a state-of-the-art radar and telemetry installation. Kwaj was built-up with modern sewage and power systems, sturdy housing, sports facilities and other amenities.[122] It became a kind of militarized "club med,"[123] where servicemen, private contractors and their families would live in an insulated simulacrum of middle-America. Kwaj and many of the other islets surrounding the lagoon in the mid-atoll corridor were outfitted with sophisticated instrumentation that provided the Army with tools to measure the re-entry phenomena of incoming warheads and for the development of anti-ICBM technologies.[124] Kwajalein was used to develop most "of the technological sophistication that has been built into US ICBM's over the years."[125] The Kwajalein missile testing continues to this day.

113 Johnson. (1986): p32.
114 The people that lived among the many islands of Kwajalein atoll.
115 Dvorak. (2007): p265.
116 Ibid.
117 RMIOCS. (2008): p3.
118 Ibid. See also Dvorak. (2007): p265, and Gorenflo, Levin. (1989): p98.
119 Most of Ebeye is covered in a one story ramshackle wood, tin and concrete block buildings, yet has a population density comparable to the most crowded islands of Hong Kong.
120 Johnson. (1986): p33. Including, for example, a polio epidemic in 1963 that left 190 people paralyzed.
121 Dvorak. (2007): p258.
122 Ibid., p260.
123 Corcoran. (2009).
124 Wilkes, Frank, & Hayes. (1991): p9.
125 Ibid., p8.

Resistance

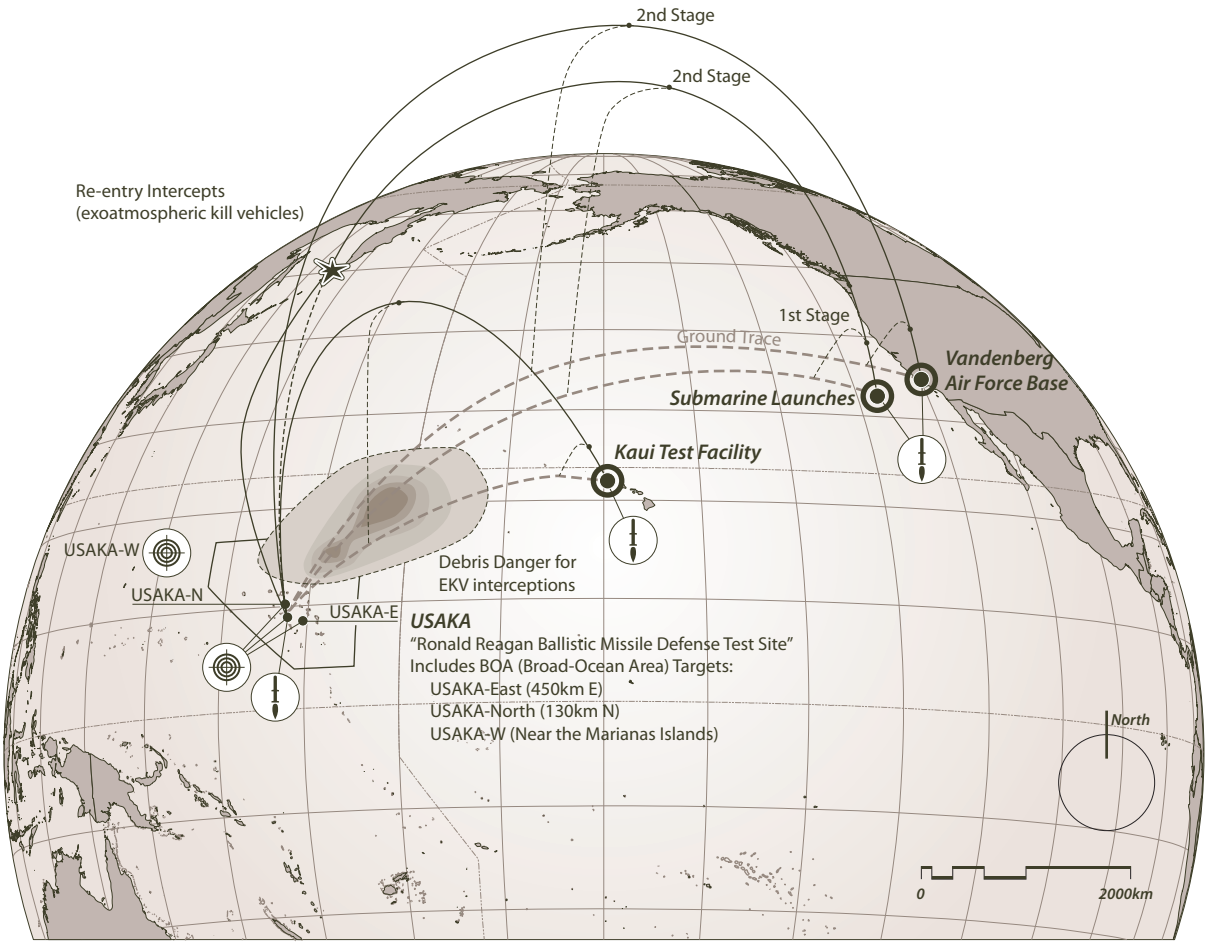
The brutality of the United States actions in the Marshall Islands has made narratives of oppression and victimhood prevalent. Such chronicles have been vital in the development of challenges to the American regime in the Pacific: internationally, in the form of social campaigns such as the Nuclear-Free & Independant Pacific Movement of the late 1970's and early 1980's;[126] and internally, with (for example) compensation claims brought against the US government, most notably by the still-displaced peoples of Bikini atoll, and the victims of the fallout from Bravo.[127] But a total focus on crisis and trauma either ignores or diminishes the actions of the Marshallese and Micronesian people, who have consciously and deliberately exercised agency in the determination of their own futures. Furthermore, such a representation fails to fully indict the American regime, which not only engaged in well-documented and overt violence, but also a covert program of confidence-games designed to undermine local progress towards self-determination.

> "Liberal critics, while expressing considerable sympathy for the islanders as victims, have failed to acknowledge the people as participants, negotiators, and shapers of their own destiny. In their analyses of American mis-administration, these critics have tended to regard Micronesians as little more than nebulous shadows falling lightly across valuable pieces of strategic property."[128]

It is important to point out what Micronesians have managed to achieve in their struggle against a belligerent and dismissive super-power. At the time of the establishment of the Trust Territories in 1947, the Marshall's, along with much of the rest of the Micronesian territories, were in a state of utter devastation. Infrastructural development implemented by the Japanese administration had been destroyed,[129] and Micronesian experiences with Japanese and German colonialism had completely excluded them from their own governance. The Japanese cultural program in Micronesia included the vigorous supression of indigenous social structures which fostered connectivity and kinship, and many local groups had come to rely on Japanese export economies for their livelihoods. In short, there was a need for co-ordinated management and capital investment which was not easily filled, which the United States inherited almost by default.[130] And yet, 44 years later, in 1991, Micronesians (as the Federated States of Micronesia) and the Marshallese (the Republic of the Marshall Islands) would be welcomed by the United Nations General Assembly

126 Doub et al., eds. (1986).
127 Hanlon. (1989): p15.
128 Ibid.
129 Dvorak. (2007): pp253-256, for a description of Kwajalein. Petersen. (2004): p53, Micronesian leaders experiences. See also Smith. (1997): p41.
130 Smith. (1997): p41.

Ebeye in the beginning
Despite overcrowding and insufficient housing and infrastructure, in the early days Ebeye had a cheerful, rural island atmosphere. By the 1960's however, the flimsy houses built by American crews had started to break down in the harsh salt air - especially the overflowing outhouses which lined the lagoon shore. "Sanitation problems began to emerge, worsening a massive fly problem that already existed from before the war and contributing to the outbreak of various diseases and health problems..." Dvorak. (2007): pp258-259.



ABM / Rocket Launch Site

Missile Target Site

Gravity's Rainbow
This diagram shows an overview of the Western Test Range - the US military's premier long-range missile testing range. From launch locations at Vandenberg, off the California coast, or Hawai'i, missile 'ground traces' pass over only open ocean. Most ICBM's are multi-stage: multiple boosters drop away and burn up in the atmosphere. The "post-boost vehicle" (PBV, or "bus") spends most of the half-hour duration of the flight coasting. The PBV guidance system alters its orientation, and at pre-determined times it releases the RV's it carries - sometimes single warheads, sometimes multiple, independantly targetable (MIRV's) - towards pre-assigned targets. Wilkes, Frank, & Hayes. (1991): p3.

as full members (the Trusteeship agreement was offically terminated in 1990).[131] By comparison with other insular peoples who have found themselves the subjects of an outwardly reluctant American imperialism - such as American Samoa (1878-), Hawai'i (1887-), Guam (1898-), Puerto Rico (1898-), and the Phillipines (1898-1946) - the Micronesians' establishment of self-governance rather than greater integration into the US has been unambiguously expeditious (refer to Fig. A1.3 in Appendix I for an overview of the diverse forms of jurisdiction in the Pacific).[132]

From the beginning of the Trust Territory period, the military administration was determined to obtain complete territorial annexation of Micronesia, but was also aware that accusations of colonial expansionism would lend credence to those opposed to annexation (both within the US and internationally) and might also set a precedent for other world powers - specifically the USSR - to begin programs of territorial annexation of their own. The US denied that occupation of Micronesia represented colonialism, but was "merely the acquisition by the United States of the neccessary bases for the defense of the Pacific for the future world."[133]

The US strategy in Micronesia resisted calls for independence while maintaining a facade of anti-colonialism. This strategy took several forms. The first is the ancient doctrine of 'strategic denial,' in which the Americans denied access to Micronesia for other nations.[134] This denial of access prevented not only foreign military entry to the western Pacific, but effectively prevented foreign investment or business, which ensured Micronesian dependence upon the US economically.[135] Paired with this was the argument that the United States and Micronesia had mutual interests, that "what was good for the security of the United States would be neccessarily good for Micronesia which relied on the United States for its own security."[136] Third was the US interpretation of the Trusteeship mandate to foster "self-government or independence."[137] While US policy in Micronesia was clearly not a program to foster autonomy, it could defend its actions by arguing that Micronesia was not economically or politically prepared for autonomy, and that the establishment of (merely) *formal* sovereignty fulfilled its duty as Trustee.[138] Finally, Americans - and especially the military administration - tended to place little value on Micronesian land.

131 Petersen. (2004): p45.
132 Ibid., pp45-49.
133 Stimson, quoted from Smith. (1997): p42.
134 Petersen. (2004): p60.
135 Lutz. (1986): p21.
136 Smith. (1997): p45.
137 UN. "Chapter XII: International Trusteeship System" (1945). Independence is a relative term, and could be construed to mean *formal* sovereignty (as in legal rights), *effective* sovereignty (as in the practical power to exercise those rights) or *autonomy* (the results achieved by exercising those rights). See Smith. (1997): p37.
138 Smith. (1997): p38.

The rhetoric which describes the military opinion of these islands is that they are essentially useless except for their strategic location. As Admiral Blandy remarked: "we wish to acquire... a few miserable islands of insignificant economic value, but won with the precious blood of America's finest sons, to use as future operating bases."[139] The clearest evidence of this opinion is the events surrounding the nuclear tests: the military had no qualms about uprooting entire communities, despite the existence of numerous *completely uninhabited* atolls which could have readily served the purpose. Taken together, these strategies were mutually-reinforcing, and formed an effective model for the continued disenfranchisement of Micronesians coupled with the sustenance of righteous belief in a legitimate American hegemony. [140]

This was highly effective in the immediate post-war years. But with the negative publicity generated by nuclear testing and the global decolonisation movements gaining traction elsewhere,[141] cracks began to appear. To satisfy its Trusteeship obligations in 1948, the US had helped to organize a "Legislative Advisory Committee" - a group of representatives from each of the 6 Micronesian territories - with the intention that this would be the prototype for a territory-wide legislature.[142] With a critical report issued by a visit from a committee representing the UN security council[143] and increasing calls for self-governance among the emerging Micronesian leadership, the US adminstration realized that the future status of Micronesia's relationship to the US would be determined in large part by the perception of the United States among the Micronesian populace. In 1961, President Kennedy "formalized the goal of attempting to permanently incorporate Micronesia into the US state structure,"[144] dispatching a task force to develop recommendations on how to achieve that goal. The result is what has been called "America's ruthless blueprint for the assimilation of Micronesia"[145] - The Solomon Report. It contained a clearly laid out strategy:

> "The US would pump large amounts of money into Micronesia, build a community-service infrastructure, establish a host of development programs and a dependancy on cash, hold a plebescite at the point at which the Micronesians' hopes had been

139 Crismon. (2005): p164.
140 There are direct parallels between these actions and American Indian policies of the 19th century (a fact reflected in the transfer of control in Micronesia from the Navy to the Department of the Interior) which systematically undermined and devalued indigenous ways of life and identity with forced relocations. Discussed at length in Petersen. (2004).
141 Lutz. (1986): p21.
142 Usa. (2011): p27. It is telling that this committee did not meet regularily until at least 1956, and it would be 8 years after this, in 1964, that the US Department of the Interior officially recognized a bicameral Congress based on the recommendations of the council.
143 Lutz. (1986): p21.
144 Ibid.
145 Belau. (1970).

raised, and then pull back support as the various development programs failed to succeed."[146]

The Micronesian Congress convened for the first time in 1965, in Saipan. The leaders who took part were predominantly a young group of men who had studied together at the University of Hawai'i; to them would fall the responsibility of negotiating with the US.[147] They organized a committee whose mandate was to explore the possibilities for Micronesia's future political status, beginning with a careful study of other states and territories which had various political relationships to the United States. Groups and individual members of the Congress and their affiliates travelled to the far corners of the American empire to observe and learn from the experiences of other minority groups. In these enterprises, they were keenly aware of the precariousness of their position: under Trusteeship status, Micronesians' negotiating position was significantly strengthened by the oversight of the UN - unlike any other territorial acquisition in US history; a change to this status would leave them without this safeguard.[148] Micronesian leaders met with Puerto Ricans, Navaho Indian leaders, American Samoans, Filipinos, and others.[149] As Petersen argues, the decision to push towards a position of complete withdrawal from the American political system was made early on. Common to all of America's territorial acquisitions with which they became acquainted was a steady and continuous loss of self-determination and dignity proportional to the amount of time and degree of integration into the American polity. One Micronesian Senator, Lazarus Salii, feared that US integration would make Micronesians into Americas' "newest, smallest, non-white minority;"[150] another realized "if we continue, we'll lose our lands like the American Indians and the Hawai'ians."[151]

The formal negotiations to determine Micronesias' future political status began in 1969;[152] it would take until 1978 to obtain a degree of self-governance among the Trust Territories. The Congress continuously found itself at odds with an American administration which was operating on the assumption that the Micronesians wanted to be absorbed into the United States; to the Americans, it was a question of how quickly. For the members of the Congress,

146 Petersen. (1984): pp89-96.
147 Petersen. (2004): p60. Though they came from diverse backgrounds, all had experienced the trauma and destruction of the Pacific War, and had also seen firsthand how the Hawai'ians "had lost everything to the whites, and we were determined not to let that happen in Micronesia."
148 It was a special UN committee on decolonization - the Committee of 24 - which had brought the Micronesian conditions to the attention of the international community, beginning in 1961, which had impelled the US to reconsider its foreign policy and formulate new tactics as outlined in the Solomon Report.
149 Petersen. (2004): pp54-58.
150 Ibid., p56.
151 Ibid., p55.
152 Lutz. (1986): p21.

the discussion ultimately boiled down to one issue: land. In all their dealings with the diverse subjects of the American republic, they recognized a common thread: where peoples had lost ownership of their land, they had lost everything else. Furthermore, the American interest was unwavering on this issue - America would retain access to Micronesian lands, whether to build military bases or to test nuclear weapons. The members of the Congress realized that if "the US were to have ultimate authority over Micronesian land, then it would have ultimate authority over Micronesians."[153] As the negotiations continuously stalled, the US sought to undermine the Congress by negotiating the land disputes with individual districts separately. Though this strategy was met with outrage, US policies impemented as a result of the Solomon Report had taken their toll. Before the war, the people of Micronesia had fed themselves with the bounty of the sea and their indigenous cultural production;[154] by the late 1970's, however, US policies of non-development had caused a complete collapse of the copra trade, prevented useful foreign investment and encouraged a complete reliance on US aid. Taro and breadfruit were replaced with white rice, fresh fish with canned fish, and coconut milk with Coca Cola and alcohol. Urbanization - encouraged by US land appropriations and the collapse of traditional livelihoods - led to severe health crises.[155]

Micronesia faced a difficult choice, between closer ties to the US (but attended with the continuing denigration of their culture and people) and the choice of complete autonomy (which American belligerence towards the land issue promised to be a difficult and long-drawn out battle). When Micronesians went to the polls for the first time in 1975 they "explicitly framed the choice between independence and free association with the US as being between 'breadfruit or rice.'"[156] The result of the referendum (the districts of Yap, Chuuk, Kosrai and Palau chose "breadfruit" with a moderate voter turnout of 53%, while the Marshallese overwhelmingly chose "rice," but with a much smaller turnout, only 35%)[157] was the fracturing of the colony into four districts, encouraged by the US negotiators who sought to undermine the Congress and by a growing separatist movement in the Marshall's.[158] In the end, Micronesia - with a population of only 100,000 at the time - would be divided up into four separate governments - The Republic of Palau, the Federated States of Micronesia (FSM), the Commonwealth of the Northern Marianas Islands (CNMI), and the Republic of the

153 Petersen. (2004): p58.
154 They made their own clothing, built canoes and made their own tools; they earned money to supplement these livelihoods from a thriving copra trade and used it to purchase cloth, tobacco and other items. Even though the Japanese presence extracted a great deal of wealth, Micronesia remained a net exporter.
155 Lutz. (1986): p22. Such as the spread of tuberculosis, meningitis, cholera, and the highest rates of leprosy in the modern world.
156 Petersen. (2004): p57.
157 Walsh. (2003): p229. See also Wikipedia: "Trust Territory of the Pacific Islands status referendum, 1975."
158 Ibid., 225.

The Micronesian Congress
Senator Amata Kabua speaking before the congress in the early 1970's.

Marshall Islands (RMI) - who would have to negotiate individual deals with the United States.

The plebescite prophesied in the Solomon Report would arrive for the Marshall Islands in the form of the Compact of Free Association, the adoption of which the Marshallese people approved in 1985. The Compact resolves the land issue with an ambiguous solution which pretty much allows the United States to do as it pleases, as long as it does so for "security" reasons.[159] In return, the Compact guarantees international defense, US aid and numerous federal programs, and the right of citizens of the associated states to live, study and work within the US indefinitely. While the Compact has been rightly criticized as a state of non-independence which maintains US suzerainty, the Marshallese choice must be considered in its contemporary context:

> "For Micronesians, their choice in the plebescites was as 'free' as those of boat passengers who have been taken far from their shore by a pilot whose interests and itinerary are not their own and who are then given the choice of remaining on the boat or swimming the 200 miles back to shore. Micronesia was *not* given the choice of complete political independence combined with an assured foreign aid package that would be directed towards the repair of the damage done to their economies and social systems by the strategic colonization of that area by the United States..."[160]

The efforts of the Micronesian Congress might be seen to have come to naught. In many ways, the Compact is a "great deal" for America;[161] and the US has maintained its position of strategic denial and access to Micronesian land. The story of Micronesian resistance has also been buried beneath the retroactive continuities of American righteousness, a retelling of history in which Micronesians have "come of age" and the United States has fullfilled its pledge as "the Guardian and Mentor of Micronesia."[162] But if independence can come in degrees - as in, those degrees which lie between formal sovereignty and total autonomy - their achievement is in fact remarkable. In less than two decades, at a time when their people were increasingly marginalized, and in direct opposition to the aims of an adversary who wielded considerable sophistication in the pursuit of its goal of total annexation, they managed[163] to achieve a degree of autonomy which Puerto Rico, Hawai'i, and Guam have not achieved in more than a century.

* * *

159 Petersen. (2004): p60.
160 Lutz. (1986): p23.
161 Ibid., p27.
162 Ibid.
163 In Palau, the FSM and the RMI; the Mariana's remains US territory.

"The Ri-Kuwajleen, the Islanders who first settled Kwajalein, told history through coral long before Darwin did. It is understood in their oral traditions that the entire atoll, this whole ring of islets, originated from one massive coral head in the centre of the lagoon, known as Tarlañ - what anthropologist Laurence M. Carucci has called the 'central symbol of Kuwajleen identity.' Today, as in the past, this coralhead is abundant and teeming with life on one side, but completely devoid of life on the other - and people say that different parts of the coralhead correspond to different parts of the atoll. This is why some islets are lush and others are barren, or why American missile testers bless Kwajalein Islet with millions of dollars in land payments for a lucky few while nearby Ebeye Islet, where 13,000 plus Marshallese laborers live, is impoverished and depressed. It also explains why, for instance, some islets of Kwajalein were devastated by the massive battle between Japanese and Americans during the war - and why others were left unscathed. Thus the atoll, in all its multiplicity and coralloid contradiction, is hewn from the same exact heritage.[1]

There is another story the Ri-Kuwajleen tell about their atoll, about a flowering tree that sat at the south end of the main islet where the first Marshallese settlers dwelled. It was a tree from which blossomed a type of night-blooming flower (utilomar) with such an enchanting and precious fragrance that everyone came to gather its petals to make chiefly ornaments. Some say that this tree did not grow on land but actually out of the reef between two islets. It was a tree that was overflowing with blossoms - and when these white flowers fell into the lagoon they turned into the most delicious flying fish, enough to feed everyone. Rū-ruk-jān-leen, 'the people who gather or harvest the fruits of the place known as Kuwajleen' is the expression from which the name 'Kwajalein' is derived."[2]

- GREG DVORAK

1 Dvorak. *Seeds from Afar - Flowers from the Reef* (2007): p37.
2 Ibid., p39.

There's no Marshall Islands without the Canoe
A modern Marshallese canoe race on Majuro lagoon.

One of the most pervasive of all Marshallese legends - appearing not only in the local anthologies and *mantin Majōl*[3] stories of elders, but also in educational readers in schools, political speeches, day-to-day conversation, and even popular songs - is the story of Lōktañūr and her son, Jebro.[4] Jebro was the youngest of 12 brothers who lived on Ailinglaplap at a time before the Marshallese had sails on their canoes. One day, his mother Lōktañūr[5] descended from the sky and informed the brothers that they would conduct a canoe race from one end of the atoll to the other to determine which one of them would become the next irooj. As the brothers prepared their boats for the race, Lōktañūr, carrying several large bundles, went to the eldest, Tūmur, asking if she could ride with him during the race. Seeing the bundles, and fearing the weight would slow him down, he refused. The mother asked each brother in turn, from eldest to youngest. At last she asked Jebro, who kindly agreed to take her, even as his brothers pushed off into the lagoon and paddled away.

She unpacked the bundles into Jebros' canoe, which contained rigging, a mast, and the first Marshallese sail, woven from the fronds of Pandanus. With a brisk wind, mother and son flew across the lagoon, quickly overtaking all but the eldest brother. Seeing their swift approach, Tūmur intercepted, demanding the sailing canoe. Obeying his elder, Jebro allows Tūmur aboard, who throws first his mother and then Jebro into the sea. But before he does, Jebro disables the canoe; Tūmur sailed swiftly away but crashed into a nearby island.[6] Mother and son paddled to victory in Tūmur's abandoned canoe. When at last Tūmur arrived, he was furious, summoning a typhoon and saying he never wants to see his brother again.

Eventually, siblings and mother returned to the sky; Jebro became the stars of *Jeleilōñ* (the Pleiades), and at opposite ends of the cosmos his brother became *Waan Tūmur* (Tūmur's Canoe - Antares and the Big Dipper). Today, Jeleilōñ is the star of good fortune, signalling calm

3 Marshallese custom.
4 McArthur. (2004): pp60-68.
5 Literally translates "she from heaven." McArthur. (2008): p268.
6 Jebro removed the *repakak* (forward cleat) and *jurikli* (boom socket).

seas to navigators and the season of plenty. When Tūmur rises, it is the season of storms, drought and poor fishing.[7]

Embedded in this myth are many of the values central to Marshallese culture: the cosmological origins of matrilineal authority; obedience to elders and ones mother, from whom all status and claims to land is received; the relationship between stars and the seasons; and the authority of the chief, which resides in his ability to bring good fortune and provide for his people.[8] As Mike Kabua, irooj and mayor of Kwajalein atoll puts it, "Jebro represents the values and traditions that provide direction and strength for security, endurance and peace."[9] Jebro embodies all the good characteristics a strong chief must have: *jouj*, *yokwe* and *an kajor.*[10] In the re-formatting of the Marshall Islands into a modern nation-state, Marshallese legends such as this have been actively re-contextuallized, narrating a present which flows uninterrupted out of a mythological past.

Many of the political leaders that have come to power in the Marshall Islands have emerged from roles as traditional leaders.[11] Most notable is Amata Kabua: the *iroojlaplap* (paramount chief) of the Ratak chain, with irooj rights on Majuro, he held the highest chiefly title in the islands.[12] Amata, one of the original members of the Congress of Micronesia, was instrumental in extirpating the RMI from the larger Micronesian federation and would go on to serve as the RMI's president for five terms - beginning with the first elections in 1979 and serving until his death in 1996.[13] In his speeches leading up to his re-election to the presidency in 1991[14] he invoked the Jebro story frequently, emphasizing the legitimacy of his chiefly authority and hinting that he, "like the god Jebro in the primordial past, would bring a promising and abundant future (after the Tūmur-like years under the United States)."[15]

7 The story told here is summarized from a number of sources, including: Tobin. (2002): pp56-59; Iroij Mike Kabua. "Iaekwoj Eo An Jebro," in Loeak, et al. (2004): pp15-16; and McArthur. (2004): p58.
8 McArthur. (2004): p60.
9 Kabua in Loeak, et al. (2004): p16.
10 *Jouj* translates as noble "kindness." *Yokwe*, the universal Marshallese greeting, translates literally "you are a rainbow;" it describes a deep "love for ones kin." *An kajor* describes both physical and spiritual strength. McArthur. (2004): p60.
11 See sidebar, p83. Note also that this is not the case in other TT nations of FSM and Palau, where traditional chiefs do not retain ownership of land in the same way. Walsh, (2003): p232, and Carucci. "Irooj Ro Ad : measures of Chiefly ideology and practice in the Marshall Islands" in White, Lindstrom. (1997): pp197-210.
12 McArthur. (2004): p67.
13 Wikipedia: "Amata Kabua."
14 The first election in an independent RMI.
15 Bendix, Hasan-Rokem. (2012): Chapter 13. At his election rally in 1991, he famously fed more than 3000 people - serving up 22 roasted pigs and mountains of food - and appeared with the powerful matriarchical figures of his *lerooj* mother and sister at his side. For months after the feast, people echoed the chant of Jebro, saying "Amata is kind, he loves his people, he feeds his people." He won in a landslide victory. McArthur. (2004): pp73-75.

Kabua the Great

While it is tempting to view successful traditional leaders such as Kabua as opportunists who have used their authority to manipulate an innocent and faithful populace to their advantage, that would miss out on the nuance and subtlety which defines Marshallese politics - and many other aspects of island life. Politics in the modern RMI is a peculiar combination of external influence and Marshallese interpretation. Just as the English name "Marshall" has been indigenized into *majel*,[16] so too have the Marshallese interpreted and appropriated many other aspects of the imperial cultures they have come in contact with: democracy, Christianity... even SPAM.[17] As Julianne Walsh writes, "too often studies of globalization revolve around the production of global discourses, and ignore how these discourses are received, consumed, and given local meaning."[18] Amata Kabua's role in the construction of the modern RMI state is a case in point; while the post-war period leading up to the establishment of the Marshall Islands as a self-governing entity is well documented as a period of 'Americanization,' there is a concurrent 'Marshallization' - "an incorporation of American resources, knowledge, skills, structures by Marshallese chiefs."[19]

Amata emerges from a long line of extremely powerful paramount chiefs - what has been called the "Kabua dynasty"[20] - which have retained ultimate authority over much of the Ralik chain, including Kwajalein, since the 19th century. While the arrival of the colonial interests and Christian missionaries are commonly credited with putting an end to constant warring amongst chiefdoms for dominion in the islands, these battles over land and power amongst iroij simply changed in character under the colonial administration.[21] The last great battles for territory in the Ralik chain date to around the 1820's; by the time Amata's great-grandfather Kabua Lebon "the Great"[22] came to power in the 1860's, iroij were settling their wars non-violently, with displays of strength and through diplomacy with their colonial overseers. In 1903, another dispute was settled in Kabua Lebon's favour by external legal counsel, in "presumably the first major Marshallese court case over land with foreign attorneys as counsel."[23] Clever and shrewd iroij such as Kabua Lebon strategically adopted "European modes of resolution and structures of authority"[24] to consolidate their power into domains of unprecedented scale.

16 Rudiak-Gould. (2009): p177. As in *ri-majel*, the "Marshall" people, or *kajin majel*, the "Marshall" language. See also Walsh. (2003): p246.
17 Ibid., pp178-179.
18 Walsh. (2003): p247.
19 Ibid.
20 Fraenkel, see Dvorak. (2007): p300.
21 Ibid., p302.
22 Walsh. (2003): p220. The so-called "king" of the Marshall Islands by the German administration.
23 Dvorak. (2007): p305.
24 Ibid., p306.

Amata
A young Kabua in his Micronesian Congress days. Photo from the *Micronesian Reporter*, 1972:4.

The struggle for land and power among chiefs - arrested by the Japanese administration and the war - was carried into its contemporary form by Amata.[25] As a member of the Marshall Islands Congress[26] he negotiated changes to the Congress format which undercut the influence of his main rival, a well-educated, english-speaking commoner. He effectively instituted a unicameral council dominated almost entirely by iroij.[27] Amata's power lay in his land-holdings; he would be the principle negotiator with the American's over compensation for the lands appropriated for missile testing on Kwajalein.[28] With the US offering $250 per acre for indefinite use of the land, Amata reportedly demanded $1500 per acre, plus interest, and refused the indefinite-use clause. A story from 1957 relates how Amata walked out on the US negotiators, who had offered $300,000 in cash piled on the table to coerce his decision.[29]

As a member of the Micronesian Congress, Kabua was critical of an absolute insistence on severing ties with the United States. He said in 1972:

> "Independence is just a degree of a person's or nations' being able to control his or its own fate, and not always in an unfriendly way. If Micronesia were to become independent with close ties to the United States, I don't see anything wrong with that. But, if Micronesia wants to be independent and just curtail all its relationships with the United States, then I see many things wrong with that. I don't know if there is a nation in the world which is purely and definitely independent. I think we find that coexistence in the world is a much more important thing than to be isolating oneself from the community of the world."[30]

Throughout this period, Amata seemed to embody a number of contradictions in his bid to disentangle the Marshallese from their poorer and more crowded allies in Micronesia[31] and the dominion of the US. He was at once a staunch traditionalist, and engineered a constitution and government format which further reinforced the

A list of past presidents of the RMI and their traditional roles:

Amata Kabua
1979-1996 (five consecutive terms)
Iroijlaplap of the Ratak Chain with iroij rights to Majuro atoll; later acquired irooj status on Kwajalein and became iroijlaplap of Bikini atoll, despite local protest.

Imata Kabua
1997-2000
Amata's cousin, Imata was elected by the Nitijela in the political upheaval following Amata's death. He was iroijlaplap of Kwajalein, and remains a champion of landowners rights.

Kessai Note
2000-2007
Notable for being the first and only "commoner" elected to lead the Nitijela. See Johnson. (2001).

Litokwa Tomeing
2008-2009
Tomeing holds irooj rights to several atolls; he was ousted from power after less than a year by a vote of no confidence.

Jurelang Zedkaia
2009-2012
Like Amata, Jurelang is the paramount chief of the Ratak atolls and iroij of Majuro; he is also the son of Atama Zedkaia, the Leroijlaplap of the Ratak chain who - along with Atama - helped to spearhead the Marshallese break from the Micronesian congress.

Christopher Loeak
January 2012-
Irooj of Ailinglaplap.

25 Ibid., p300. The son of Lejelon Kabua. Kabua Lebon's grandson - who used to be seen wandering around Kwaj island wearing a nametag reading "king" and a Ratak chain lerooj (TRANS. "chieftess" or "queen" MAR.) named Li Tarjikit, Amata was Irooj bweio (TRANS. "two-shouldered" MAR.) from birth. See Walsh. (2003): p220.
26 The local body through which the Marshall Islands corresponded with the Trust Territory administration and later the Micronesian Congress
27 Walsh. (2003): p221.
28 Much of it his father Lejelon's domain.
29 Ibid. The initial agreement he reached with the military was a 99 year lease, beginning in 1964, which included only the 750 acres making up Kwajalein island, and was payed for up front with a lump sum to the various landowners.
30 Ibid., p225. Quoted from the Micronesian Reporter, 1972:4.
31 Kluge. (1993): p55.

power of the traditional leaders;[32] at the same time, his criticisms of the independence increasingly called for by other Micronesian leaders centred upon their conservative views of development. Though he believed in maintaining traditional Marshallese authority structures, he was more progressive in his views on economic development, imagining a future which would capitalise on wealthy Japanese tourists - "the world's most affluent" - and casino gambling, and once said that in Majuro "the greatest thing that has ever happened is the development of the new airfield."[33] He notably presided over the first Pacific Islands regional climate change conference, held in Majuro in 1988, where he lamented that "our ocean will turn against us;"[34] in that same year, he suggested that Bikini could be used as a nuclear waste site for other nations to generate revenue for the RMI.[35] He was openly critical of the Bikinian's, who he described as being "enthralled and entranced" by their US captors, who they have come to see as their iroij; and yet he displays a similar deference to the Americans, speaking of the RMI as if it is a kind of bad-tempered child of the US.[36] And despite his foundational role in the Micronesian Congress, and the incredible gains made as a member of that federation in opposition to American hegemony, the other leaders came to see him as a bully who attempted to "unseat those who don't play his way;"[37] As one observer put it:

> "Kabua wants an autonomous district, his own little 'fiefdom' where he can control all the money raised from the income tax at Kwajalein, and wheel and deal with anyone else who comes along his way."[38]

The structure he built into the RMI government prevented public dissent - even from *within* the government. Over the course of his 27-year presidency, Kabua gained "near *exclusive* control of the distribution of *all* US Compact funds, not only those designated for the RMI government, but also those provided for the rental of Kwajalein, and for compensation for *the victims of nuclear testing*."[39]

In spite of all of this, Kabua seems to be universally venerated as the

32 Walsh. (2003): p230. The government he formed was a unicameral Parliament controlled by a 33-member *Nitijela* (TRANS. Legislature MAR.) which effectively combined the executive and legislative powers into one body, without the checks and balances of the bicameral presidential constitutions adopted by the rest of Micronesia.
33 Ibid., p225. Incidentally, the airport is now called "Amata Kabua International Airport."
34 Woonton. (2011): ¶9.
35 Earnshaw. (2001).
36 Walsh. (2003): p226.
37 Ibid., p228.
38 Ibid. In his later years as RMI president, he even used his influence over the Nitijela to expand his traditional landholdings in similar acts of bullying: in 1994, despite overwhelming Bikinian opposition, he obtained Iroojlaplap status over Bikini atoll; in the same year he also emerged victorious in an expensive legal battle with his cousin, Kabua Kabua, to gain Iroojlaplap status over Kwajalein.
39 Ibid., p235; emphasis added.

Amata Kabua International Airport (MAJ)
Inter-island travel within Pacific nations is usually straightforward, but travel to neighbouring nations can be very difficult. For example, to travel from Majuro to the nearest large foreign settlement, South Tarawa (population 29,000) in the neighbouring nation of Kiribati (a distance of just over 700km (a mere hop by Pacific standards) it is necessary to fly first to Honolulu, thence to either Auckland or Sydney, then Nadi, and finally Tarawa - a total trip distance of some 12,800km. See Dvorak. (2007): p66.

Built beginning in 1971, MAJ required an enormous infill operation - what Kabua called "the greatest thing that has ever happened." The airport occupies several kilometres of reef flat on the south side of Majuro atoll. It has an elevation of 6 feet above sea level: in recent years, flooding has become a serious issue. A new seawall was constructed in 2009. See Wikipedia: "Amata Kabua International Airport." Photo credit: D. Ching.

preeminent hero of the Marshallese in the modern period. While the American administration had actively sought to undermine the authority of the iroij, Kabua's legacy is the endurance of traditional authority structures - which continue to be the "providers of and liasons to valued resources," even as the "development discourses, practices and priorities simultaneously eroded the percieved value of indigenous ways, skills and knowledge in a modern world dependent upon 'green peba.'" (TRANS. cash MAR.)[40]

Following Kabua's death, the political theatre in the RMI has been heavily contested, and the Marshallese people have been increasingly vocal about the activities of their government - critical even of powerful traditional leaders, such as Amata's cousin Imata who succeeded him in the presidency, or Amata's "right hand man" Tony deBrum.[41] And yet, Amata remains sacrosanct, even among his former rivals. Reverence for Kabua - who might appear to outside observers as a ruthless autocrat and at times a "puppet" of the United States - makes a great deal more sense when seen in the context of a traditional chief who nimbly manipulated foreign agency in the Marshalls to acquire resources for his people.

Letao the Trickster

This brings up another source of confusion and frustration for critical external observers: the way in which the Marshallese describe their relationship with the United States, and the role of the US in Marshallese history and in its future. Peering in from beyond the horizon, the historical actions of the United States (nuclear tests, land appropriations, continuing missile tests, and political subterfuge) and the current conditions in the RMI which seem to be clearly correlated to these actions (overpopulation in urban centres, the staggering impoverishment of Ebeye, the degradation of traditional ways of life, irradiated atolls and a legacy of radiation-related illnesses, and complete economic dependency on the US) suggests a clear-cut narrative of ruthless imperial power exploiting a "helpless indigenous community and a small, recently independent nation-state."[42] It would seem reasonable to expect the Marshallese to view the US with - if not outright hostility - at least suspicion and resentment. But "this is not a place where people are burning American flags and saying 'go home America' - they're not."[43] The impression garnered from reading

40 Ibid., p236.
41 Kluge. (1993): p53. Both Imata Kabua and deBrum would later be ousted for a scandal involving Jack Abramoff - the same high-profile lobbyist who was involved in the "Made in the USA" scandal involving garment factories in the Northern Marianas Islands. See <freermi.wordpress.com> documenting Tony deBrum - Jack Abramoff connection.
42 McArthur. (2008): p265.
43 Giff Johnson - an American expat who once lived on Ebeye, has been one of the most vocal advocates for the rights of disenfranchised ri-Kuwajleen. This quote is taken from Corcoran. (2009) - an Australian Broadcasting Corporation editorial documentary called *Rocket Island*. Johnson also runs the Marshall Islands Journal, the major local newspaper.

through pages of commentary on Yokwe.net[44] - and borne out in academic research[45] - is overwhelmingly the language of partnership rather than opposition. In many ways, the Marshallese echo the official American rhetoric which describes the relationship: friendship, beneficial partnership, mutual allies, symbiotic relationship. Vigorously aware of contemporary history, the Marshallese are nevertheless forgiving of the US for its many transgressions, describing the United States as a parent or coach who has made mistakes, but has good intentions at heart.[46]

This seemingly paradoxical ambivalence is partially explained by the positive experiences which the Marshallese have had with their imperial ally over the years. In the post-war years, on atolls unaffected by the nuclear testing program, the American presence was percieved in a positive light for many reasons.

> "From the time of the WWII liberation, and the US occupation, which inoculated the Marshall's with canned SPAM and westernized thinking, Marshallese have valued their relationship with the US and looked up to Americans."[47]

The American agenda brought martial conditions to the few, but 'liberation' for most meant an abundance of new, imported food; access to alcohol and cigarettes, which the Japanese had kept out of the islands; and of course, American culture itself - Elvis Prestley, John Wayne and Coca Cola.[48] Later, US aid would bring typhoon-resistant homes, evacuations and rescues from natural disasters, education, and clothing. And under the Compact - despite Marshallese sovereignty and exemption from taxation - the RMI receives access to US federal programs, its citizens can freely study and work in the US, and the US provides the majority of the government budget. There is a saying - *bwiin eppallele* - which roughly translated means "the smell of America." Like the plasticky smell of a freshly opened package - toxic but also narcotic - the legacy of American involvement is as seductive as it has been destructive.[49]

The high esteem with which many Marshallese hold both the United

44 The official Marshall Islands website, a remarkable moderated resource where essentially the entire international community has a forum to voice their opinions - it is reportedly watched carefully by the US administration and RMI government, who frequently weigh in on conversations.
45 This disposition towards the US appears frequently in Dvorak. (2007), and Walsh. (2003). McArthur. (2004) specifically deals with the concept of the United States as a Jebro figure. This "ambivalence" was striking to the author as well, who encountered it frequently amongst Marshallese commentators on Yokwe.net.
46 Walsh. (2003): interviews, chapter 7.
47 Dvorak. (2007): p211. Quoting Aenet Rowa.
48 Ibid., pp200-215. See also Horowitz. (1990): kids moon-walking, Dribo impersonating John Wayne, and the pervasiveness of American symbols, products, and aspirations.
49 Rudiak-Gould. (2009): p179.

States and Kabua is summed up in an aphorism which describes the role of the traditional chief and something about his nature:

> "*Jab alkoj pien ak.* Don't twist the wings of the frigate bird.[50]

One of the results of American 'generosity' in the post-war period - whether emerging from a genuine desire to bring liberation and independance or as an act of coercion and cultural sabotage - is a Marshallese narrative which (both figuratively and quite literally) viewed American gifts and gestures of goodwill as the customary distributions of chiefs.[51] In effect, the United States became a kind of supreme chief to the Marshall Islands: as Amata Kabua says sarcastically, "Irooj Uncle Sam."[52]

The irooj is a complex character; while the Jebro myth narrates the positive aspects of his personality, he is also known to be "jealous, easily offended, and spiteful."[53] Jebro is a useful figure for constructing the identity of the modern-nation state - as he is an unambiguously positive force and succinctly collapses the role of democratic / populist leader into the tradition of the iroij - but he does not capture the more Machiavellian aspects of chiefly identity.[54] There is another Marshallese mythical hero who competes for prominence with Jebro: the quintessential pan-Pacific trickster, Letao.[55] The Letao corpus describes a paradoxical character - at once hero and villain - who both creates and defines the limits between nature and culture, while simultaneously destroying or subverting those boundaries. Letao introduces sexuality, fire, and teaches the people how to exploit their natural realm; but his 'gifts' often serve his own ends and result in destruction, catastrophe,

50 Walsh. (2003): p191 - from *Jabonkonnaan in majel*. "This proverb is used when someone is about to refuse a present or actually refuses it. Every gift, no matter how small, must be accepted; refusal is a serious insult to the donor. One does not mistreat a person he is counting on... and whoever twists the wings of the eagle of the sea makes it impossible for him to fly in the upper regions. This is similar to 'Don't bite the hand that feeds you;' and 'Don't look a gift horse in the mouth."
51 Dvorak. (2007): p214.
52 Walsh. (2003): p227. I am condensing the theories of a couple of authors here, and I am keenly aware of the danger of simplifying too much. It is certainly not my intention to suggest that the Marshallese do not fully understand their relationship - for good or ill - with the United States. Rather the opposite: I believe that the thesis presented here, which is informed primarily by Walsh and McArthur, (who both provide a much more complete picture than I am able to) is an incredibly subtle and insightful way to understand this relationship, and furthermore places much more emphasis on local agency.
53 Ibid., p191.
54 McArthur. (2004): pp63-64. In fact, as McArthur notes, Jebro's prominence is a contemporary phenomenon, perhaps because of the importance given to the story in the ethnographic studies of outsiders, such as Tobin, Carucci and Mitchell. It is worth considering also how easily the Jebro story fits into the format of a kind of Judeo-Christian morality story, and also readily translates Marshallese concepts into a simple "black and white" Americanized format.
55 The trickster figure is the predominant mythological character amongst many islander groups. The most famous of these is Maui, who appears in the legends of many Polynesian cultures across the Pacific, from Hawai'i to Aotearoa New Zealand.

Spam
"If the US can continue to buy military advantage, it will do so. The US government is buying Micronesia, however, not with genuine development; genuine development would empower the people of Micronesia to opt for independence by giving them an economic infrastructure that would allow them to produce their own food, buy their own medicine and train their own doctors. Rather, Micronesia's land and independence are being bought (in a coerced transaction) with imported food, tabacco, alcohol, and government payroll cheques." Lutz. (1986): p26.

The prevalence of American food such as SPAM has contributed to a number of serious health crisis in the Marshall Islands. "It would be difficult to design a diet that could more efficiently induce type 2 diabetes than the one the Marshallese people have adopted. Not surprisingly, the rates of type 2 diabetes in this population are among the highest in the world. An estimated 28% of individuals over the age of 15 have type 2 diabetes. For those older than 35, the figure is nearly 50%. Close to 75% of women and more than 50% of men are overweight or obese. Approximately one half of all surgeries performed on the island are amputations due to complications from diabetes." See Davis, B. (2008).

or invert dominant social relationships. Like his cousin Jebro, he is the youngest of several brothers; but in contrast to Jebro - who is the archetypal 'good son,' Letao is a *lakabwe* (literally a "little shit").[56] He shape-shifts, manipulates nature, and speaks in *riab* (TRANS. lies MAR.) in order to deceive the empowered or entitled, subverting social realities to achieve his selfish ends - the ultimate hero of the little guy. He reflects a culture with a long history of dealing with sometimes powerful or antagonistic foreigners.

In one common narrative, Letao travels to the atolls south of the Marshalls, Kiribati, where he finds the people starving. Desiring the many wives of the chief, Letao helps them build a fire in an earth oven. When it is ready, Letao lays down in the coals, and bids the people to cover him; when they remove the coverings, they find piles of delicious fish and breadfruit. And yet, the women still have eyes only for the chief. When Letao prepares to leave, the chief takes him aside and begs to know the secret, so that he can feed his people in the same way that Letao has done. Once more they build a fire. When it is ready, Letao bids the chief to lay amongst the hot coals, which he does. The people cover him, and though they can hear him screaming in agony, they do not let him out. When they finally do uncover him, they find not a bounty of food, but a cooked chief, and Letao has his way with the women.[57]

These parables are not only relegated to prehistory; like the appropriation by Kabua of the Jebro narrative to lend legitimacy to his modern political authority, Letao myths similarly burst into the present, recontextualizing contemporary global realities. As McArthur puts it: "Marshall Islanders do not imagine their past as complete. Rather, through the trickster Letao, the past is dynamic, mobile, and interconnected" with the present.[58] In contemporary versions of the story, Letao continues his journeys, and is eventually kidnapped by the Americans. In exchange for his release, he agrees to help them with their military experiments. Thus, the "source of the force" of the nuclear weapons unleashed on Bikini lies not with the US, but in the Marshallese trickster god.[59] With this playful recontextualizing, Marshallese storytellers "reverse the orders of centralization and globalization, by placing themselves at the centre, rather than at the periphery, of global power."[60] More than just expressing the "longings of the oppressed," this reversal reveals a nuanced imaginary of the Americans: like Letao, they have been a subverting force (in removing the Japanese regime, or in attempts to politically undermine traditional leaders); and like Letao, they make offers which reveal a deep understanding of human weakness (trading an atoll for world peace, or

56 McArthur. (2008): p282.
57 Ibid., pp272-278.
58 Ibid., p267.
59 Dvorak. (2007): p353.
60 McArthur. (2008): p277.

offering goods and money for occupation).[61]

> "Letao is the embodiment of all extremes; he is at once good and bad, possesses all knowledge and all stupidity, all love and all hate, all kindness and all meanness, all truth and all lies. Isn't that just like the Americans?"[62]

This "pre-history" of the globalized present makes it clear that the Marshallese are fully aware of their peripheral position on the global stage.[63] Amata Kabua became a national hero not because of his explicit claims to legitimacy based on shared characteristics with Jebro, but because of his ability to subvert the international relationships of power in his dealings with Micronesian neighbours and with the United States - in effect to *out-Letao* Letao. Surely this is a more poignant representation of reality than the American fantasy of liberation.

Reparations

While the American tricksters have provided inspiration for shrewd leaders on Majuro, those who have been directly effected by the US presence - namely the people of the atolls poisoned by fall-out and those people evicted from the Mid-Atoll Corridor (MAC) of Kwajalein - are seldom so generous in their view.[64] Whenever the RMI government capitulated to American interests, local people were forced to take action. It is due to local direct action that both nuclear testing and the problems of Ebeye have remained, throughout the 33 year history of the RMI government, the central issues of contention in US / RMI relations - despite the efforts of both governments to sweep them aside at various times. Within the RMI, the trajectory of these issues reflect a deep schism between the centre of wealth and the locus of political / traditional power at Majuro, and the broader interests of smaller groups of islanders on the many outer atolls.

In both cases, the US negotiators and the Kabua regime had attempted to settle the issue for good with the original Compact of Free Association[65] which offered $9 million per year in payment for the lease of Kwajalein atoll.[66] It is notable that of "the 8 atolls with extended historical interactions with the Americans, 6 voted against the Compact" - including Bikini, Kwajalein and Rongelap.[67] A key point of

61 Ibid., p278.

62 Ibid., p263. The quote is attributed to Kometo Albōt, McArthurs informant and a significant "Letao" character himself...

63 Ibid., p287.

64 Walsh. (2003): p358.

65 Voted on by the Marshallese people in the 1983 plebescite.

66 Walsh. (2003): p352. $7 million to the landowners and a $150 million dollar trust fund for the compensation of victims of nuclear testing.

67 Ibid., p348 & 358.

contention in the original Compact was "section 177," which essentially stated that by signing the Compact into law, the Marshallese people forfeited the right to seek further compensation for damages incurred by the nuclear tests.[68]

The issue of nuclear reparations is a complex issue with many separate claims, and it is impossible to go into detail here. However, it is important to understand 2 key problems with the original Compact. Firstly, it limited the scope of who would be eligible for compensation to the "4 atolls" - Bikini, Enewetak, Rongelap and Utrik. In 1994, a detailed 5-year study would reveal that in fact 15 atolls (half of the RMI) had been seriously impacted.[69] Reparations were not available for many victims - sometimes several generations from those who had been exposed - who developed serious health issues but could not prove that it was the result of exposure to the testing program.[70] Secondly, section 177 of the Compact created a Nuclear Claims Tribunal, which "would handle all claims and payments arising out of the nuclear testing program," but only authorized $150 million, which was to constitute "'a full and final settlement of all claims,' past, present, and future."[71]

The Bikinian people continue to live in exile. Though many had returned home after the US administration declared Bikini safe back in 1969, 139 Bikinians were once again forced to leave in 1978 as a result of ongoing Interior Department testing which had found 75% increases of radioactive cesium in those who had returned.[72] People on most of the other affected atolls never left, and several generations later their decendants continue to suffer from multiple forms of cancer and other ailments. Throughout the 1970's and early 1980's, as hard data on the numbers and severity of those affected was disseminated, negative publicity impelled the United States to make incrementally larger settlements with the people involved.[73] The $150 million trust set up in the Compact agreement was a significant increase over earlier settlements; but by 1991, as the list of claimants grew longer and longer, the Tribunal could no longer afford to pay them.[74]

A question that has always lingered in the minds of the Marshallese is whether or not the exposure of the people of Rongelap was premeditated. At the 1972 Congress of Micronesia, the Marshallese

68 Ibid., p353.
69 RMI Embassy. (2005): Chronology.
70 Ibid. An ongoing thyroid study, also made available in 1994, revealed that "even if only 50 percent of the survey results are verified...the incidence rate is still significantly higher, by a factor of 100, than the rate of thyroid cancer found anywhere else in the world." -Rep. George Miller, in a letter to Bill Clinton.
71 United States Senate. (2003): p4.
72 The people of Enewetak were eventually able to return to their land following a $218 million clean-up was undertaken by the United States.
73 These claims were initially settled on a claim-by-claim basis: $1000 per person, $25,000 each for a case of thyroid cancer, $100,000 to families whose loved ones had died.
74 RMI Embassy. (2005). The complete story is available on the website.

Signing over the MAC
In this photo, Kabua presides over a signing ceremony, as Kwajalein landowners sign the first Compact, giving the US military access to the Mid-Atoll Corridor. Left to right: Iroij Lejolan Kabua, Amata Kabua, Acting Attorney General Bowles.

representative Ataji Balos alleged that the Bravo exposures were intentionally committed, the people of Rongelap chosen as subjects due to their marginal status; the Atomic Energy Council and the US government denied this.[75] Immediately after the Bravo shot, it is claimed that the AEC and the military authorities responsible realized that they had a unique opportunity to study the effect of radiation on humans; a secret program was instituted, called Project 4.1.[76] The Rongelapese "inadvertently were to provide otherwise unobtainable data on the human consequences of high radiation exposures."[77] In 1994, a Castle program prospectus was discovered which seemed to lend some veracity to these allegations, as the document made specific reference to Project 4.1 a full six months before the "accident."

The Bikinian diaspora has been actively fighting for compensation from the US government since 1955.[78]

Jojoḷāār

Like the Bikinians, the ri-Kuwajleen have learned from experience that the only way to force action is to take action themselves. While the battles over Bikini atoll were fought in distant courtrooms, the Kwajalein people have resisted American presumption more directly. Protests began in 1969, just 5 years after the evictions from the MAC had taken place. After repeated requests for action on living conditions and compensation issues were ignored, 31 landowners occupied their islands, threatening to distrupt missile testing and forcing a quick

75 Hacker. (1994): pp226-228.
76 Martin, Rowland. (1982). In Project 4.1 US scientists sought to: "(1) evaluate the severity of radiation injury to the human beings exposed, (2) provide for all necessary medical care, and (3) conduct a scientific study of radiation injuries to human beings."
77 Hacker. (1994): pp226-228.
78 Niedenthal. (2012). Of the original 196 Bikinians evicted from their atoll in 1946, only 34 are still alive, but their direct decendants now total an estimated 4700 people - scattered throughout the Marshall Islands and the world, fighting to obtain sufficient funds to undertake a full radiological clean-up of their atoll. The first decision in 1955 - made without legal council - relinquished use rights to their land for a $300,000 trust fund - about $15 per person per year at the time. In 1975, the Bikinians brought a lawsuit before a US federal court demanding a complete radiological assessment of the islands. The results of these tests would result in the second forced exodus from the atoll in 1978. Two more settlements were reached in federal court in the 1980's resulting in two separate trust funds, independent of the nuclear claims dealt with in the Compact. Beginning in 1994, they undertook further action, resulting in a 7 year legal battle which would grant them $563 million in damages. Despite this victory, there would be no pay-out: the source of the funds (the Nuclear Claims Tribunal) as outlined by section 177 of the Compact, described even by US government officials as "manifestly inadequate," (Crismon. (2005) p188) had run dry. 10 years of appeals, extensions and dismissals would follow; in 2010, the Supreme Court denied any further extensions. As of 2006, with interest, they are owed approximately $725 million; they wait, spread around the Marshalls and United States, hopeful to one day return to their homeland.

Nuclear Legacy
At the annual meeting between the US Department of Energy and the Republic of the Marshall Islands, representatives of ERUB (Enewetak, Rongelap, Utrik and Bikini) stressed the urgent need for the DoE to include their children and grandchildren in the DoE health program, which currently does not cover them. In 2004-2005, six babies born on Utrik suffered from terrible mutations: swollen skulls, no ears, grey hair, and other horrible disfigurments. All died within weeks. See Nuclear Age Peace Foundation. (2012). Phot credit: Hiroshi V. Namamura.

Concertina wire erected during the protests on Kwaj
"The history of Micronesia during the three decades of American rule has been the saddest history we can remember. History will show that it was we Marshallese who had the 'trust' while America had the 'territory.'" Quote from Hon. Ataji Balos (one of the key figures in the sail-in protests) excerpted from Johnson. (1986): p38. Micronesian Congress, during Interior and Insular Affairs Hearings, Ebeye, 13 July 1976.

Part of the motivation for the razor wire was actually to prevent American sympathizers - some of whom had wives and girlfriends on Ebeye - from transporting goods to them across the reef flats at night. Even Marshallese who are married to American base workers are not allowed to stay on Kwaj overnight. The concertina wire was met with incredulity on the part of many Kwaj residents, one of whom redesigned the popular 'Kwajalein: Almost Heaven' t-shirt, altering the slogan to read 'Almost Poland' in protest and solidarity with the Marshallese protestors. See Crismon. (2005): pp497-499.

response by the Trust Territory administration.[79] Persistence paid off, and after a 2-week stand-off, the landowners signed what would become the first of many agreements with the Americans.[80]

In June of 1979, the US and USSR concluded the second round of Strategic Arms Limitation Talks, resulting in the SALT II treaty. In the peculiar logic of the Cold War, a treaty ostensibly designed to limit arms development resulted in a drastic increase in the number of missile programs scheduled for Kwajalein.[81] A number of sail-ins occurred in 1978 and 1979 - again organized by local leaders - resulting in the first major victory for the ri-Kuwajleen: the US upped the lease agreement to $9 million annually, and furthermore agreed to upgrade Ebeye's overtaxed sewage system and hospital. Unfortunately, despite the agreement the US would continue in its characteristic pattern of snuffing out the fire only when it became intense - and 3 years later the situation had "deteriorated rather than improving."[82]

The demonstrations would reach their peak in 1982, in protest against the details of the Compact which Kabua's government had finally finished negotiating. In what was known as "Operation Homecoming," more than 1000 Marshallese - many of them women and children - occupied 11 islands, including the military base on Kwaj and a smaller base which had been built on Roi-Namur at the north end of the atoll. For four months they camped out on the restricted islands; their presence in the "danger zone" of incoming ballistic missiles forced the MX tests to be redirected.[83] The military responded, arresting organizers, conducting daily body searches of Marshallese employed at the military base (who were not participating in the protests), and eventually even erecting fortifications which included concertina wire and searchlights to keep protestors off Kwaj.[84]

But in their haste to get on with business as usual, the military administration merely strengthened the position of the non-violent

79 Johnson. (1986): p36. The small group which participated in this first demonstration was led by a man named Handel Dribo; they called the occupation a "sail-in," and based it on the non-violent "sit-ins" of the civil rights movement in the United States at the time. See also: Dvorak. (2007): p310.
80 Ibid. 10 years later, in 1979, conditions had gotten progressively worse on Ebeye. The original agreement had resulted in only $285 annual payments to the iroij; but the population on Ebeye had exploded, impelled by the increasing prospects of work on the base as the military ramped up missile testing activities.
81 Ibid. "In July 1979, 500 Kwajalein people occupied eight islands, including Kwajalein Island, the army's headquarters... the Kwajalein protest threatened to shut down the range and prevent scheduled MX (Experimental Missile) tests. With SALT II and the MX in the balance, the Kwajalein people had the leverage they needed to secure concessions from the US."
82 Ibid. Remarkably, some of these concessions were organized as the result of direct meetings between Kwajalein landowners and the US Department of Defense. Crismon. (2005): p489.
83 Ibid., p38.
84 Crismon. (2005): pp499-500.

Marshallese. Base personnel were increasingly sympathetic to a cause which they saw as just, going so far as to send their children to bring food and supplies to the demonstrators;[85] even a US congressman openly condemned the military response: "We're occupying their land and we're denying them the right to peacefully assemble and petition for redress of grievances that our Constitution guarantees our own citizens. And yet we're in their country."[86] The position of the Marshallese was unambiguous: they carried signs proclaiming "Give me liberty or give me death!"[87] which made the base command extremely nervous. Sail-in leaders[88] were hailed as "Marshallese Martin Luther Kings."[89] Photos from the period are remarkable, showing large groups of children playing peacefully on the beach or lounging on the grass of the base.[90] "Operation Homecoming" was ultimately concluded forcefully by the military - who shut off water to the campsites, barred Marshallese workers from their jobs and the only bank, on the base - and by the intervention of Amata Kabua, who was able to negotiate for the incorporation of some of the landowners demands into the first Compact. Ultimately, the last straggling resistors were removed by private security forces. By 1986, support from Majuro and American sympathy had dried up, and later occupations were forcefully removed.[91]

In subsequent years, as the relationship became increasingly polarized between Kwajalein landowners on the one hand, and the RMI and US governments on the other, the landowners became more and more marginalized from discussions regarding the future of Kwajalein atoll and Ebeye. American observers (on the base and abroad) and Marshallese living elsewhere would increasingly accuse the ri-Kuwajleen of being greedy trouble-makers, a thorn in the side of the RMI in its relations with the United States. Critical Marshallese also accused the protesters of having anti-American sentiments, which were seen as counter-productive to the health of the young nation which relied upon the US for so much. Curiously, this does not seem to have been the case; while some certainly did desire to return to their lands for good, they did not frame this desire in antagonism towards the US. As one Ebeye resident remarked:

> "You know, with America you try to be nice and you get

85 Ibid., p493.
86 Johnson. (1986): p38.
87 Crismon. (2005): p498.
88 Such as Handel Dribo, as well as Imata Kabua, Mike Kabua and Ataji Balos. Imata is Amata's cousin; Mike is his younger brother; and Ataji, like Amata, was a key figure in the Micronesian Congress.
89 Dvorak. (2007): p314.
90 Ibid., p316.
91 Johnson. (1986): p39. In order to comply with the RMI's agreement with the US, Kabua invoked "eminent domain" rights over their land, strong-arming the landowners to acquiesce. This required the declaration of a "state of emergency" - the first in RMI history - as the appropriation of land for anything but "public use" goes against the RMI constitution. The protestors in the 1986 sail-ins were removed by *Marshallese* police.

> sidestepped and pushed aside. In America, people speak up!.. It's very American to go after what is right. In fact, if anything we've been taught by the Americans to stand up for what is right. But if you just want to be trampled on, that's not American! So I believe the Kwajalein landowners are actually representing the core of [American] values! Do what is right, stand up for what you believe is right - it has nothing to do with anti-Americanism whatsoever."[92]

They were further condemned for mis-managing and wasting the money, as evidenced by the continual decline of conditions on Ebeye. And yet, this perspective "conflates landowner payments... with infrastructure or 'development' funding, two completely separate issues."[93] Many of the most prominent iroij[94] are dedicated to their communities, living together with them on Ebeye and distributing the rent payments among the networks of people who rely on them.

Ironically, these internal antagonisms echo external criticism from the United States concerning the Marshall Islands as a whole. As a *New York Times* columnist wrote in an infamous 1997 article entitled "Yankee Go Home. Send Cash":

> "Thus the paradox of foreign aid: there is almost no place in the world where America, as America sees it, has been so generous as the Marshall Islands... Yet the local economy remains a shambles and the United States is broadly resented. Something went badly wrong, for usually it is possible to be resented without paying $1 billion for the privilege."[95]

Media portrayals which either condemn the Marshallese - as "crippled and corrupt," "professional victims," or otherwise greedy and inept - or conversly, express sympathy for a naive / passive culture which has been powerless in constructing its own destiny and express nostalgia for traditional practices which have been lost, grossly oversimplify the degree to which Marshallese agency has determined the present conditions.[96] Consider the examples presented in this chapter: the Bikinian diaspora and the ri-Kuwajleen of Ebeye. Both groups, at various times, have been represented as victims and opportunists. In both cases, a single issue emerges again and again - the absolutely

92 Dvorak. (2007): p314.
93 Ibid., p303.
94 Such as Imata Kabua, who would go on to be RMI president from 1997-2000, and remains one of the most vocal champions of Kwajalein residents rights among high-ranking traditional leaders. His brother Mike Kabua lives on Ebeye and teaches Ebeye kids to sail traditional canoes.
95 Kristof. (1997): ¶3.
96 Walsh. (2003): pp395-417. As we have gotten some hint of up to this point; rather than outlining these criticisms and sympathies in detail, the following is simply an attempt to connect the histories of the Bikinians / and ri-Kuwajleen presented thus far with an easily misunderstood - and often misrepresented - motivation.

paramount importance of land. Accusatory and sympathetic observers alike often fail to grasp just what it is these people have lost; the argument, over and over again, is framed in terms of "damages" and "reparations." How and to what extent have the Marshallese been injured? (either by radiation, or by being forced to live in overcrowded and unsanitary conditions on Ebeye.) But in a culture which values nothing more than land - which remains staunchly determined that the traditional social order which derives all of its authority and power from that land - no amount of money will ever replace what has been taken. The Marshallese have a word which succinctly describes this situation. A "landless people," those who have been evicted from their land, are called *Jojoḷāār* (TRANS. literally "a chick without its mother" MAR.).[97]

Paradise is an Island. So is Hell.[98]

In 1986 an American filmaker, Adam Horowitz, travelled to Kwajalein to document the final sail-in protests. The film, *Home on the Range*, is emotionally staggering, following an energetic and eloquent 72-year old Handel Dribo[99] around as he explores the islands of his youth. Early in the film, Dribo and his extended family - children, grand-children, great-grandchildren - leave their Ebeye home and travel to the Kwaj base, where they enter the officers club, an open-air pavillion near the beach. The club is built upon Dribo's ancestral land. As his grandchildren mill about, Handel reads aloud the words prominently displayed on a sign at the entrance to the club, written in Marshallese and English:

> "NO MARSHALLESE ARE ALLOWED ON THESE PREMISES. ANYBODY CAUGHT WILL FACE IMPRISONMENT AND WILL BE RUINED."[100]

Later, Dribo and his family return to the island where they lived prior to the American liberation - Meck - where they see for the first time the changes wrought by the anti-ballistic missile testing. On Meck, the military had constructed a massive launch facility where the ABM systems are launched to intercept incoming warheads. Handels' daughter, Joann - who left Meck when she was 12 years old - hangs laundry to dry on the windswept beach, the barbed wire and concrete of the launch facility behind her:

> "I remember in those days this island was covered with tapioca, breadfruit, pandanus and coconut trees. There wasn't anything that didn't grow on this island. There was no such thing as hunger - every type of Marshallese food grew here. And this

97 Dvorak. (2007): p306.
98 Schalansky. (2010): p6. This quote opens a book which chronicles the 'island dreams' of a land-locked woman.
99 A central figure in organizing earlier resistance efforts. See footnotes 74, 83.
100 Horowitz. (1990).

Apartheid
An overview of Kwaj island from the south; Ebeye can be seen at the top right of the image, with the modern causeway connecting it to several smaller islands to the north. "Despite the physical closeness of the two islets... the postwar American influence to the atoll created an ever-growing contrast - a binary that is quite difficult to reconcile." Ebeye and Kwaj are not even on the same telephone network; USAKA shares an area code with Vandenberg AFB in California, while Ebeye is patched into the RMI national exchange. Calling Kwajalein is an expensive long-distance call from Ebeye. See Dvorak. (2007): p271.

Daily ferry commute for 1800 Ebeyans employed at the Kwaj base

LEGEND

South Atoll Area

- Sewage Outfall
- Ferry Service
- Shipping channel
- Excavated Coral
- Buildings & Roadways
- Land (coral sand, to 4m above sea level)
- Reef Shelf (exposed at high tide)
- Deep Reef Structure
- Lagoon (sand, isolated coral-heads)

Direct sewage discharge for entire Ebeye population; outfall has contaminated all lagoon beaches.

Kwajalein Lagoon

Inbound Shipping Channel

Outbound Shipping Channel

R Buoy Coral Head

Bravo Buoy

ER-2 Coral Head

Barracuda Coral Head

K-7 Coral Head

N Buoy C.H.

GBR North C.H.

GBR Coral Head

G Buoy Coral Head

Pacific Ocean

North

0 1km

Depths in feet (metres)
Contour lines 100m intervals

(100) (200) (300) (400)

Urban Settlement

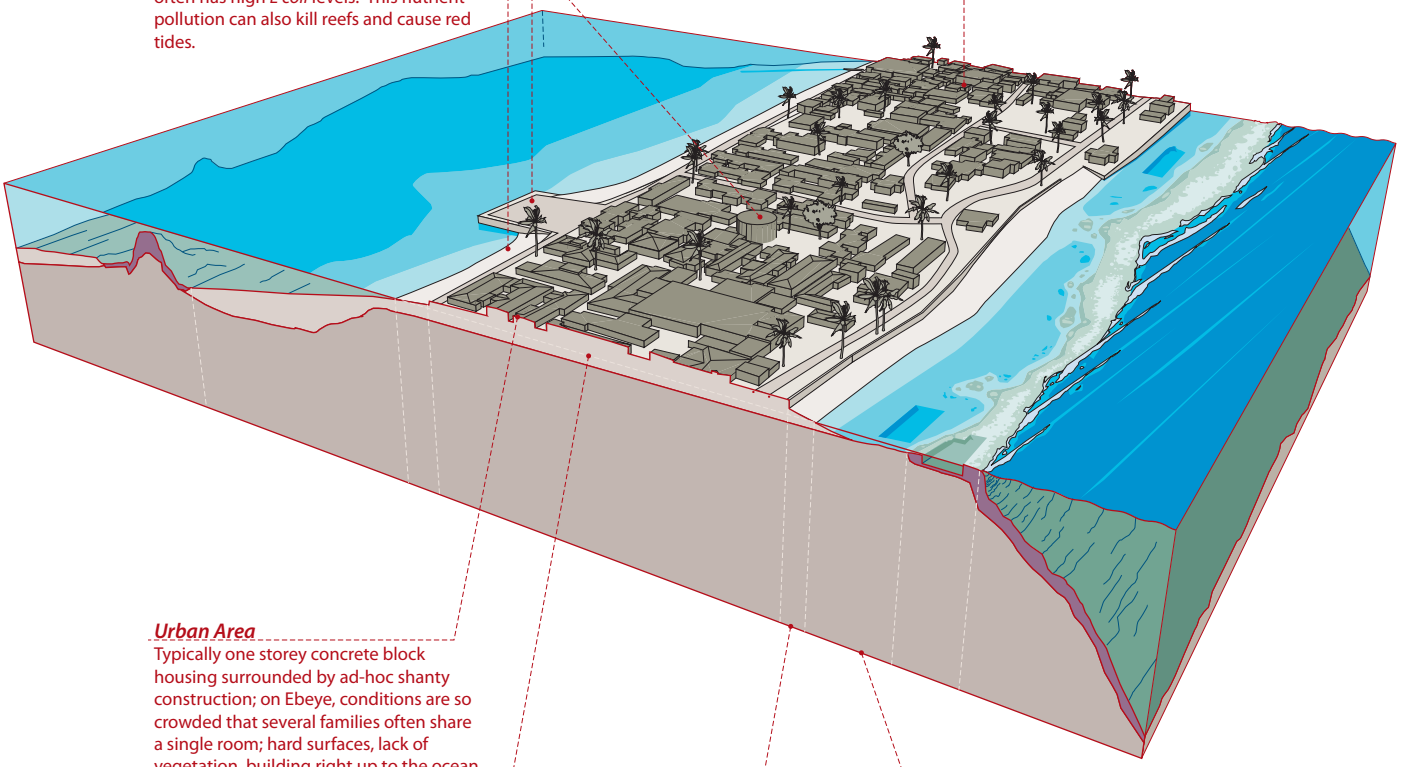
Expanded Wharf Facilities
As almost all foodstuffs and other material goods are imported, modern shipping facilities are essential. Deeper channels have been excavated through the reef barrier, and the lagoon has been dredged to provide safe passage.

Impermeable Surfaces
The urbanized atolls and military bases are largely impermeable; the fresh-water lens is brackish and often contaminated by effluent, and fresh-water run-off can cause coral bleaching and reef death.

Land Reclamation
On both Ebeye and in the D-U-D, significant areas of reef flat have been built upon; this is threatening to the future of the islets in several ways: coral sand is prevented from being added to the islands by sea-wall construction; the reef flats are comprised by removing construction material from them; and the new built areas are in severe risk zones during storm events.

Lagoon Beach
Coral sand, dredged inlets and artificial wharf. On Ebeye, sewage flows directly into the lagoon, 500 feet offshore; the beach - used for bathing and swimming - often has high *E coli* levels. This nutrient pollution can also kill reefs and cause red tides.

Water Tanks
On Ebeye, all fresh water is stored in several above-ground metal storage tanks, or in private rainwater collection tanks.



Urban Area
Typically one storey concrete block housing surrounded by ad-hoc shanty construction; on Ebeye, conditions are so crowded that several families often share a single room; hard surfaces, lack of vegetation, building right up to the ocean bank provides little to no protection from salt-laden air, storm surge, high tides or typhoons. Sewage is pumped into the lagoon, and garbage is placed in a landfill or burned.

Fresh-water Lens
Urbanisation has made large groups of people reliant on desalination processes, which are energy-intensive and have failed in the past on Ebeye.

Ocean Beach
In urban areas, the natural strand-wall of shells, cobbles and boulders has been replaced with concrete embankments; land reclamation has allowed construction up to or on top of the reef flats.

Reef Flats
The reef flats have been excavated in some places to supply coral rock for land reclamation or construction; these efforts can weaken the reef buttress, which becomes susceptable to storms. There are some positive aspects to reef flat pools however: they make accessible low-tide fishing locations, and provided they have an outlet to the ocean, a favourable habitat for new coral growth.

'The Slum of the Pacific'
A contemporary view of Ebeye islet. The power station occupies the foreground, with the low-lying shantytown spread out beyond. Excavations into the reef shelf are visible in the immediate foreground, as is the narrow causeway connection to the north.

> protest is the first time I have returned to the island since then. And when I saw what they had done to the island, I began to feel quite sorry about it, just like my father."[101]

This was the nadir of Kwajalein: at the height of Ronald Reagan's Star Wars development, the American base was busier than it had been since the 1960's and there were missile tests every other week. At the same time on Ebeye, the funding promised by the Compact, in the form of moneys accompanying the land payments and put into a special Kwajalein Atoll Development Authority (KADA), had yet to take effect. The sewage system was decrepit: when people flushed their toilets, sewage gushed into their sinks.[102] With no access to jobs and nothing to do, drug and alcohol use became widespread among Ebeye's youth. In the film, Dribo discusses the death of his son, who committed suicide "for reasons I couldn't understand." Suicide had become epidemic among young men. But the most enduring images the film captures are those of the children of Ebeye. They are everywhere! Dancing, running, and playing amongst rusting decay, their exuberance is a powerful foil to the hopelessness of the classic David-vrs-Goliath tale represented by Dribo.

Thirty years after the people of the Marshall Islands voted to enter into a relationship of 'free association' with the United States, and twenty years after the United Nations welcomed them as a sovereign, independent nation, life on Kwaj and Ebeye remains pretty much the same. The Americans are still testing missiles here, though these days there are only 4 or 5 tests a year. The American base is still tidy and inhabited by smiling, slightly sun-burned personnel, their kids tended by gentle Marshallese nannies. The lawns are still spick-and-span. And the ferry still carries Marshallese workers across the blue waters of the lagoon to their homes each evening.

And Ebeye is still crowded - in fact, more so than ever - but other things have improved somewhat since the mid-1980's. As one Ebeyan put it, with characteristic local wit, what was once a "hell hole" is now a "hell hole with sidewalks."[103] Over the years, a lot of time, money and energy has been thrown - by both the RMI government and the USAKA adminstrators - towards the problems of Ebeye; but there is no quick fix, and most of the programs and infrastructural solutions, intended to be permanent, have turned out to be very temporary indeed, failing to address the systemic causes.[104]

101 Joann Dribo, in Horowitz. (1990).
102 Crismon. (2005): p303.
103 Ibid., p309.
104 Ibid., p293-303. KADA funds provided modern sewage systems, a desalination plant, and a the massive diesel generator which supplies power to Ebeye, and most recently a new hospital, completed in 2004. All of which quickly fell into disrepair, and in any case provided no solution to the root problems: no jobs and a totally disastrous education situation.

Perhaps the most visible transformation involved the construction of a causeway, which was built to connect Ebeye to several neighbouring islets to the north. The causeway was begun in an attempt to relieve overcrowding - it would allow Ebeye residents to settle on the nearby islands. However, land tenure disputes resulted in refusals to allow an exodus from Ebeye, and despite an outlay of $9 million, the causeway was never completed. It is also questionable whether there was a desire to leave for many: Ebeye may be crowded, but it has services and goods available which are not found on the rural islands to the north.[105] In recent years, a marked degree of social stratification has arisen, spurred in part by the burgeoning population and the fact that there are only so many jobs on the base.[106] Even amongst crowded Ebeyans, there are the haves and have-nots. There is no social safety net here, beyond the traditional obligations of kinship which made the difficult life on Ebeye bearable in the past.

Compared with the antiseptic "small-town" character of Kwaj, Ebeye is often represented as its dark other, the favela "across the tracks" from the American dream. Descriptions which have proliferated in media and academic reports describe Ebeye as a "concentration camp" or "ghetto," and the USAKA / Ebeye relationship has been called "Apartheid, US Style."[107]

> "Kwajalein, they presume from this standpoint, has it all - it is the Shangri-La of the Pacific, like the 'Almost Heaven, Kwajalein' T-shirts once worn by Americans in the 1970's proclaimed."[108]

This representation of Ebeye certainly has a grain of truth in it; but it must be remembered that it has often been in the interests of both the USAKA administration and the ri-Kuwajleen leadership to maintain the image of the island as a "cesspool," "playground of demons" or "dumping ground."[109] For the Ebeyans themselves - as with the Marshallese in general - a stress on the negative can help to maintain the importance of local issues and keep aid monies flowing.[110] For the Americans, this rhetoric has been used to prevent further inter-sectoral migration to Ebeye from other Marshallese atolls, and to impell out-migration.[111] Furthermore, the "degeneration" of Ebeye is a useful tool for arguing in favour of western style development, by laying the blame for Ebeye squarly upon traditional Marshallese kinship and family structures which have encouraged people to come here and expect

105 Ibid. See chapter 6.
106 Ibid., pp310-315.
107 Crismon. (2005): p288.
108 Dvorak. (2007): p277.
109 Ibid., pp277-282.
110 Ibid., p278.
111 Crismon. (2005): p302. This has been "encouraged" with a long history of programs attempting to get people to leave Ebeye - the most famous being 'Project Exodus' of the 1970's.

Almost Heaven
A suburban street on Kwaj. Spacious 2-storey houses line tidy streets fronted with verdant tropical lawns kept immaculate by Marshallese landscapers.

Shoreline of Ebeye
The ramshackle housing literally spills over into the lagoon.

familial support. As David Hanlon puts it, the American discourse of development, which sees "economic stagnation and backwardness" - underdevelopment - as a "threatening and dangerous condition for the capitalist West," "possesses the power to create or recreate reality in colonized settings."[112]

Places like Ebeye became "known and controlled through the writing, describing, interpreting and teaching" of "experts whose tools of measurement reflected the rationality and logic of their own very privileged, powerful world."[113] In short, (mis)representations of the Ebeye / Kwaj binary in terms such as "Heaven / Hell" reflect a dangerous Orientalism which parallels Hau'ofa's warning that "belittlement in whatever guise, if internalized for long, and transmitted across generations, could lead to moral paralysis," apathy and fatalism.[114]

Many outside observers, initially struck by the decrepit and crowded housing, or children playing amongst garbage in the dump, are quick to point out that despite this, there are surprisingly uplifting things to be found on Ebeye.[115] The ri-Kuwajleen are "generally happy people" who go to great lengths to "take care of each other."[116] Despite the emerging socioeconomic stratifications, traditional social supports endure: food sharing, adoption, and care for ill or mentally disabled residents. In spite of the poor sanitary conditions, what is perhaps most remarkable is that outbreaks of disease have actually been very rare.[117] Ebeye "is an island that is loved and cared for by its residents, many who sweep the surroundings of their homes clean every morning, and the crime rate is extremely low despite the population."[118] And today, as in 1986, the most urgent argument against Ebeye as a kind of hell, are the kids. They are still here: or rather, they have grown and had their own - Ebeye remains an island of children.[119]

Waan Aelõñ in Majel

In 2003, canoes lined up on the shore of Woja island, the home of the legendary Jebro on the "atoll of kings" - Ailinglaplap. [TRANS. literally "the Greatest Atoll" MAR.] Each canoe represented a Marshallese

112 Hanlon. (1998): pp8-9.
113 Ibid., p10.
114 Hau'ofa. (1993): p6.
115 Perhaps the most numerous and vocal being American teachers and missionaries who are enlisted to teach in the schools on Ebeye, and whose voices can be found in the numerous blogs and monographs found online. There are literally dozens, but one of the more interesting ones blogs is from a missionary teacher at Ebeye Gem Christian School - Ashely Gatewood. See Gatewood. (2011).
116 Crismon. (2005): p289.
117 Ibid., chapter 6.
118 Dvorak. (2007): p279.
119 There has not been a recent census, but as of 1999 the population was more than 60% under the age of 18, and more than 40% under the age of 14. Recent overall RMI estimates suggest that increasing outmigration of adults and a high birth rate has contributed to an even younger population.

atoll, and they had travelled here from all over the to re-enact the Jebro race for the first time in living memory. Local canoe races are held in Majuro each year, but this was the first race which represented the whole of the Marshall Islands. The event - held in March - commemorated the 50th anniversary of the American liberation of Ailinglaplap from the Japanese. Not every atoll was able to attend, but fittingly, 12 managed to organize a team and field a canoe.[120] Politicians and leaders from all corners of the RMI were present, and people from as far off as Europe joined the celebrations; ri-Kuwajleen drove outboard launches 200km across the open ocean to attend. It was a truly national event.[121] The organizers were keen to make the festival representative of all things Marshallese, with as little money as possible, and using only those things provided by the atolls themselves. "I particularly wanted to motivate people to realize what they could do," said Mike Kabua; we "could have real *mõñã in Majõl* (TRANS. Marshallese food MAR.), not frozen turkey tails."[122] The canoes were a motley bunch; a few were handcrafted beauties, but many had been cobbled together immediately before the race. This only reinforced the "Marshallese-ness" of the event. Kabua builds his canoes on Ebeye out of PVC pipe and plastic sheet because there are no trees. "Experimentation is part of our culture" he says.[123] In the end, the experimental plywood canoe fielded by the Ailinglaplap hometeam won the race.

Events such as this are becoming more common in the Marshalls, no doubt inspired by the established practice of holding similar cultural revival events throughout Oceania.[124] Many Marshallese lament the loss of traditional skills and ways of life; but these kinds of events do pose the danger of drifting into nostalgia. As Walsh writes:

> "Some might argue that the desire for 'modernity' is 'traditional' and historically rooted, perhaps more so than the 'progressive' neo-traditionalist movements in other Pacific nations."[125]

The question of what role skills such as canoe building, navigation, traditional food production, artisanal fishing, and the like should or

120 People from the north and south sent whatever they could afford; businessmen from Majuro sent contributions, and the Ailinglaplap iroij donated $20,000 to the event.
121 Loeak, Kiluwe, Crowl. (2004): pp16-17. The event was organized by irooj Mike Kabua, of Ebeye.
122 Ibid.
123 Ibid., p19. Immediately off the starting line, the Kwajalein canoe took the lead; but before the end of the first day, it and the canoe from Lae sank. "*Eindrein*" says Mike Kabua (these things happen); "those two experiments failed." One event that illustrates Marshallese "modern traditionalism" well is the Marshallese participants in the 1992 Festival of Pacific Arts in Raratonga: while participants from other Micronesian and Polynesian nations wore "traditional" or customary dress for the opening parade, the Marshallese wore black jeans and white, high-top basketball shoes. See Walsh. (2003): p386.
124 For example, the Festival of Pacific Arts and the International Festival of Canoes.
125 Walsh. (2003): p386.

The *Modern* Marshallese Canoe

Experimentation is at the heart of Marshallese culture: every aspect of traditional life belies a deep-rooted belief in the merits of experimentation. From land-tenure practices to contemporary political organization, the Marshallese are quick to adopt, test and adapt new ideas to suit their needs. The modern canoes are a case in point.

Traditional canoes were fast, but the new breed of lightwieght boats blow them out of the water. For example, Irooj Mike Kabua is an avid *riwuit* sailor and mentor on Ebeye (a riwuit is an extremely lightweight and fast twin-hulled dingy). His dingy - built of a lightweight wood called *Wa* (a hibiscus) and PVC pipes - won the cross-lagoon race on Majuro in 2000, going 5 miles in 20 minutes. See Anderson. (2002) for a description of Kabua's riwuit.

Especially in comparison with motor boats, the modern canoes have an enormous potential to reinvent islander mobility. Even in Majuro, fuel costs are upwards of $6.00/gallon, and on outer atolls it can be more than $12.00/gallon.

could play in a modernizing, developing Marshall Islands is a difficult one. But while some might view this revival with scepticism in the face of chronic unemployment, the collapse of the copra industry as a viable livelihood, and rapidly increasing urbanization, others see in Marshallese tradition the potential to powerfully impact the futures of Marshallese youth who have been cast adrift by the contemporary situation.

Of the actual participants in race, many had been involved in a Majuro-based outreach organization dedicated to providing vocational and life skills training to at-risk youth: Waan Aelõñ in Majel (Canoes of the Marshall Islands) or simply "WAM."[126] The mandate of the project was initially documentary in nature. The founders - Dennis Allesio and Alson Kelen - set out to document what was left of the canoe tradition on the outer atolls. Over the course of 7 years, they joined local communities and constructed 6 canoes, documented and translated the process and made documentary films.[127] The documentary created a great deal of interest amongst both the local communities and back on Majuro. The project included fish catch surveys on the outer atolls, determining that the 2000 year-old canoes are an appropriate technology for the future.[128]

Alessio and Kelen were determined that the canoe project had value beyond a documentary of traditional culture.[129] By 1999, WAM was incorporated as a grass-roots non-profit, non-government (NGO), with a clear mandate for "entry-level workforce development and employment preparation through the use of traditional Marshallese skills for men and women."[130] As of 2006, about two-thirds of the RMI population was under 24 years old, and the population was growing at one of the fastest rates in the region.[131] Alessio describes the youth crisis:

> "[H]alf of secondary age children are not attending school due to lack of classroom space and teachers... inability to pay school-related costs, lack of parental interest and support, and

126 WAM. (2008): "history." WAM began in 1989 with a partnership between an American expatriate carpenter and boat builder, Dennis Alessio, and members of the local Alele Museum and National Archives in Majuro, including a local named Alson Kelen.
127 Ibid. In order to gain this type of knowledge, Kelen and Alessio were given the blessing of the Nitijela, and were formally adopted into the families of the last people to maintain the canoe tradition. The owners of the knowledge are not allowed to give the skills away to others out of the family circle. The last surviving families who maintained the canoe tradition lived on remote outer atolls - Enewetak and Ujae - and the traditional lore had to be translated into Ratak Marshallese from the local dialects.
128 Ibid.
129 Ibid. In 1996, they teamed up with a local youth program: Jodrikrik nan Jodrikrik ilo Ejmour (Youth to Youth in Health, or YTYIH). Incidentally, this program was founded by Darlene Keju Johnson, Giff Johnsons wife and like him a very vocal critic and activist in the community.
130 Ibid.
131 Alessio. (2006): p606.

> inadequate motivation by students... From 1988 to 1999, the number of people of working age grew by about 7500 but there were only 85 more people employed in 1999 (a total of 10,141) than in 1988. The Marshall Islands has the highest unemployment rate of any US-affiliated island [nation] in the Pacific."[132]

The gap between the size of the labour force and the number of wage earners is growing quickly. In 2006, unemployment stood at an estimated 36%;[133] but it is young people who bear the greatest burden, with employment for those under 24 hovering somewhere above 60%.[134]

The WAM program attempts to address the situation by providing "vocational skills training in the context of cultural reinforcement."[135] WAM addresses the contemporary circumstances by teaching a range of vocational skills: woodworking and carpentry, cabinetry, fibreglass technologies, and construction.[136] At the centre of the program is an emphasis on the importance of the canoe; WAM teaches students with a combined focus on both traditional and modern techniques which cover canoe and boat-building, navigation, sailing, maintainence and repair. The practical education prepares students to enter the workforce as a wage-earner with valuable skills, while the cultural education serves to address the lost sense of worth amongst youth with few prospects besides migration. WAM also fosters community connectivity through outreach programs, which brings WAM students in contact with children throughout the country.[137] WAM provides training in traditional livelihood skills which will be vital for the RMI to attain economic sustainability.

Small is Beautiful

Regardless of the wage-earning potential WAM imparts in its students, the stark economic realities of the RMI remain a major obstacle to be overcome. Over the years, there have been numerous 'top-down' development schemes implemented in the Marshall Islands, most prominently those driven by US federal development programs and by

132 Ibid. School non-attendance has become so common-place - not only among secondary-age teens, but increasingly among primary-age children, especially on Ebeye, that the Marshallese have a word specifically to describe such children: "JS" which is short for "Jab School." As of 1999 on Ebeye, 20% of primary children were not attending school - more than 400 children. See also Graham, Paul. (2002).
133 CIA. (2012): "Marshall Islands country profile."
134 Alessio. (2006): pp606-607. The 15-19 year age group has an unemployment rate of more than 70%, and 20-24 year-olds don't fare much better at about 55%. It is also important to note that the true situation is probably worse, skewed by youth who have migrated to the US seeking work.
135 Ibid., p608.
136 Ibid., pp609-612.
137 WAM. (2008): "history." Between 1999 and 2004, WAM students built 4 major projects, including a new home for YTYIH, a Canoe House, offices and a housing project.

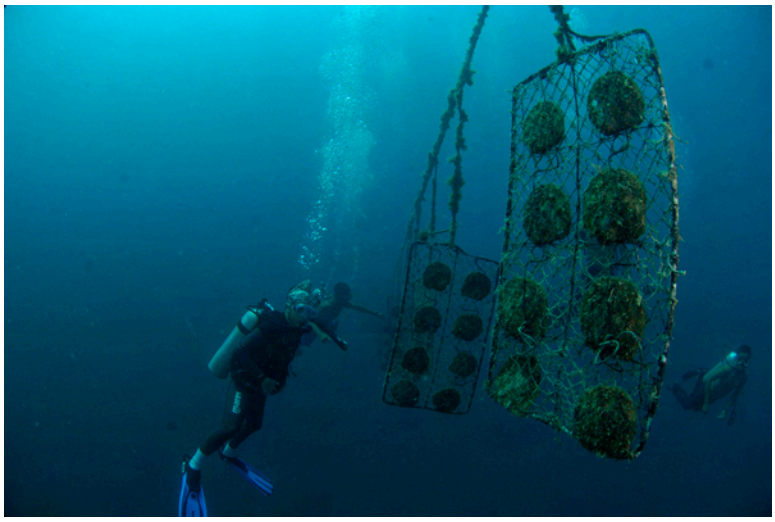
the Asian Development Bank.[138] There have been some past successes, including some successful small-scale pelagic fishing operations in Majuro.[139] A number of fish processing plants have operated successfully in Majuro over the years, with production peaking in the late 1990's.[140] But there have also been spectacular failures, the most notable being the purchase in the early 1990's of a domestic fishing fleet[141] which achieved low catch rates and were never able to cover operating costs.[142] The bulk of commercial fishing in the RMI's EEZ continues to be carried out by foreign vessels.[143] Following many setbacks, the local fisheries management determined that the best course of action, rather than developing a local fishery, was to develop Majuro as a major trans-shipment and fisheries support centre.[144] Whether this results in significant job-creation remains to be seen.

It is beyond the scope of this investigation to comment on the viability or potential for the development of a major locally-run commercial fishery in the RMI; but it is important to point out that the private sector job market in the RMI - with the single exception of jobs on the USAKA base - has been characterized by nothing if not instability. Rather than speculating on reasons for these failures or wavering successes, it is more useful to point out some of the bright points suggested by a couple of very small, locally implemented and run initiatives which have begun to have an impact, especially on rural atolls away from Majuro where all of the major commercial enterprise is concentrated.

The first such project is a pearl-oyster operation spearheaded by a local company, Robert Reimers Enterprises, Inc. (RRE). RRE began a pilot research project on Arno atoll in 1994 in a bid to create the first

138 ADB. (2012): "Marshall Islands." Along with AusAID (the major development agency administered by the Australian Government) the ADB is one of the most prominent development / investment agencies in the Pacific region; ADB has contributed a little over $100 million to the RMI since 1990. ADB has a strong private-sector development bias.
139 Barclay, Cartwright. (2007): p158. While the bulk of the commercial fishing being practiced in the RMI's Exclusive Economic Zone (EEZ) is carried out by "distant water" fleets, these boats take in 400-500 metric tonnes of fish annually.
140 Marianas Variety / PAC News. (2007). However, the largest - a tuna-loining plant run by an American company - went bankrupt in 2004. The loss of 600 jobs dropped RMI national employment figures 16% overnight. The plant re-opened in 2007 under management based in Hong Kong. Today, the plant once again employs about 600 workers, but it should be pointed out that these wage-earners start at only $1.50 / hour. See also: USSD. (2012).
141 Graham. (2008): p2. With the aid of $7.5 million ADB loan. This failure has made later developments cautious, on the part of both the RMI government and investment agencies, contributing significantly to the present plan to develop Majuro as a fisheries support cente.
142 Barclay, Cartwright. (2007): p153.
143 Ibid. Once only Japanese, today the licenses go to Japanese, Taiwanese, Chinese, US, New Zealand and Korean firms. The RMI government receives a significant proportion of its GDP from these sources, up to 5% per year (p158).
144 Ibid., p160. The Marshall Islands Marine Resources Authority (MIMRA) in consultation with continuing ADB technical assistance. See also Graham. (2008).

Ebeye Kids
Scenes from Horowitz' film *Home on the Range* (1990).



Pearl Farming
French Polynesia produces more than $200 million worth of pearls annually; the Cook Islands produce about $40 million. Marshallese pearl farming represents an enormous opportunity for outer islanders if it can get off the ground; it requires patience, time and funding.

Micronesian pearl industry.[145] Unfortunately, RRE was forced to close its Arno operation by 2005 due to high operating costs and difficulty with production; but the project sowed the seeds for local development. The College of the Marshall Islands (CMI) recently partnered with local leaders[146] to begin reviving the industry in outer atoll communities. In 2010, the community driven project on Rongelap produced its first crop: 1300 pearls, worth about $20,000. The Rongelap project is part of a larger, holistic approach to sustainable development of the atoll. While the Rongelapese remain exiled from their home, they are developing a program for reinhabitation: this includes building a marine research centre, establishing the atoll as a marine sanctuary, and combining ecotourism with aquaculture to provide a livelhoods solution in the near future. This is a tiny victory, but the enormous success of the pearl industry for transforming local livelihoods in French Polynesia and the Cook Islands are an enticing bellwether for what might be possible here.[147]

The second project was initiated by an American company, based out of Florida: Oceans Reefs and Aquariums (ORA). ORA is a major 'aquarium products' supplier, shipping live fish, corals, and other products throughout the United States and worldwide. ORA's involvement in the RMI is related to two important facts: some of the most valuable exotic species can be found and grown here; and Majuro is ideally located to supply the burgeoning Asian market for aquarium products.[148] Today, ORA runs an outreach program which trains families living on outer atolls to grow clams and corals in near-shore cages. These products can then be shipped via Majuro to the United States or Asia. Already, in the short time the outreach program has been in operation, on some outer atoll islands the aquarium products have surpassed copra as the number one export by value.[149] The ORA initiative is particularly exciting because it has been initiated without government involvement or funding, but rather by an external for-profit interest, and yet has great potential to benefit the local outer atoll economies. By removing the complete reliance on copra production as the only viable export,

145 Smith. (1992): p38. That is, the first modern attempt. From 1935 to 1942, a Japanese enterprise conducted pearl culturing experiments on Ebon island, but this effort was cut short by the arrival of the Pacific war. There was also an attempt by MIMRA to establish a pearl farm on Namodrik in 1991. Following several years of experimentation with techniques imported from French Polynesia, the RRE farm finally began producing a commercially significant pearl crop in 2000. A US federal grant - jointly through the National Marine Fisheries Service and the Workforce Investment Act - helped to instigate a training program in 2002-2003, run by a Hawai'i based pearl enterprise, which trained a group of Marshallese technicians in the complicated science of pearl oyster seeding. See Sims, Sarver. (2004). Unfortunately RRE was forced to shut down the operation in 2005, due to a lack of government support.
146 James Matayoshi of Rongelap atoll and Mattlan Zackhras of Namorik.
147 Sims, ed. (2002): p6.
148 In 2003, ORA acquired a small mariculture facility on Majuro, the Marshall Islands Mariculture Farm (MIMF); here, a small group of Marshallese are employed, growing various species of Giant Clams and hard & soft corals native to the Marshall Islands.
149 ORA. (2012).

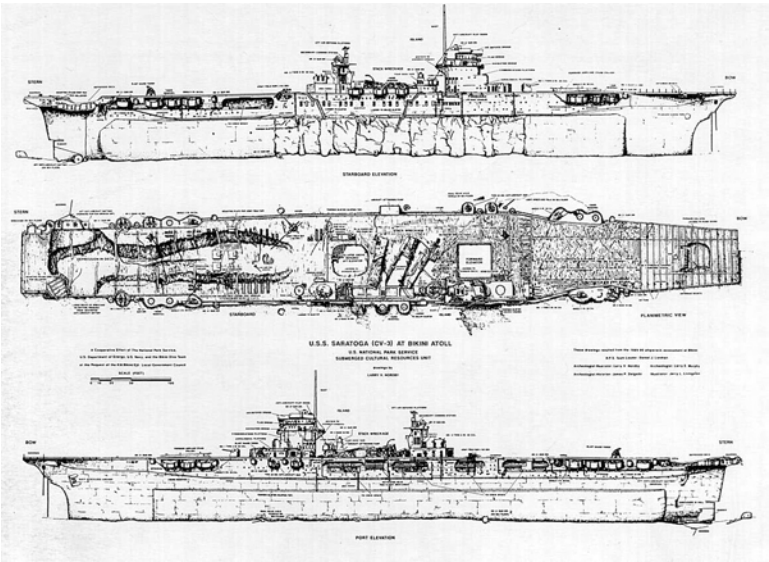
small-scale mariculture enterprises such as this present the possibility to begin the shift from an economy based upon a single-resource to a more resilient and sustainable combination of cash export and local subsistence. Beyond the aquarium trade, aquaculture has great potential for supplying the live seafood markets and the pharmaceutical industry. "In all cases, the products are of high value and can be grown in small areas with relatively simple technology."[150]

Finally, there is the example of a small-scale tourism enterprise being developed by the council of Bikini atoll. Though the atoll remains unsafe for long-term settlement, a report completed in 1998 determined that "it is safe to walk on all of the islands."[151] Bikini was opened to dive tourism back in 1996, with the goal of creating an economic base upon which the Bikinian community could build a resettlement plan. The ironic legacy of the nuclear devastation is that Bikini atoll has become one of the most attractive dive locations on earth. The reefs of Bikini are some of the richest and most pristine in the world due to the lack of human presence here for 50 years; they teem with reef-fish, sharks, and pelagic species such as manta rays which are rare almost everywhere else. In addition, the lagoon contains Bikini's "nuclear fleet."[152] The atoll became the first World Heritage site in the Marshall Islands in 2010.[153]

These projects are still in an embryonic stage, and together register as scarcely a blip compared with the money flowing into the RMI in the form of aid and compact payments. But these 'little' projects - including WAM - represent an enormous potential for locally driven economies to take the "Middle Way" between "materialist heedlessness and traditionalist immobility,"[154] a step towards production based on local resources, for local needs. As Hau'ofa suggests, "smallness is a state of mind."[155]

* * *

150 Adams, Bell. (2000): p302. Potential seafood products include: napoleon wrasse, groupers, sea cucumbers, spiny lobsters, trochus, pearl oysters, giant clams, green snail, abalone, crabs, clownfish, angelfish, hard corals, soft corals. Coral reef products also have an enormous potential value to the pharmaceutical industry: notably algaes, sponges, soft corals and sea horses.
151 Niedenthal. (2012): "What about radiation?"
152 Ibid: "Dive/Tourism Information?"
153 Ibid.
154 Schumacher. (1973): p51.
155 Hau'ofa. (1993) p7.



Bikini's Nuclear Fleet
A divers' drawing of the USS Saratoga - the worlds only diveable aircraft carrier and the largest diveable vessel in the world.

It is interesting to note that the ships sunk by the nuclear tests in 1946 in Bikini Atoll's lagoon belong to the people of Bikini. This is a very unusual situation as most places in the world where there are sunken US warships their ownership is retained by the United States government. The ownership was negotiated as part of section 177 of the initial Compact of Free Association. In a sense, the fleet has become a submerged cultural resource, part of the atollscape which must exist in perpetuity to support the future of the Bikinian people.

"So the question of history returns. How do we act on what we know? The time has come when we have to solve this puzzle, because the future, from where we look at it now, is different than past futures. Before we just had to keep on trying to do our best, and we would be OK. Things seemed to slowly get better, for some people in some places anyway; in any case, we would keep trying things, and probably muddle through. This is no longer the case. Now the future is a kind of attenuating peninsula; as we move out on it, one side drops off to catastrophe; the other side, nowhere near as steep, moves down into various kinds of utopian futures. In other words, we have come to a moment of utopia or catastrophe; there is no middle ground, mediocrity will no longer succeed. So utopia is no longer a nice idea, but a survival necessity. This is a big change. We need to take action to start history on a path onto the side of the peninsula representing one kind of better future or another; the details of it don't matter, survival without catastrophe is what matters. In essence the seven billion people we have, and the nine to ten billion people we're likely to have, exist at the tip of an entire improvised complex of prostheses, which is our technology considered as one big system. We live out at the end of this towering complex, and it has to work successfully for us to survive; we are far past the natural carrying capacity of the planet in terms of our numbers. There is something amazing about the human capacity to walk this tightrope over the abyss without paralysing fear. We're good at ignoring dangers; but now, on the attenuating peninsula, on the crazy tower of prostheses - however you envision it, it is a real historical moment of great danger, and we need to push hard for utopia as survival, because failure now is simply unacceptable to our descendants, if we have any."[1]

- KIM STANLEY ROBINSON

1 Robinson. *ARENA* (2011): ¶25.

Sunset over Saya

The cyclone lasts for 3 days. 120 knot winds whip up a maelstrom, breakers as high as office buildings plunging down into silt-choked water, a great rumbling violence scouring the crest of the reef. The swells march to their deaths, each surging onslaught giving way to a sucking withdrawal, a brief instant revealing a terrain of broken coral and jagged limestone normally submerged under 10 metres of water. On the fourth day, the winds subside. Out of the drizzly mist a black-hulled vessel emerges; it tacks back and forth for a while, crossing and re-crossing a murky lightness beneath the rolling swells, a group of men pearing out over the gunswales into the water below, searching. At last they seem satisfied: an anchor is dropped and a dinghy disembarks to investigate.

Evening settles in and the breeze shifts from west to east; low clouds break up, giving way to staggering starlight. Aboard the vessel all is sound and activity. A radio cracks into the night, voices can be heard, heavy metallic clanging, dragging, dropping. A generator fires to life, its throbbing hum drowning out the ambient sound of surrounding ocean. And then a searing, high-pitched mechanical scream, more clanging steel, a fiery arc. One man cuts, another steadies, another carries cut pieces and stacks them. This mysterious activity carries on into the night.

Morning dawns clear and hot. Under the full glare of the tropical sun, the unusual appearance of the location is revealed: the sloop is anchored at the brim of a spectacular precipice, a turquoise reef beneath the vessel dropping away to the south and east into azure abyss. Beyond the boat, stretching to the northern and western horizon is a vast, submerged plain of dark-green seagrass, punctuated here and there with small reefs which project up from the swaying fronds of vegetation.

The men once again busy themselves: on deck they set to work welding together long tubular steel sections into triangular frames, while cut steel is lashed together and hoisted over the side into the water, where divers attach the load to a pair of inflated lift-bags. They make several trips, ferrying steel to a cache on the seafloor. In the early afternoon, another sail appears in the distance, and yet another, as two more yachts arrive and moor nearby.

The following day, more steel is unloaded from the sailboats and placed on the seafloor; one of the vessels moves off, and begins to sail up and down the bank in the distance, tracking out a rectangle some 2 kilometres on a side. Divers continue to work on the seafloor near the first vessel. Another group of men depart on a dingy loaded with scientific instruments and tear off to the north, stopping periodically to lower the devices to the seafloor. They mark each deployment with an orange plastic buoy and move on. This pattern of activity is repeated over the next few days. One of the two boats which arrived on the second day departs.

The triangular frames are lowered into the water. The divers carefully position them on the bottom, stacking them and lashing them together with blue goretex straps. The completed object resembles a pyramidal tower which stands several meters above the seagrass, reaching towards the surface. It is anchored with large blocks of dead coral salvaged from the nearby reef and floated into position.

Each day, the boats swing back and forth on their moorings as the tidal surge shifts the current from east to west across the shallows. The tide changes direction four times per day here, causing a dramatic shift in the colour of the water, from crystal clear turquoise to a murky green as the nutrient-laden water of the deep ocean is pulled by upwelling to the surface. Pods of dolphin, whales, green sea turtles and schools of pelagic fish appear near the vessels. At dawn and dusk, the sea is covered in swarms of millions of strange insects dancing on the surface.

Welding continues on deck; a large rectangular frame takes shape, steel angles welded to oil drums. A grizzled man with a cigar waves directions as two younger men guide large photovoltaic cells which are hoisted out of the hold and then attached to the frame. The completed array is in turn hoisted into the water to the waiting divers, who tow it to their mysterious undersea sculpture, where it is anchored. They work hurriedly, aware of a darkening in the northwest sky. One of the sloops beats a hasty retreat as the last adjustments are made and deployed instruments are collected. The remaining sailboat pulls up her anchor and drifts slowly away to the west over the shallows as the sun sets, the throb of distant lightning indicating the imminent approach of another cyclone.

* * *

These scenes describe an expedition carried out in 2002 to the Saya de Malha bank, a huge, little-studied region of shallows and reefs in the middle of the Indian Ocean east of Madagascar.[2] The expedition was organized by a man named Wolf Hilbertz, an architect and the founder of a Hamburg-based non-profit organization called Sun & Sea e.V., which is dedicated to applied research and applications for a technology he spent his entire career developing - Mineral Accretion Technology, (MAT). The expedition had a number of diverse goals, and as such included among its participants people from a spectrum of backgrounds: coral biologists, environmental law, a GIS expert, a geophysicist and expert in underwater construction, a writer and journalist, a marine biologist, a merchant marine and engineer, and an expert sailor and diver.[3]

Despite its enormous size[4] Saya is little known, being one of the most remote shallow marine ecosystems on earth. Prior to 1997, there had been no documented scientific survey; during that year, Hilbertz organized the first such expedition, which managed in 1.5 days of diving to conduct surveys of a small area, film and collect specimens, and deploy a small artificial reef of Hilbertz' own design.[5]

The second expedition, in 2002, was motivated by reports from a British group which had visited in 2000, describing extensive areas of coral bleaching, dead coral, and coral over-run with algae and sea-grasses. One of the most severe recorded El Niño events occurred in 1998, causing record-high ocean temperatures across the Indian and Central Pacific. The warming devastated many reefs; on reefs surveyed both before and after the event, as much as 90% of hard coral cover was found to have been lost.[6] Hilbertz had himself seen the effects of the die-off on reefs in Bali and Thailand, in the Maldives and elsewhere. The 2002 expedition had as its primary goal to witness the damage wrought on the reefs first-hand, to compare the situation to the healthy ecosystems which had been found here in 1997, and to document this unique ecosystem before it was lost.[7]

2 For a complete report, see Hilbertz. (2002): pp6-10. Saya lies approximately half-way along an enormous undersea mountain range known as the Mascarene Ridge, which connects Mauritius in the south to the Seychelles in the north.
3 Ibid.
4 The banks are one of the largest coralline structures on earth, some 40,000 square kilometres in area.
5 Ibid., p31. They were surprised to find that the reefs here were not dominated by any one species of coral, as is typical with Indian Ocean reefs but was characterized by smaller outcrops which harboured a great variety of species.
6 Flannery. (2005): pp104-110.
7 Hilbertz. (2002): pp6-10.

Cybertecture

Wolf Hilbertz was an architect by training.[8] In 1967, he began a research studio which he called the Responsive Environments Laboratory at the University of Texas, which focussed on exploring concepts related to the automated construction of built environments, and led to the formulation of a theoretical architecture he called 'Cybertecture.' Cybertecture was a critique of contemporary building practices and ways of thinking, a futurist manifesto which anticipated the radical change which would be made possible with the introduction of the computer and other automated systems. Cybertecture - literally CYBERnetics + archiTECTURE - would use cybernetics as a paradigm to design responsive environments which behave like living systems: emergent, self-regulating, pliant, adaptive.

His early work was unabashedly utopian in nature. In a Progressive Architecture article from 1970, "Towards Cybertecture," Hilbertz proposes enormous floating cities with self-supporting life systems, underwater colonies, and self-constructing structural systems with speculation on the technology and systems required to bring them to fruition. Fundamental to all of these proposals is a regulatory system which is modelled on natural systems - bone, spider webs, etc.

> "Living systems use a very few basic materials yet highly complex organizations of all kinds are built and these have the capacity to a vast variety of functions... Always using the same basic materials and construction methods, bone systems achieve the utmost flexibility. The wide adaptive range is clearly reflected by the contrast of the massive bone of a dinosaur alongside the delicate filigree of a hummingbirds skeleton."[9]

The document is a strange mixture of systems theory, technocratic proposal, and revolutionary manifesto: "constantly learning how to adapt itself to changing conditions," Cybertecture can learn to "enrich its wealth of characteristics of living systems... It will create a habitat which, being the result and generator of human activities, is highly responsive to changing needs of the individual as well as society."[10]

This and other writings from the period are speculative and theoretical, and were certainly influenced by the revolutionary culture among academics at the time. Hilbertz was building on and borrowing from the work of contemporaries such as Buckminster Fuller, Constant Nieuwenhuys, Frei Otto, Archigram, and the multidisciplinary Gregory Bateson, among others. While the rhetoric which colours his early writing can be correlated to this contemporary influence (here there are

8 He researched and taught at various universities throughout his career, including McGill, MIT, eventually ending up at the University of Texas, where he became a full-time member of the faculty.
9 Hilbertz. (1970): p100.
10 Ibid., p103.

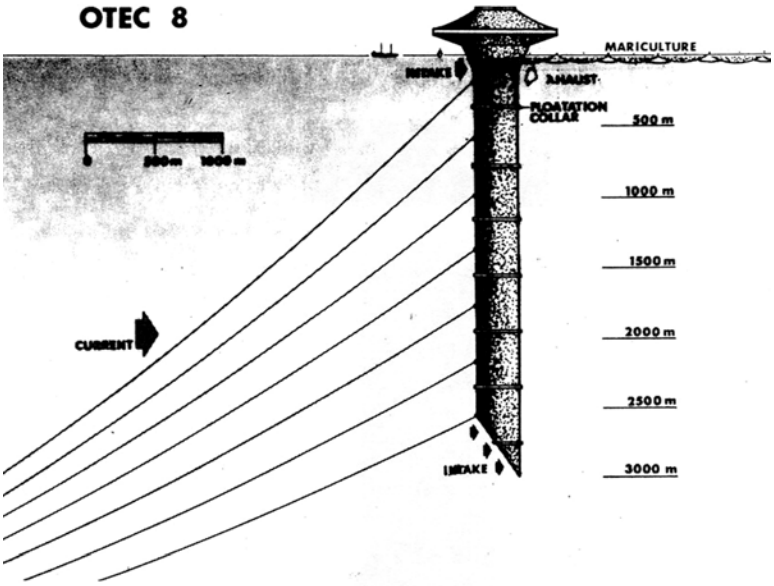


Fig. 30. Proposed multifunctional OTEC plant.

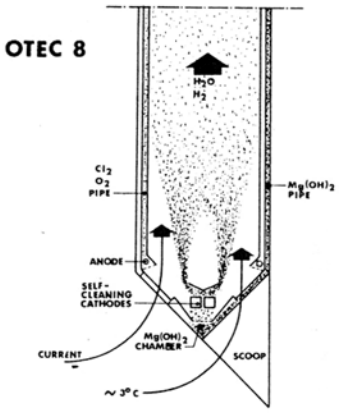


Fig. 31. Functions of proposed OTEC plant.

Utopian dreams

An enormous Ocean Thermal Energy Plant designed by Hilbertz. The principles of OTEC are simple: there is an enormous potential for energy production in the tropical ocean: warm surface waters float atop a deep reserve of frigid water. In some areas, the temperature difference between the surface water and the mesopelagic layers is >25°C. Hilbertz OTEC design proposes the construction of an enormous tube which floats vertically in the water column. If a chimney effect can be instigated, the natural temperature differential will cause natural upwelling in the tube, creating what is called a "perpetual salt fountain" - so-called because the deep water contains rich reserves of nutrients and dissolved salts which are then used to supply mariculture activities.

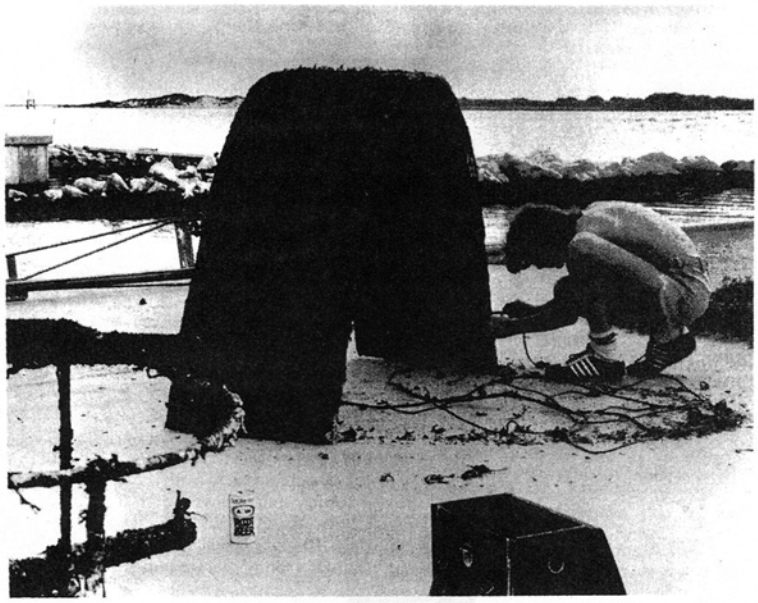


Fig. 27. Catenary formation after accretion.

Mineral Accretion Technology (MAT)
In one of Hilbertz early experiments, he used MAT to create simple catenary forms. A lightweight 1/4" steel mesh was suspended in seawater for a period of 20 days. The resulting catenary form required an input of low-voltage (5-10V) energy to produce a rigid structure with compressive strength comparable to concrete (4250psi on average). See Hilbertz. (1979). While Hilbertz' work would soon diverge from structural experimentation to developing artificial reef armatures, this type of structure was further developed by Alvaro Ortega in the late 1980's. See Ortega. (1989).

obvious parallels with Fuller, whose writing is similarly idiosyncratic) it is clear that Hilbertz was a deeply rational individual who was genuinely troubled by the injustice of a world full of war, environmental degradation, and political upheaval.

But Hilbertz differed from many of his contemporaries in the direction these utopian dreams took him. He was committed to not only propose technocratic solutions, but to act on their implications; like Fuller, his early theoretical work drove him to research practical solutions to the problems he identified. Cybertecture led him to research potential systems which could enable the responsive, adaptive environments he was proposing, such as Ocean Thermal Energy Conversion (OTEC), which uses the temperature differential between surface and deep seawater to generate energy. One such series of experiments, in which he was trying to replicate the processes in which shellfish and corals grow their carbonate skeletons, led him to a remarkable discovery: applying a low-voltage current to metals immersed in an electrolyte like seawater results in the electrodeposition of minerals, which forms a coating on the surface of the metal. This process is analogous to the precipitation of minerals which organisms such as molluscs and corals achieve biologically. Though the principle had been described experimentally since the 19th century, Hilbertz was the first to comment on the potential for this technology as an adaptive, resilient construction medium.

In 1979, after more than 5 years of research on the subject, he published his findings. "Electrodeposition of Minerals in Seawater: Experiments and Applications,"[11] is a remarkable document. The first half of the paper is dedicated to describing in detail the development of mineral accretion processes; in a number of experiments, he demonstrates the potential for this technology to literally 'grow' structural components in seawater - at very low cost, with simple, cheap components, in short time-frames. Seawater contains a number of elements in solution.[12] Marine organisms utilize these dissolved salts to build structural formations: "Mollusc shells, for instance, are generally composed of calcium carbonate crystals enclosed in an organic matrix."[13] Hilbertz realized that electrodeposition was capable of not only coating a metal surface and protecting it from corrosion - as had been shown by earlier experiments - but over time could produce a thick layer of calcium carbonate essentially identical in composition to the shells and coral structures produced by marine organisms.[14]

The basic components required are: a power source, which provides

11 Which appeared in the *IEEE Journal of Oceanic Engineering* in 1979.
12 Namely sodium, magnesium, calcium, potassium, strontium, chlorine, sulfur, bromine and carbon.
13 Hilbertz. (1979): p94.
14 Actually a mixture of brucite and aragonite, depending on the mineral contents of the seawater.

low-voltage current to catalyze the accretion process; a metal substrate, which becomes the cathode in a galvanic cell - this can be a solid section such as a tube or other shape, or a mesh; and an anode, ideally made from a corrosion resistant metal such as zinc or lead. The substrate is submerged in seawater, with the anode suspended in close proximity. With low-voltage direct current applied, the flow of electrons causes the water molecules to break down around the cathode to form hydrogen and around the anode to form oxygen. This effect causes the acidity of the water surrounding the cathode to greatly decrease, resulting in the precipitation of the dissolved minerals on the substrate material.[15] After initial experiments which test the power consumption, strength and composition of the materials created, and various other parameters, Hilbertz speculates on its applications. He realized that the accreted minerals were an ideal substrate for the construction of artificial reefs, because marine organisms could readily attach themselves to the material; he develops techniques for the accretion of simple construction elements such as sheets and catenary shapes; and he proposes various possibilities for the application of MAT in the construction of marine architectures.[16] But the striking thing about this paper, despite its utopian conclusion, is its pragmatism. While Hilbertz remained committed to the theoretical underpinnings he had developed with Cybertecture, his development of practical applications of mineral accretion technologies would lead his future work in an unanticipated direction for the remainder of his life.

Biorock™ Reefs

Instrumental in this shift from theory to practice was his contact with another researcher in the early 1980's - Dr. Thomas J. Goreau - whom he would meet through his research into the use of MAT in the construction of artificial reefs. Goreau is a coral scientist with a doctorate in biogeochemistry from Harvard, but like Hilbertz, Goreau combines theoretical work with a practical approach.[17] His father, Thomas F. Goreau, was a pioneer in the science of coral reefs, and the younger Goreau spent his early life in Jamaica diving extensively with his father. Notably, the elder Goreau was involved in the Crossroads nuclear tests at Bikini as a diver responsible for the collection of radioactive specimens from the lagoon - which resulted in his exposure to a dose of radiation which led to his early death from cancer at 45.[18] His son and his widow Nora carried on the legacy of his work on the biology, function, and threats to coral reefs.

The partnership between Hilbertz and Goreau led to their development of practical technologies and methods for grass-roots implementation

15 Spenhoff. (2010): p13.
16 Including a fanciful design for a massive OTEC plant which harks back to his earlier work.
17 GCRA. (2012).
18 Wikipedia: "Thomas F. Goreau."

of artificial reef construction. In his earlier research, Hilbertz had noted that his test strips were often vigorously colonized by marine life during the accretion process.[19] In later practical experience, it was discovered that not only was biorock™ an ideal substrate for colonizing corals, but that corals installed on biorock frames actually grew at greatly increased rates, in some cases 4-6 times faster than natural corals in adjacent locations, and healing up to 20 times faster after shocks.[20] Together, they patented the systems they developed under the name Biorock™ and launched a company to promote the use of their products for shore protection and reef rehabilitation. They also started non-profit organizations: The Global Coral Reef Alliance (GCRA), a "coalition of volunteer scientists, divers, environmentalists and other individuals and organizations committed to coral reef preservation;"[21] and Sun & Sea e.V., which Hilbertz founded to promote "science and arts in the field of mineral accretion"[22] and to direct investment to reef restoration projects around the world. Their approach was to tackle both advocacy, research, and fund-raising to influence changes to ecosystems and fisheries management at a top-down, policy level, while simultaneously working with communities and groups of stakeholders to develop strategies for local, sustainable development. At the top-down level, the GCRA has been very active in developing management plans for marine resources; advocating against developments and industries which are detrimental to reef health, such as golf courses and deforestation; and working to promote global awareness for issues surrounding climate change, sea level rise, pollution and industrial fishing practices.[23] But most important has been the work his organization has produced on the ground. Since the late 90's, the GCRA / Sun & Sea e.V. group has organized local development initiatives involving reef restoration and fisheries management projects in over 20 countries worldwide.

To construct a biorock™ reef, rebar and welded-wire mesh are used to construct a lightweight frame - which can take on any manner of form - which is then installed on the seafloor in areas where coral is under threat or has been damaged. Hilbertz experimented with a number of different techniques to supply power to the frames, utilizing floating or bottom-mounted solar arrays, small-scale wave generators, or shore-mounted wind generators. Once a thin coating of aragonite appears on the metal frame (within a few days under power) live corals are transplanted to the frame by divers. Usually, fragments of coral which have broken from nearby reefs are collected and gently tied to the frame. Once established, corals growing on the biorock substructure have several distinct advantages which allow them to flourish. First,

19 Hilbertz. (1979): p94.
20 Goreau, Hilbertz. (2008): p151.
21 GCRA. (2012).
22 Spenhoff. (2010): p2.
23 GCRA. (2012). For example, Goreau has worked with various United Nations committees, acting as coordinator of the UN Commission on Sustainable Development Partnership in New Technologies for Small Island Developing States.

as mentioned, the electric current increases the corals natural rate of growth.[24] Secondly, corals on biorock frames are elevated above the bottom, which affords them both access to food sources in the water column and protection from coralivorous predators such as crown-of-thorns starfish. Thirdly, the biorock-mounted coral becomes much more resilient to stresses caused by pollution, temperature increases, and algal blooms.[25] When stressed, the corals symbiotic algaes stop producing energy and are expelled by the polyps - resulting in the loss of colour and coral death known as coral bleaching. Corals installed on biorock reefs can survive traumatic shifts in temperature, salinity or nutrients that will kill natural reefs because they do not expel their symbiotic partners.[26]

Pemuteran Bay

While coral bleaching is well understood today, prior to the catastrophic bleaching events which devastated reefs in 1998, 2002, and 2006 it was relatively unknown.[27] But there are also other serious anthropogenic threats to reef ecosystems. In the early 1990's, the reefs on the north coast of Bali, centred around the village of Pemuteran, were a rich indigenous fishery, a site of unprecedented biodiversity, and an emerging eco-tourism destination. However, an Indonesian economic crisis and political upheaval in the late 1990's led to the displacement of millions of farmers and workers, who took to destructive subsistence fishing practices in order to survive. "One would hear 5 or 10 bomb blasts a day in Pemuteran Bay, and since diving was no longer safe, the local diving businesses collapsed. The bombers destroyed almost all of the shallow reefs on the offshore banks, leaving only deep waters and the area in front of the beach untouched."[28]

It was these events that impelled Hilbertz and Goreau to get involved in 1998, and produced what would become the flagship biorock reef project in the world: the Karang Lestari project in Pemuteran Bay, Bali. The GCRA worked with local dive shops, resorts, and the

24 Spenhoff. (2010): p7. The precise mechanics of the process is not fully understood. One theory is that this increased growth rate functions similarly to human accelerated bone fracture healing by electrical stimulation; another speculates that because the galvanic reaction decreases the acidity around the frame, the polyps have to expend less energy to construct their shells.
25 Goreau. (1979): p124. Corals rely on a symbiotic relationship with zooxanthellae algaes (which synthesize energy from sunlight via photosynthesis). Zooxanthellae provide corals with up to 90% of their energy requirements under normal circumstances; in return, the corals provide the algae with a safe habitat for reproduction. "The algae live, conduct photosynthesis and divide within the cells of their coral host, and on this symbiosis rests the entire biological productivity of the coral-reef ecosystem."
26 Hilbertz, et al. (2002): p22. These properties have led Hilbertz and Goreau to label their structures "coral arks," and have theorized that small numbers of biorock reefs could be used as a kind of lifeline which would spur regrowth after devastating natural or man-made events which have impacted reefs.
27 Flannery. (2005): pp104-110 for history of bleaching events.
28 Goreau, Hilbertz. (2008): p148.

Pemuteran Reefs
One of the early biorock reefs in Bali. The structures are assembled on the beach, floated into position by hand, and positioned on the seafloor by divers using inflatable lift bags for control. The corals have only been growing on the frame for a short time; eventually their prolific growth will completely obscure the frame.

Coral Growth
After initial accretion (a few days) coral fragments are gently installed on the frame. Once the coral begins growing, it firmly cements itself to the aragonite coating on the frame. Coral growing on a powered biorock frame grows as much as 4-6 faster than wild coral in the same location.

local fishermen and villagers to construct over 40 individual biorock structures which now stretch over 500 metres. The project has been hugely successful: the reefs, initially stocked with hard corals, have been vigorously colonised by other marine organisms, including soft corals, sponges, and clams which attracted huge numbers of reef fish to an area that had been barren. The project has won a number of awards, the village now has an established and sustainable fishery and tourism infrastructure, and the natural reef has begun to recover. Hilbertz and Goreau used Pemuteran as an opportunity to refine their techniques in the field, and also conducted workshops to train both locals and foreigners in the construction of the reefs, fisheries management, mariculture, shore protection, and the use of renewable power sources. Many of these participants went on to start their own biorock projects throughout the coral triangle, in Java, Sulawesi, Lombok, Flores, and elsewhere in Indonesia. As news of the project spread, fisherman from all over Bali began requesting biorock projects of their own, to restore fisheries which had been destroyed in the preceding decade.[29]

The success and exposure of the Pemuteran Bay project, and other early biorock initiatives in Panama and Palau, provoked many new projects around the world. Today, there are biorock reefs established in many locations in Indonesia, the Maldives, Mexico, Panama, Papua New Guinea, the Seychelles, and Thailand, where Hilbertz lived in the final years of his life. What unites all of these projects and played a big part in making them successful was the commitment Hilbertz, Goreau and the GCRA have shown to not only protect the reef ecosystem, but to consider the social impacts that such protection will entail, and to formulate solutions which put the life and livelihoods of local people on the same level of importance as the ecology which must support them. "In many tropical coastal communities two critical issues are persistent: the depletion of natural resources and pervasive poverty. These two issues are closely interlinked in a vicious cycle whereby poverty drives the coastal communities to increase fishing pressure and the use of harmful fishing practices that, in turn, leads to further depletion of coastal fisheries resources and as a result: even more poverty."[30] In contrast to many development initiatives imposed from above - either by governments, NGO's, or foreign lending agencies - the biorock™ projects initiated here and elsewhere were driven by a belief that the participation, priorities and decision-making of local stakeholders is essential to the successful rehabilitation of the ecosystems. The participation of local people in the restoration and tending of the reef empowers them to develop alternative and supplementary livelihoods, to become marine farmers rather than subsistence fish-hunters, and to take ownership of their own destiny.[31]

29 Ibid.
30 Spenhoff. (2010): p15.
31 Ibid., p15.

Utopia

In this era of dawning anthropogenic climate change, new utopian dreams have proliferated; it seems that in the face of catastrophe, utopias are once again justified, perhaps even vital for survival. This situation is not so very different from that of the early 1970's. A world-wide oil crisis threatens the global economic system - a crisis which will likely be much more pervasive and final than the energy crises of the 1970's. The United States is embroiled in another long-term foreign war which has helped to galvanize dissent and direct action at home, and fomented opposition to American foreign policy among other nations and among radicals. And severe weather events, troubling research results, and expanding awareness have inspired renewed interest and support for the environmental movement, which first gained momentum in the late '60's and early '70's. The work of designers, architects, and planners is again populated with utopian visions of what a post-oil, sustainable future might entail. The conspicuous difference between these two periods, however, is that while many of the contemporary proposals (self-contained cities and megastructures, massive landscape manipulations, arcologies, vertical farming, etc.) in many ways mimic or expand upon theoretical and formal propositions of the earlier period, the revolutionary political and social agenda of the projects from the 1970's is notably absent. At the so-called 'end of history,' those who dare to dream impossible dreams about future alternatives seldom contest the global political and economic regimes in which these visions will play out. As Slavoj Žižek argues in his book *First as Tragedy, Then as Farce*, the "contemporary era constantly proclaims itself as post-ideological, but this denial of ideology only provides the ultimate proof that we are more than ever embedded in ideology."[32] Contemporary utopian visions often fail to contest the framework of global capitalism, not recognizing - or at least not challenging - that this framework is inexorably linked to the collapse of natural systems in the first place:

> "this uncontested hegemony of capitalism is sustained by the properly utopian core of capitalist ideology. Utopias of alternative worlds have been exorcized by the utopia in power, masking itself as pragmatic realism. It is not only the conservative dream of regaining some idealized Past before the Fall, or the image of a bright future as the present universality minus its constitutive obstacle, that is utopian; no less utopian is the liberal-pragmatic idea that one can solve problems gradually..."[33]

It is in this sense that the examination of Hilbertz and Goreau's biorock initiatives, and the other 'small' projects examined in the previous chapter are important: while they work within the framework of

32 Žižek. (2009): p37.
33 Ibid., p77.

globalizing capitalism, they provide a challenge to it at the level of the lives of ordinary people. How? All of these projects suggest a way of life that defies the western lifestyles, urbanisms, and livelihoods that have for so long been held up as a legitimate goal for peoples of the 'developing' world. These projects strike a balance between traditional and modern social organizations - they foster strong traditional communities, while integrating international connections through trade of new commodities and small-scale forms of tourism. They challenge the western model of wage-earning consumer, replacing it with a combination of commodity production, subsistence hunting and fishing, and environmental stewardship to create varied and resilient livelihoods. And they provide attractive alternatives to increasingly crowded and untenable urban conditions imported from the west: in a wired and connected world, the rural offers the promise of a better quality of life and greater opportunities for choice. They suggest that the possibility to leap straight from a pre-industrial, imperialist past to a decarbonized, post-industrial future (which might offer all of the best parts of modern technology and a rich, complex life without the hyperconsumption that drives life in the west) is a transition which small-island nations such as the Marshall Islands are uniquely positioned to make. The "dream of universality (of the universal capitalist order) without its symptoms, without any critical points in which its 'repressed truth' articulates itself"[34] may well be a utopian premise; but what is also clear is that the smallness, remoteness and uniqueness of island states positions them to invent their own realities, which may have little relevance elsewhere but can be world-changing for the people involved.

Hilbertz and Goreau's work with coastal peoples in southeast Asia and elsewhere shaped a perspective which was highly critical of coastal management as practiced by top-down imposition - whether instigated by government agencies or foreign experts - as opposed to a genuine bottom-up approach which values community needs and local, long-term priorities and concerns.

> "The dogma that nature exists only for humans to exploit it is common to 'modern,' 'universal' ideologies including globalism, capitalism, communism, Christianity, Islam, and the 'monetary value is the only measure of worth' theorizing of economists... 'native' or 'aboriginal' traditions are largely viewed by outsiders as 'backward' and are being actively exterminated, forcibly displaced, marginalized, or at best undermined, by the 'universal' forces of modernist ideologies that value resources only insofar as they can be converted into money."[35]

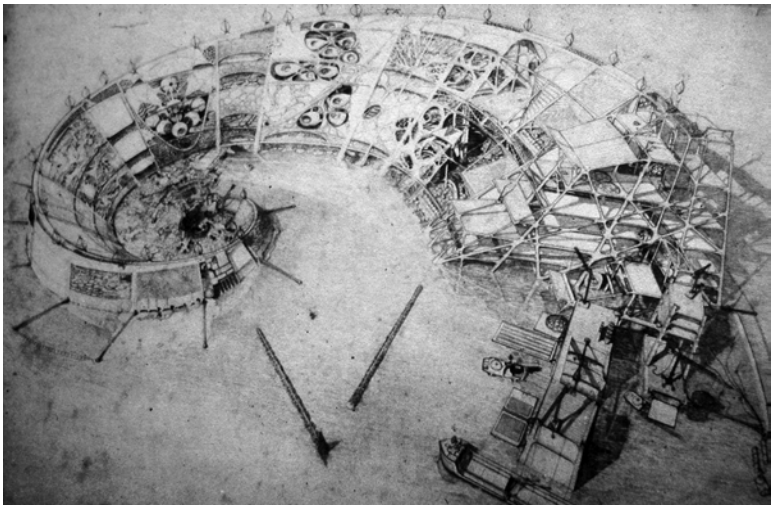
Hilbertz remained a radical thinker to the end, and despite the practical solutions he worked so hard to promote, he never lost sight

34 Ibid., p78.
35 Goreau, Hilbertz. (2008): p144.

of the revolutionary underpinnings of his early work. The 2002 Saya expedition was exemplary of this. Overtly, it was a scientific research expedition, with the goals of cataloguing the flora and fauna of the region, assessing its biodiversity, and mapping geology, morphology and composition.[36] But this purely scientific program concealed a more radical agenda: besides being an environmental wonder, Saya is *jurisdictionally* rather special. In this huge region of shallows, there are numerous charted and uncharted shoals where the water is only 7 metres deep, and vast flat areas that lie under 10-15 metres of water; however, nowhere in the entire region is there a shoal or coral-head that punctures the surface. The vast majority is in international waters - which means that despite its remoteness, it is unprotected by laws imposed on territorial waters, meaning it could at any time be harvested at will.[37] The potential to grow artificial reefs in this location raises another possibility: to use biorock structures to grow artificial islands - out of natural corals - which could then be claimed by individuals or agencies, who might then be able to *establish sovereignty* over this fragile ecosystem, and even initiate laws to protect it.

Hilbertz long-term goal was to create a kind of futurist enclave for like-minded individuals[38] - an autonomous zone[39] on the high seas established with the goal of protecting the ecosystem surrounding it. He called this project "Autopia Saya." After scouring the globe for a suitable site to initiate such a project, he says: "Saya de Malha Banks in the NE Indian Ocean eclipsed them all. Having about the size of Belgium, most of Saya lies in international waters, 'in the high seas' legally speaking, governed only by the UN Law of the Sea."[40] The plan was to organize funding and materials for a third expedition to Saya, to get the biorock reef established above sea level and stake a permanent

36 Hilbertz, et al. (2002): p86. Saya differed from all previous biorock projects. It is extremely remote, and so not under direct threat from overfishing or pollution, at least at present. Saya is a marginal habitat for coral due to the large-scale upwelling of cold, nutrient rich water which occurs here; it is this trait that gives it the potential to be a crucial refuge for coral and coral species threatened by anthropogenic threats in these other locations. The 'coral ark' the team installed at Saya was a prototype of sorts; in the event of future catastrophic coral bleaching, the tiny biorock reef, powered by a single floating solar raft, might provide a haven for a few living corals to survive a catastrophic die-off that wipes out the rest of the living, natural reefs. Limited by funds, time, and by bad weather which delayed the start of the expedition and hastened its conclusion, they managed only 8 days at the bank, but in that time managed to construct a scaled-down biorock reef, make a highly detailed map of a 4km^2 area as well as less detailed maps of a much larger area, and conduct numerous surveys and censuses of the corals, plants and fauna.
37 Parts of the far northwestern and southern outlying shoals fall within the 200 nautical mile Exclusive Economic Zones of the Seychelles and Mauritius.
38 An interesting inheritor and current proponent of the kind of high-seas sovereign autonomy Hilbertz was proposing is the so-called Seasteading Institute, the brainchild of Peter Thiel - the billionaire founder of PayPal. See Seasteading Institute. (2012) and Miles. (2011).
39 Bey. (1991). In the spirit of Bey's TAZ; exactly what Hilbertz imagined would take place in Autopia is unclear, as he never wrote extensively about it.
40 Love. (2004): ¶9.



Autopia Saya
An image depicting Hilbertz vision - a self-supporting marine city built out of accreted biorock.

claim to the surrounding reefs. However, the 2002 expedition would be the last; Hilbertz became ill and died 2007.[41]

* * *

A Speculative History of the Future

For continental people, utopias are easy enough to imagine. They spill forth from every new technology which promises to repair the ills we have wrought - from every promising new industry, every lucrative new investment, every ending of a war. Our modern history is defined by the constant invention and re-invention of our collective dreams: an aspiration to reach that "epoch of rest" where we had "cast away riches and attained to wealth."[42] The golden ages we dream of today - fulfilling and sustainable post-carbon capitalisms?[43] - are different from those which populated the 1950's, or the 1970's. But they share the same problem: how to imagine the bridge that will get us from the 'here-and-now' to the 'ought-to-be.'[44] The void that bridge must span is the history of the future, and given the staggering implausibility of even the recent past, there is no reason to suspect that we are able to prophesy what will come next. Yet we continue to judge the viability of our fantasies on the plausability of the designed fiction - the future which accompanies them.

Islanders - and in particular the people of Ebeye, "confined to mental reservations" in a "perpetual state of wardship"[45] - face the opposite problem: for them there is no clear line of flight, no approaching revolution, no storm of release. Only the perpetual bootsteps of a future which proclaims itself inevitable, obvious, inescapable. For Marshall Islanders, the future seems to promise at least three clear barriers to changing the current state of affairs. The most exigent of these are the threats posed by climate change: the islands are threatened by rising sea levels, an increased likelihood of severe weather events as climate patterns change, and rising ocean temperatures and changing ocean chemistry which may impact the health of the reefs on which a sustainable future might be built. The second 'incontestable' fact is that USAKA will remain. The US has made clear its intention to retain lease rights to Kwajalein, and is guaranteed that right until 2066 under the amended Compact II.[46] Finally, despite 26 years of independence,

41 Goreau and the members of the GCRA continue to work on establishing biorock projects throughout the world. One recent project from 2010 was conducted on Arno atoll in the Marshalls.
42 Morris. (1890): p234.
43 As Robinson puts it, "the Palaeolithic plus good dental care!" Robinson. (2011): ¶34.
44 Ibid., ¶20.
45 Hau'ofa. (1993): p6.
46 USSD. (2012): "Marshall Islands." Compact II was renegotiated between 1999-2003. It was ratified in 2004, contested by the subsequent Imata Kabua regime in 2008, and ultimately amended in 2011.

the RMI remains economically reliant on the United States, a situation which seems unlikely to change in the near future and increasingly drives the younger generation to depart for the US mainland or Hawai'i in search of a brighter future.[47]

Of course, it is a rhetorical flourish to say that there is no bright future in the dreams of islanders; some of the possibilities have already been suggested, embodied in the continuing work of local leaders[48] who remain dedicated to their local communities.[49] But framing the question of the future in this way gets at the root of the issue: namely, what is the use of dreaming if the future is already determined? What is the use of utopia? For the Marshallese the failures of hard-won independence to bring autonomy and self-sufficiency have dealt a devastating blow; the shroud of imperialism was partially drawn aside only to reveal the dark clouds of climate change.

Higher High Water

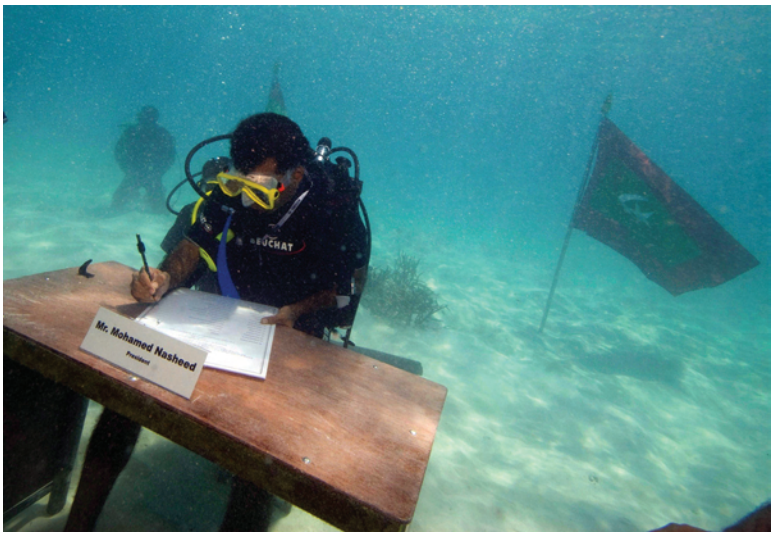
On Christmas Day in 2008, President Litokwa Tomeing was forced to declare a state of emergency. 2008 was one of the most extreme La Niña events on record.[50] This compounded with a storm surge and high spring tides to cause the worst flooding in Majuro and Ebeye since tropical storm Alice in 1979.[51] Waves swamped the urban centres and inundated cemetaries "contributing to the already alarming sanitary conditions" caused by the flooding.[52] Although the atoll was not hit directly by any of the three storms which passed nearby in a 2 week period, the flooding damaged more than 300 homes and forced the relocation of more than 10% of the population.[53] Another La Niña event brought similar flooding in 2011 and 2012.[54] The pattern is becoming familiar. Similar, less severe floods occured throughout the 2000's. In this period, 6 out of 11 seasons registered as El Niño Southern Oscillation (ENSO) 'cool' cycles,[55] bringing rain to Asia and raising local sea levels by as much as 15 centimetres. The same

47 Ibid. Direct US Aid accounted for 62% of the RMI budget in 2011.
48 Such as James Matayoshi of Bikini, Mike Kabua of Ebeye, James Matayoshi of Rongelap atoll and Mattlan Zackhras of Namorik.
49 RMI Govt. (2003). The RMI government has clearly stated its goals; the Nitijela is determined to promote a future which rests on small-scale, grass-roots community development in the outer islands. Also, recent moves such as establishing the Marshall Islands as a shark sanctuary in 2011; Marshallese leaders appear dedicated to moving the country away from large-scale commercial and urban projects, funded but owned by external entities, towards small-scale, locally managed human and natural-resource based enterprises. See Black. (2011).
50 NOAA. *Pacific Islands Ocean Observing System* (2012).
51 BBC. (25 Dec 2008). See also RMI Typhoon Map, Fig. 3.2.
52 Ibid.
53 Dyoulgarov, Bucher, Zermoglio. (2011): p6.
54 NOAA. *NWS* (2012) - both also La Niña years.
55 ENSO 'warm' cycles are commonly referred to as El Niño seasons; 'cool' cycles as La Niña seasons.

period saw only 3 ENSO 'normal' years.[56] What this reflects more than anything is how much we still have to learn about the long-term Pacific climate cycles. In the 1990's, the ENSO 'warm' cycle was dominant, culminating in the most extreme El Niño on record, the 1997-1998 season, which caused the unprecedented coral bleaching events across much of the Pacific and Indian oceans and brought severe tropical storms to Asia.[57] The 2000's, despite the flooding events, have so far been calm years. But as one climate climate scientist puts it, "the Earth's climatic system is an ornery beast which overreacts even to small nudges."[58] It remains unclear what the next decade will bring with regard to the changes in the ENSO pattern; but despite the irregularities of the past 2 decades, there is a definite increase in the magnitude of ENSO events.

What is not in question is that there is a direct correlation between the occurrence of typhoons in the Marshall Islands and El Niño years.[59] "The single most destructive climatological phenomenon affecting atolls are typhoons."[60] Examining the history of tropical storms in the Marshall's since 1850[61] the most striking pattern is that the most severe storms usually coincide with El Niño seasons. Severe typhoons are relatively rare; in 160 years there have only been 11 really devastating typhoons, all in ENSO 'warm' seasons.[62] The Marshall atolls sit at the eastern edge of what is known as the "western Pacific warm pool." This enormous area of warm water is a typhoon breeding ground: tropical storms form here and then move west towards Guam and the Phillipines, growing stronger as they go. Most of the storms do not become "typhoons"[63] until after they leave Marshallese waters. But during ENSO 'warm phase' the pool of warm water shifts far to the east and the sea surface temperature is also raised. More typhoons form, and they form further east, putting the RMI directly in their path. During El Niño, cyclones are more than 3 times more common than during 'normal' years, accounting for 71% of all Marshall Islands

56 Ibid. See also ENSO Maps, Fig. 3.5-3.7. In fact, ENSO 'normal' has become an oddity - over the past quarter-century (from 1985-2010) - only 8 seasons were considered normal.
57 Kao, Yu. (2009). The ENSO cycle has become so erratic that climate scientists have had to come up with a new definition for the special cases of El Niño which have occurred over the past 2 decades: *El Niño midoki*, which describes new observations of an ENSO warm cycle which takes place in the central Pacific, rather than the eastern Pacific. All of the ENSO warm cycle events of the 2000's fall into this newly minted category.
58 Broecker. (1995): p212.
59 Well, at least the old definition, now known as Eastern Pacific El Niño...
60 Spennemann. (2005): p50.
61 Spennemann & Marschner. (1994). The extent of the *instrumental* record for ENSO events. See Urmann. (2012) for a list of available ENSO data sources. Reliable typhoon records in the Marshall's are not available prior to the German administration. Spennemann & Marschner provide an analysis of the correspondence between ENSO and typhoons.
62 Ibid.
63 JMA. (2012). That is, with sustained wind speeds in excess of 118kph (RSMC typhoon scale).



The Politics of Vulnerability

"High levels of gross domestic product per capita registered by small island states nevertheless conceal a fragile base, one that can be easily wiped out: in a flash by a hurricane; rapidly by a decline in the demand and the world market price of a specific commodity; or slowly but surely with creeping sea-level rise. About the latter, the international community, especially the richer and most polluting nations, is being encouraged to see themselves as responsible for the increasingly tragic predicament of small island communities. Some financial payments have been extracted; but the notion of environmental refugees - which would then grant asylum rights to small island residents seriously threatened by sea-level rise - remains stalled." Baldachinno. (2011): p237.

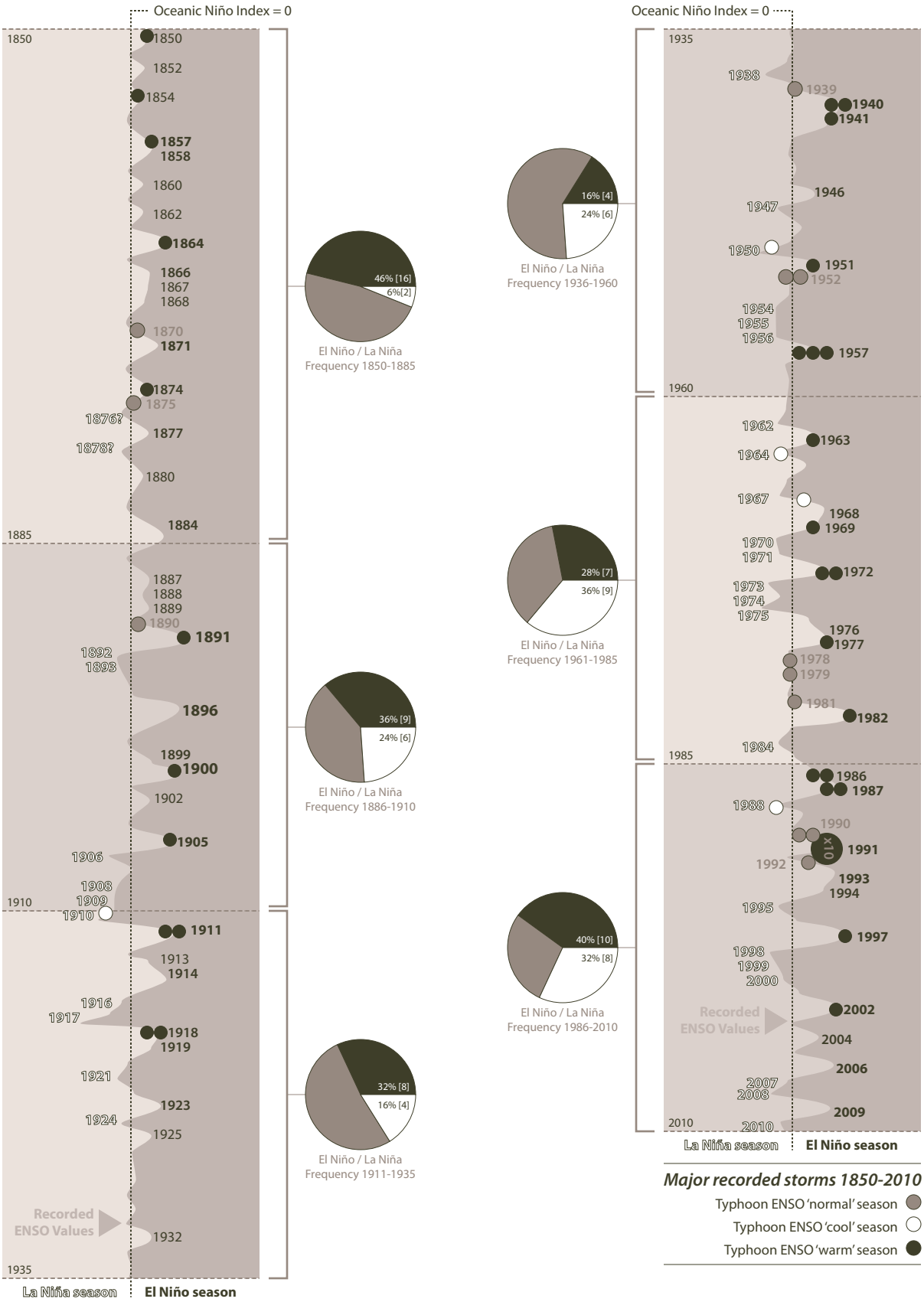
typhoons recorded.[64]

Typhoons and floods have always occurred. The difference today is urbanisation: whereas traditional settlements were mobile, today 70% of the Marshallese population is living in the two major urban settlements of Ebeye and Majuro. Urban populations are under significant risk for several reasons. The urban atolls have much less vegetation, and buildings have been constructed right up to the seaward shore; during an overwash, buildings and land are at risk of washing completely away. Urban areas produce pollution and run-off which can damage or kill the neighbouring reef which acts as a natural breakwater for large storm waves. Most problematic is the location of urban areas: both Ebeye and Majuro are built on the south-eastern corner of their atolls, in areas traditionally avoided during typhoon season.[65] Finally there is the issue of land-reclamation and causeways between islands. Natural atolls are very good at dispersing the energy of a storm because they do not present a 'hard' barrier to incoming waves - in contrast to high islands or continents. Incoming storm waves are efficiently dissipated through interactions with the reefs and lagoon. Storm surges are able to pass through channels between islands into the lagoon. However, artificial connections between islands - such as those which exist on Majuro and connecting Ebeye to the islands to the north - disturb this dissipation effect, making these urban areas subject to greater erosion and flooding than natural islets, and under significantly greater risk of catastrophic storm impacts.[66]

Typhoons and floods are the most significant short-term risk for atoll people; but in the long run a more significant danger is posed by sea-level rise. It is due to this risk that "the worlds 5 atoll nations face the prospect of the erasure of their sovereign territory within the next century."[67] Today, the atoll countries of the world are probably best known for their activism against climate change induced sea-level rise, which threatens their very existence. Leading this charge has been Maldives (former) President Mohamed Nasheed[68] who famously held a cabinet meeting underwater to raise awareness of the plight of atoll nations. "'Saving small island states from sinking' is a current and probably the most highly visible policy item on the international agenda that features small island states today" - an agenda put forth not least of all by small island states themselves, as it "allows their concerns to remain somehow present and visible on the international relations table

64 Asanobu. (2012). See RMI typhoons Figs. 3.1-3.2.
65 In the southern Marshalls, most typhoons approach from a south-easterly direction and move west or north-west across the atolls. Typhoons in the northern atolls follow a different pattern, sometimes approaching from the west.
66 Chunting, Howorth. (2003).
67 Sem. (2005): pp5-12. Namely the RMI, Kiribati, the Maldives, Tokelau and Tuvalu, with a total population of about 500,000; but worldwide, at least 500 million people are at least partially dependent upon coral reefs for their survival. See also Wilkinson. (2008).
68 BBC. 7 Feb 2012. Sadly, Nasheed was ousted from power in February 2012 by an internal coup engineered by supporters of the former dictatorship and remains in exile.

El Niño / Typhoon Correlation



Cyclones in the Marshalls
"Normal" seasons 1985-2010

Major Tropical Storms
wind speeds >120kph

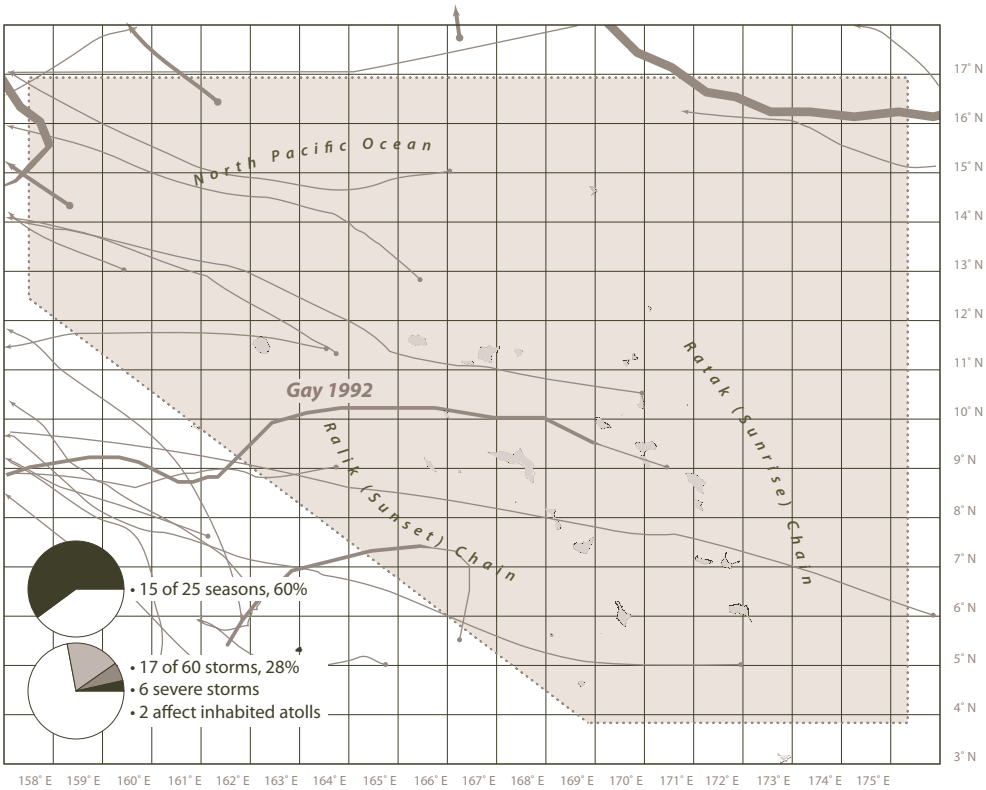
Typhoons
wind speeds >150kph, 500km radius

Super-Typhoons
wind speeds >180kph, 800km radius

During typical "normal" years, major tropical depressions are rare in the Marshalls; they occur most frequently in the north-western region of the RMI, increasing in intensity as they move away to the west.

• 70 of 160 seasons; 44%

• 12 of 59 major typhoons; 20%



Cyclones in the Marshalls
El Niño seasons 1985-2010

Major Tropical Storms
wind speeds >120kph

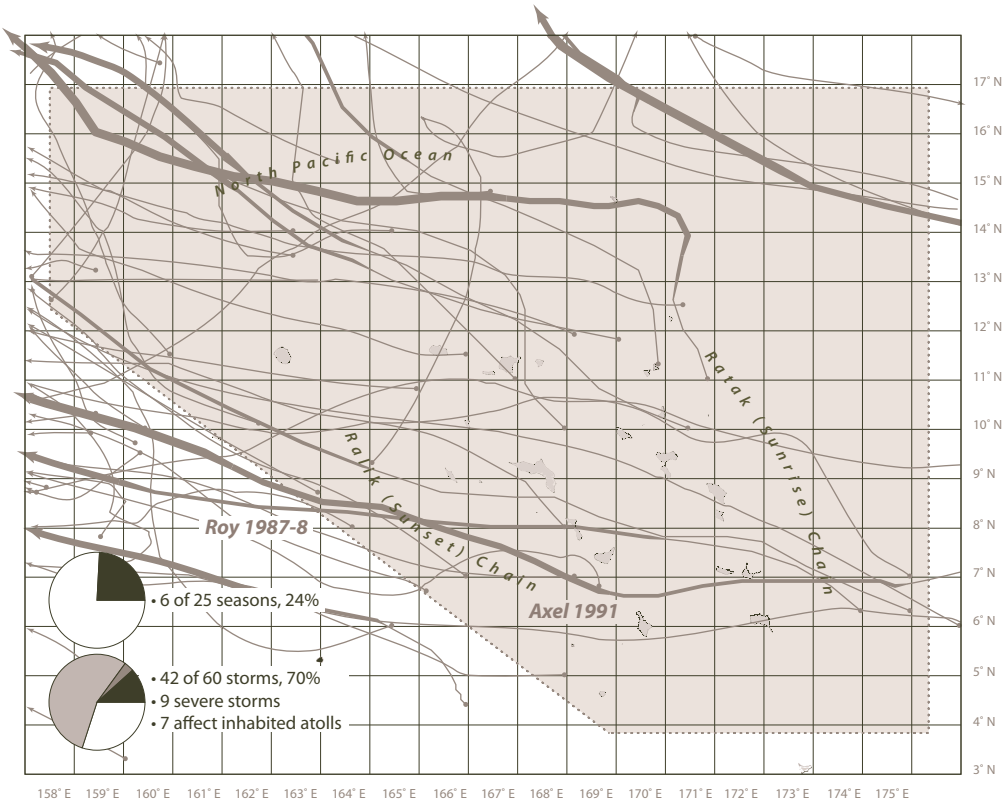
Typhoons
wind speeds >150kph, 500km radius

Super-Typhoons
wind speeds >180kph, 800km radius

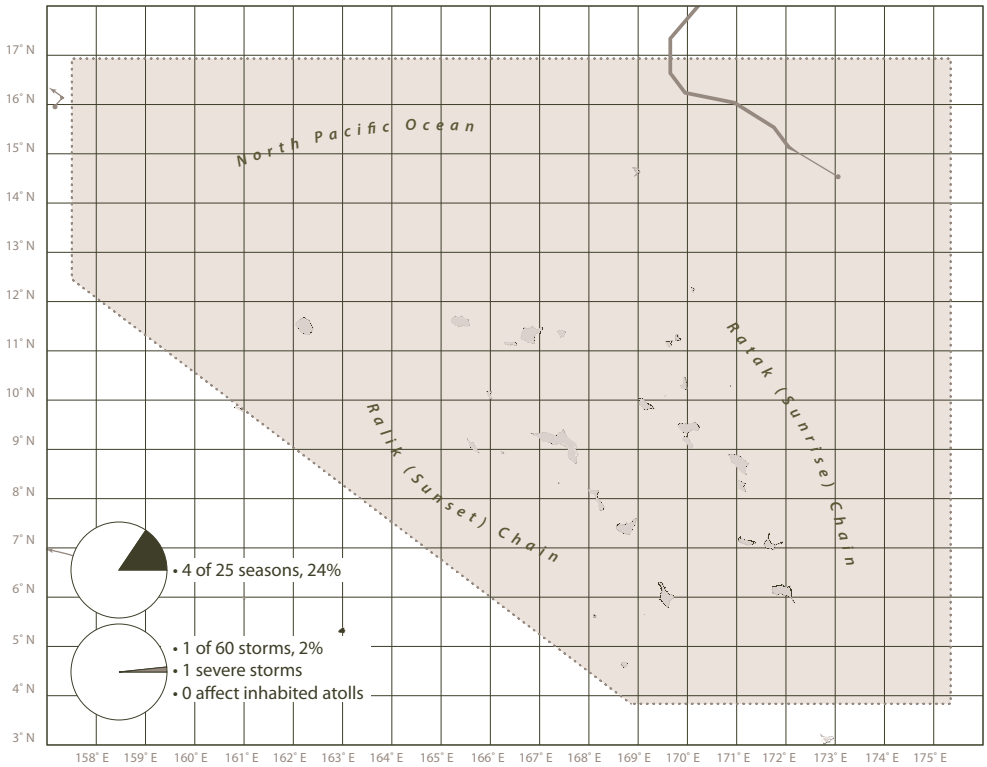
During El Niño seasons, the Western Pacific 'Warm Pool' is shifted to the east by a change in the intensity of the Equatorial Current; during El Niño the Equatorial Counter-Current becomes dominant. Tropical depressions occur much further to the east during these episodes, making severe storm events much more common in the RMI.

• 55 of 160 seasons; 34%

• 42 of 59 major typhoons; 71%



Typhoons in the Marshall Islands



Cyclones in the Marshalls

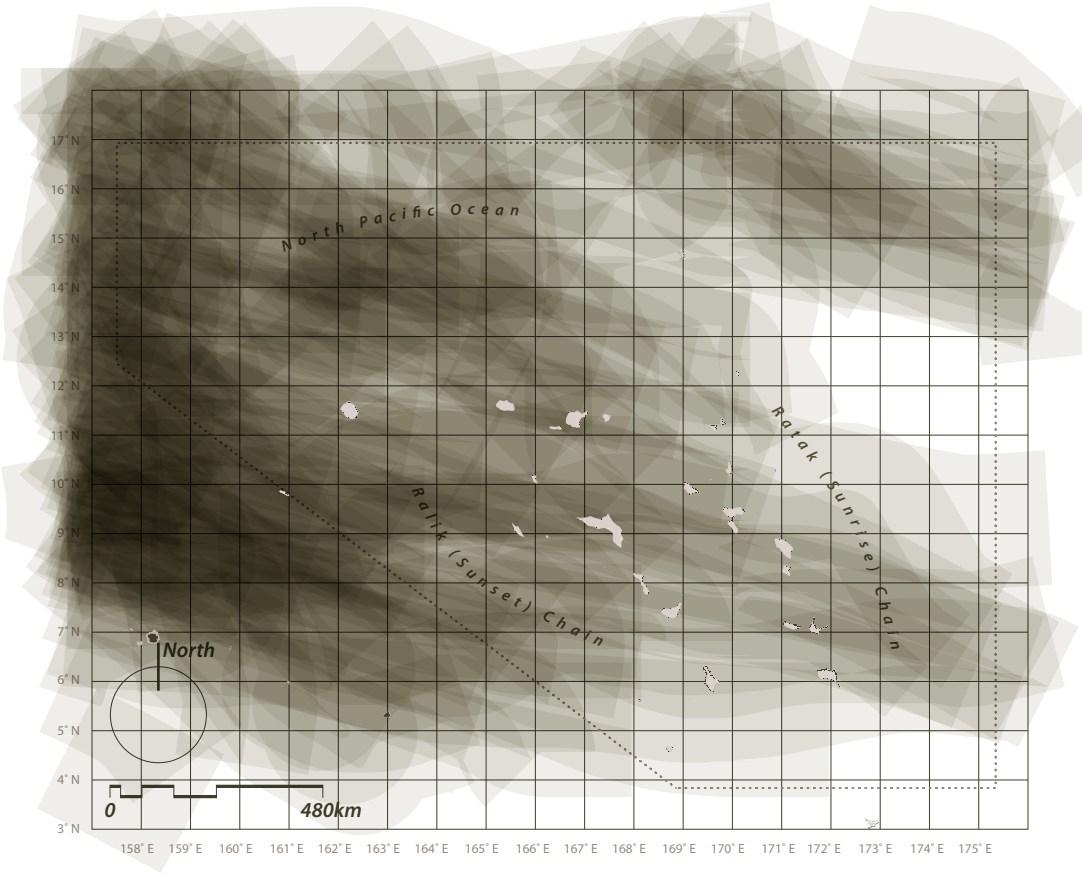
La Niña seasons 1985-2010

Major Tropical Storm Tracks
wind speeds >120kph

Typhoon Tracks
wind speeds >150kph, 500km radius

Super-Typhoon Tracks
wind speeds >180kph, 800km radius

Typhoons and cyclones are extremely rare during La Niña seasons, as the Pacific Warm pool shifts to the west and the waters of the RMI tend to be cooler.



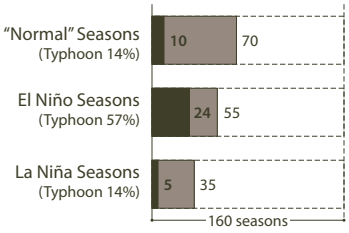
Cyclones in the Marshalls

Typhoon Frequency (1985-2010)

Tropical Storms Extremely Rare
(No major storms in past 25 years)

Severe Storms Common
(More than 5 in past 25 years)

During El Niño seasons, cyclones are more than 3 times more common than during "normal" years.



of 59 major typhoons in 160 seasons...

Major recorded typhoon events in the Marshall Islands:

1850 - typhoon wiped out the populations of Rongerik and Rongelap.

1864 - separate events devastated Ujelang and Ebon atolls.

1905 - the most destructive in Marshallese history. The port of Jaluit was destroyed overnight, and hundreds of people died throughout the Marshalls. Nadikdik was completely annihalated, washed away; 58 out of 60 inhabitants perished.

1911 - Ujelang was struck by back to back typhoons, requiring evacuation and ending yearly copra production.

1940-1941 - Wartime fortifications at Wake (Eneen-Kio) were repeatedly damaged by typhoons in 1940-41.

1951 - Typhoon Georgia struck Utrik, washing much of the land away.

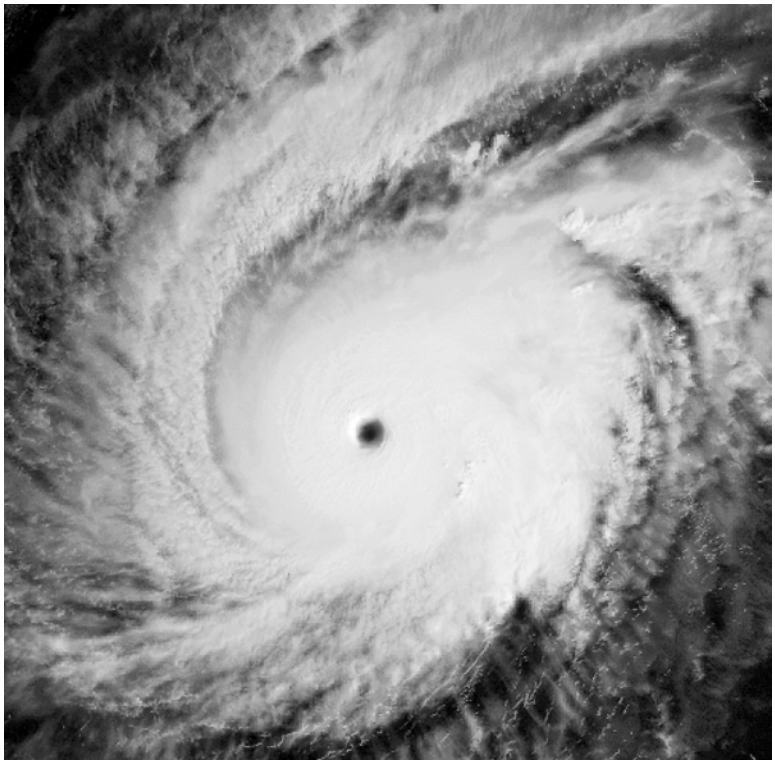
1957 - Typhoon Ophelia struck Jaluit.

1979 - Tropical storm Alice passed within 70km of Kwajalein, and caused severe flooding in the D-U-D area of Majuro and at Ebeye.

1987 - Roy devastated Lib, destroying 50% of all housing.

1991 - An unprecedented typhoon year, 10 major storms in the RMI; Axel and Gay caused flooding on Majuro, Jaluit, Mili, and Arno.

1997 -Paka caused $80 million US in damage.



Typhoons
The image shows super-typhoon 'Paka' which passed through the Marshall Islands in the 1997 El Niño season.

in the post-cold war scenario."[69] Current projections suggest that sea level will rise between 9-88cm by 2100.[70] But "it is not sea-level rise *per se*, but rather projected increases in sea-surface temperature (SST) that poses the greatest long-term risk to atoll morphology."[71] As previously discussed, atoll islets (*motu*) are formed entirely of coralline sands generating by the living reef. Atolls are bio-dynamic environments, and healthy reefs are capable of growing apace with rising sea-levels, as they have done at times in the prehistoric past.[72] But rising sea temperature and increases in CO_2 concentrations dissolved in seawater threaten to impact the rate of coral growth;[73] this poses a much greater threat, and could result in the disappearance of atoll islands on a time scale of years rather than decades. Current projections suggest SST will rise globally by 1.0-2.0°C by 2100.[74]

> "Between 1945 and 1955 the temperature of the surface of the tropical Pacific commonly dipped below 19.2°C, but after the magic gate opened in 1976 it has rarely been below 25°C. The western tropical Pacific is the warmest area in the global ocean and is a great regulator of climate... for among other things it controls most tropical precipitation and the position of the Jet Stream, whose winds bring snow and rain to North America. The best analogy is perhaps that of a finger on a light switch. Nothing happens for a while, but if you slowly increase the pressure a certain point is reached, a sudden change occurs, and conditions swiftly alter from one state to another."[75]

Despite all of these threats, there are reasons to remain hopeful. To date, studies indicate that Marshall Islands reefs are some of the healthiest in the world.[76] The RMI location within the western Pacific warm pool (WPWP) means that reef species here are adapted to some of the highest ocean temperatures on earth (typically above 28°C year-

69 Baldacchino. (2011): p236.
70 Barnett, Adger. (2003): p323.
71 Ibid.
72 Schaeffer. (2010): pp3-4. See also Roy, Connell. (1991). This does not neccessarily imply that islands would remain habitable, as the natural freshwater lens of atoll motu would no doubt be impacted by the rise in sea-level projected for the next century; merely that so long as the reefs continue to grow, the atolls islands will continue to exist in some form or other. Analysis of prehistoric Maldives islets indicates motu with healthy reefs are able to keep pace with sea-level rise on a similar order to that observed in recent decades (2mm/year) but not neccessarily with rates which are projected (>3mm/year, perhaps as high as 8-18mm/year by end of century) Schaeffer: the rates "projected for the 21st century appear to be more consistent with periods when atoll islands and coral reefs failed to keep up with sea level at the end of the last ice age."
73 Sea-temperature can produce coral bleaching; rising CO_2 affects the ability of polyps to synthesize the aragonite which they use to build their skeletons.
74 IPCC. (2001): see section 6.4.5. ¶4.
75 Julia Cole, excerpted from Flannery. (2005): pp83-84.
76 Turgeon et al. (2002): p61. Though it should be noted that there have not been many formal studies conducted in the RMI, and this assessment rests on a few general studies covering limited areas.

round).[77] While WPWP SST has been stable, what *has* changed is its location and size, growing much larger in recent years,[78] and moving further to the east during the intense El Niño events. That urban atolls will become increasingly untenable as the century proceeds appears very likely, but the atolls themselves will persist. The future of inhabitation on these atolls will rely upon Marshallese ingenuity, adaptability and the willingness to experiment with new forms of urbanism and inhabitation. The major challenges to be solved will be water and food security, protection from typhoon events - especially through increased mobility, and the ability to secure livelihoods from what is likely to be an increasingly marine environment. All of this is possible.

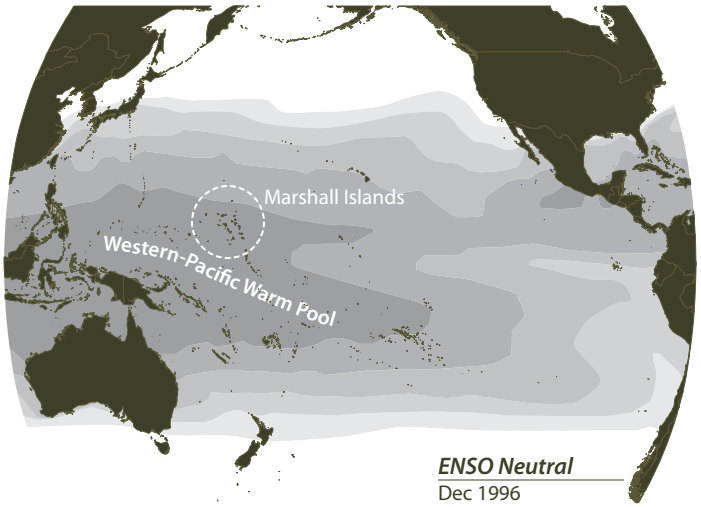
The End of the Rainbow

During the renegotiations of the US / RMI Compact, between 1999 and 2003, there was a very visible faction - driven by ri-Kuwajleen landowners and led by Imata Kabua - demanding the withdrawal of the US military from Kwajalein once and for all.[79] Compact II came into power in 2004; but the landowners negotiating team strongly protested that they had not been consulted in the renogotiation of their lease.[80] Ultimately, after 8 years of political turmoil[81] the issue was finally settled in 2011: under pressure from the government on Majuro, the landowners ratified the document, signing over their rights to the USAKA lands until 2066, with a US option to remain a further 20 years beyond that.

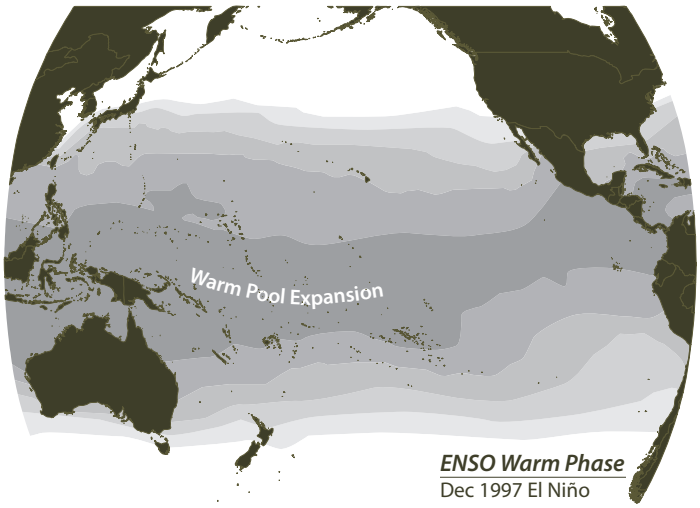
One might wonder why - in spite of the end of the Cold War - the US continues to be willing to spend an enormous amount of money on Kwajalein.[82] During the 'Star Wars' heyday of missile testing, there were 10-20 missile tests per year, and the strategic logic and economics of the Kwajalein range were fairly straightforward. The purpose of the installation is clearly described here:

77 Mehta, Mehta. (2012). While the global SST trend has given rise to the infamous 'hockey stick' graphs, (See Wikipedia: "Hockey stick controversy," for an enormous number of links and interesting discussion) showing a sharply increasing rise in recent years, these changes are not so evident in WPWP studies, which remain fairly stable, varying within about 1°C over the 20th century.
78 Ibid. 200% increase in area since 1960s - however, similar to 1940's.
79 Their Land Use Agreement - called the Military Use and Operating Rights Agreement (MUORA) - was set to expire in 2016.
80 Yokwe Online. (2012): "Kwaj Landowners Tell Committee MUORA Is Inadequate Called the Kwajalein Negotiating Commission, KNC."
81 The pro-US / pro-Taiwan regime under Note was replaced with the pro-Kwaj landowners regime under Litokwa Tomeing; he was ousted in a vote of no-confidence, and ultimately the MUORA was signed by landowners in 2011 under US threat of aid withdrawal. See USSD. (2012): "Marshall Islands," Wikipedia: "Kwajalein / land disputes," and Dvorak. (2007): pp325-333.
82 Under the conditions of Compact II, the RMI is guaranteed at least $57 million per year until 2023 - a combination of aid, lease money, and various grants and federal programs active in the RMI. See USSD. (2012): "Marshall Islands."

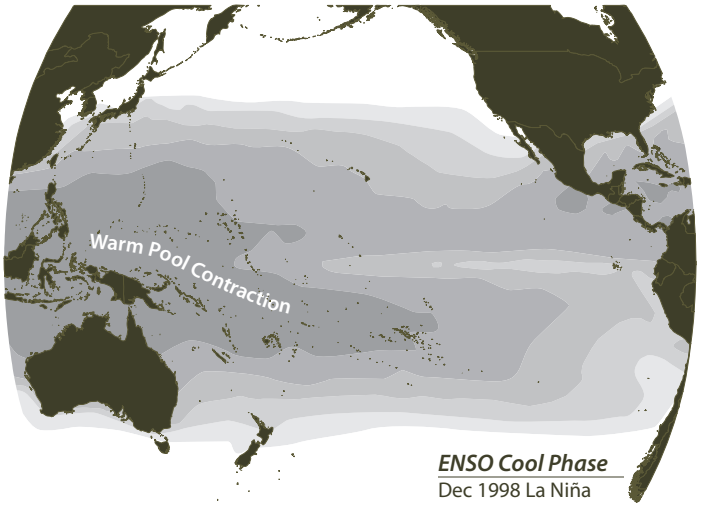
Western Pacific Warm Pool



ENSO Neutral
Dec 1996



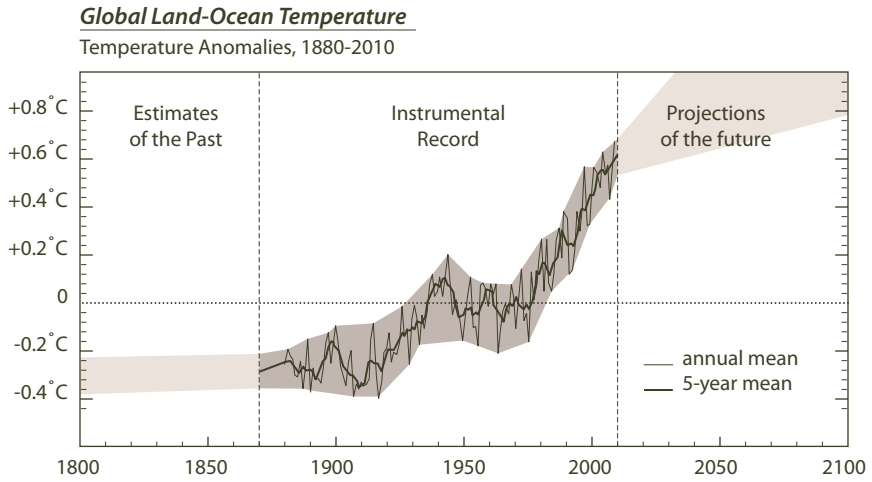
ENSO Warm Phase
Dec 1997 El Niño

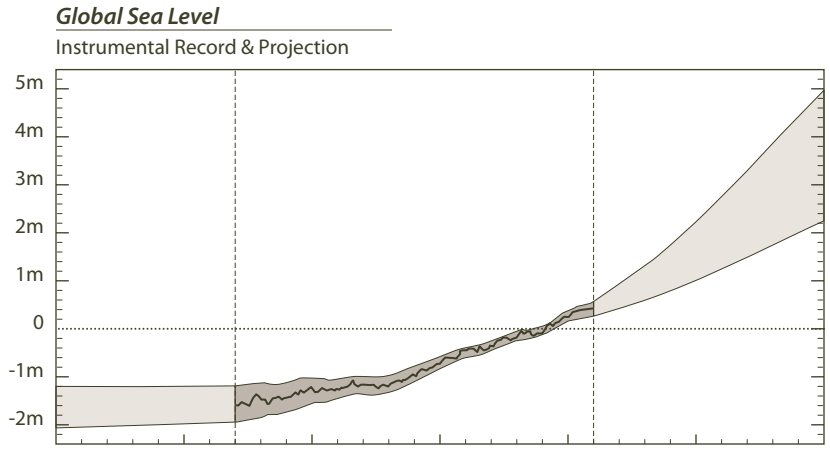


ENSO Cool Phase
Dec 1998 La Niña

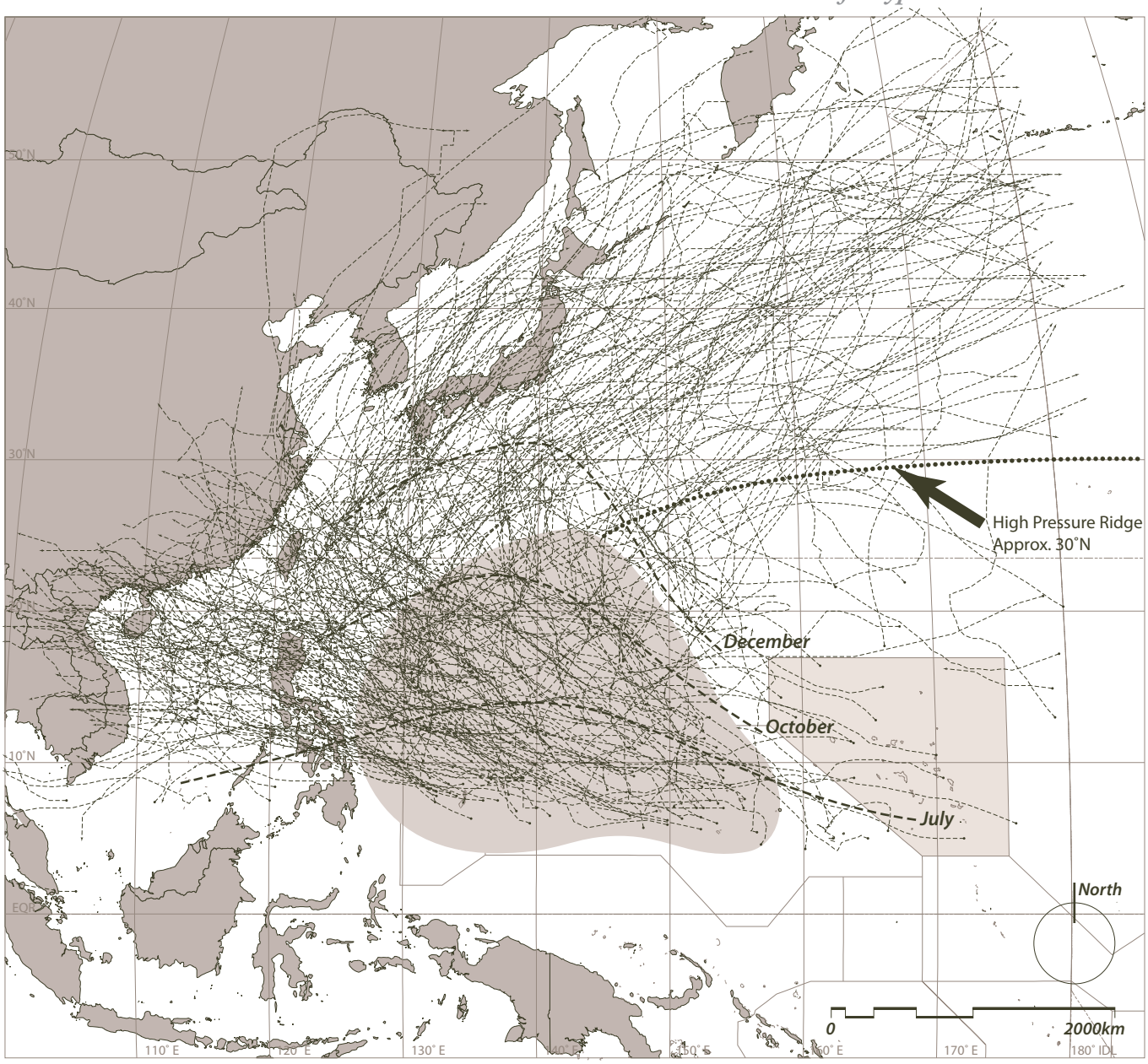
Sea Surface Temperature (SST)

- >28˚C
- >25˚C
- >22˚C
- >19˚C
- >16˚C
- <15˚C

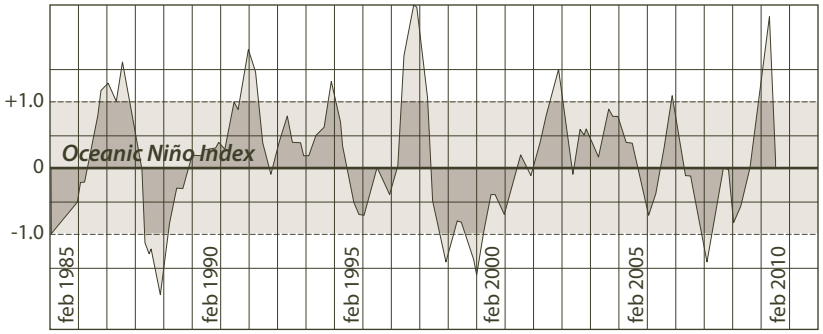

Global Land-Ocean Temperature
Temperature Anomalies, 1880-2010
+0.8˚C
+0.6˚C
+0.4˚C
+0.2˚C
0
-0.2˚C
-0.4˚C
Estimates of the Past
Instrumental Record
Projections of the future
annual mean
5-year mean
1800
1850
1900
1950
2000
2050
2100


Global Sea Level
Instrumental Record & Projection
5m
4m
3m
2m
1m
0
-1m
-2m

Pacific Typhoons – ENSO 'normal'



All typhoon tracks for moderate ONI seasons, 1985-2010



Typhoon Tracks

Subtropical High Pressure Ridge

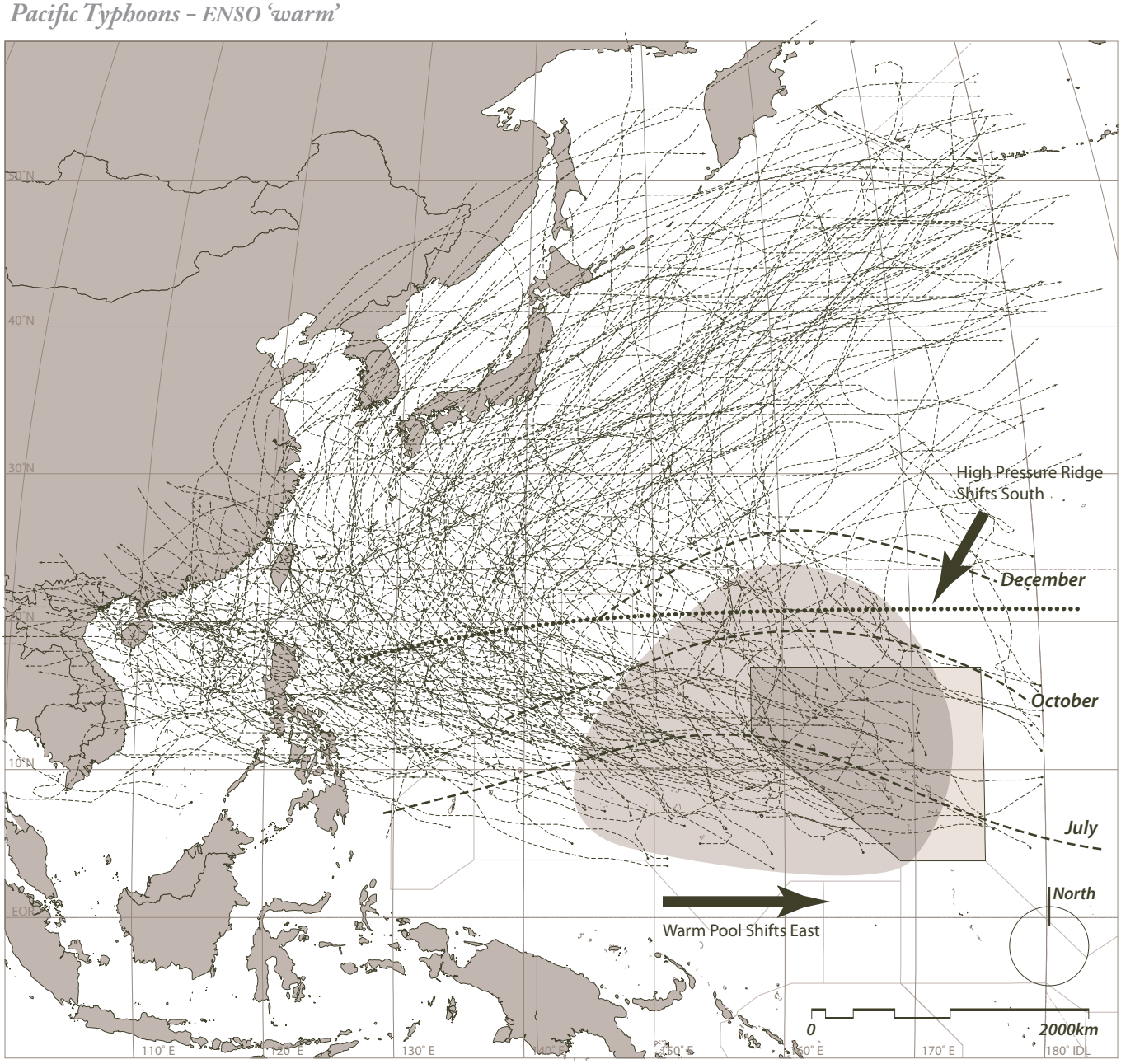
Pacific Warm Pool boundary

Typhoon Formation Zone

Republic of the Marshall Islands

FIG. 3.6

Pacific Typhoons – ENSO 'warm'



All typhoon tracks for El Niño seasons, 1985-2010

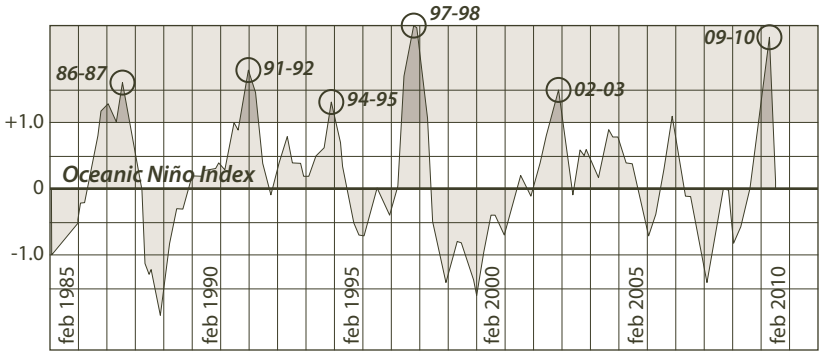
Typhoon Tracks

Subtropical High Pressure Ridge

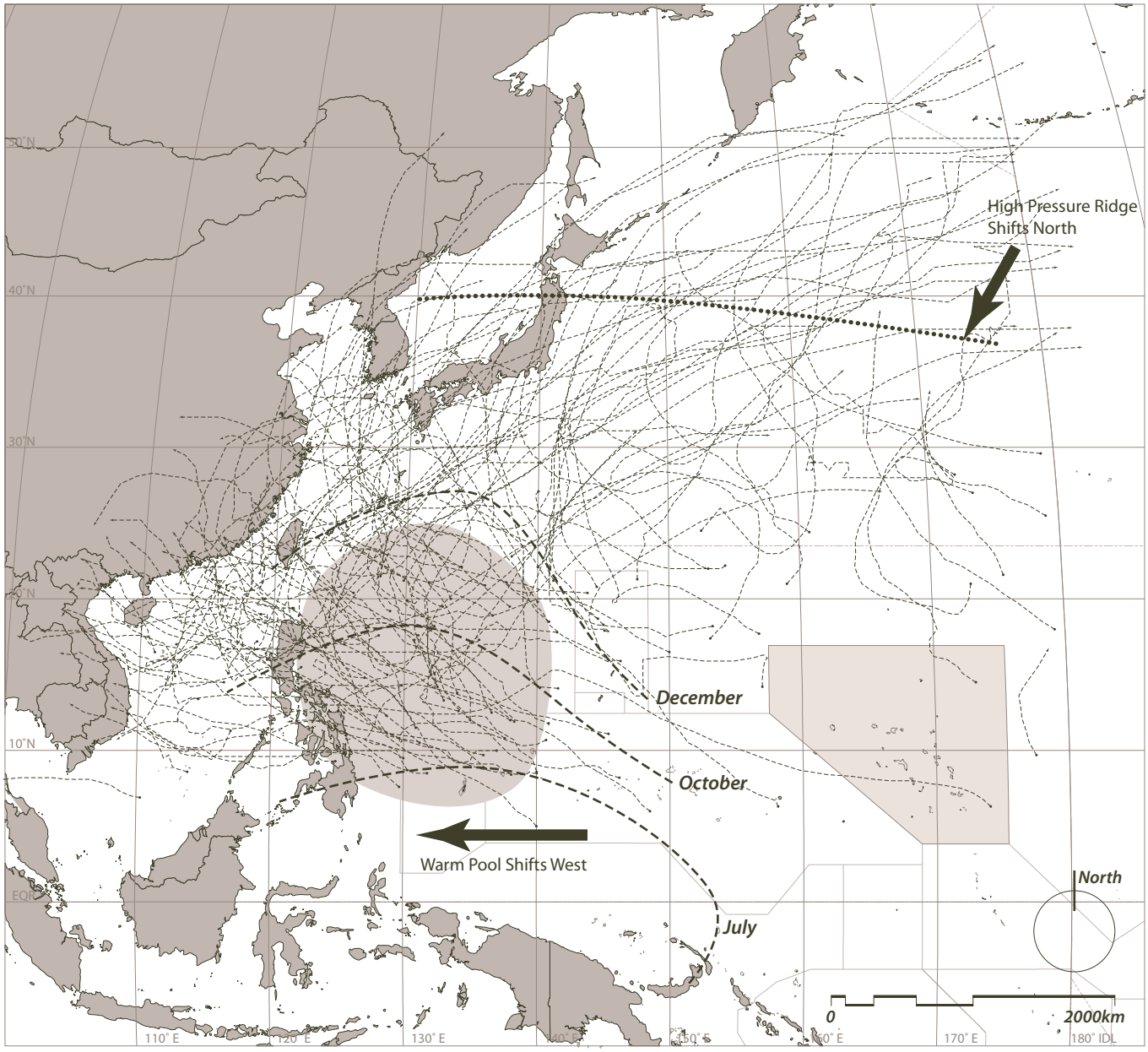
Pacific Warm Pool boundary

Typhoon Formation Zone

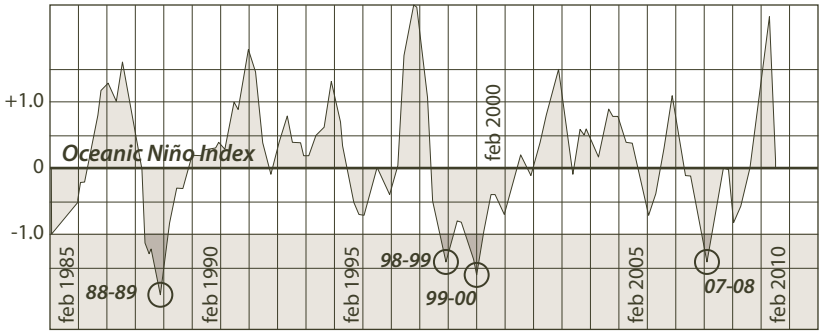
Republic of the Marshall Islands



Pacific Typhoons – ENSO 'cool'



All typhoon tracks for La Niña seasons, 1985-2010



Typhoon Tracks

Subtropical High Pressure Ridge

Pacific Warm Pool boundary

Typhoon Formation Zone

Republic of the Marshall Islands

> "The US Air Force wields an ICBM sword from Vandenberg that strikes again and again at the US Army's Star Wars Shield at Kwajalein. The immense array of measuring devices at Kwajalein, especially the radars, serve as an umpire in each duel between the missile sword wielded against the anti-ballistic missile shield. The KREMS radars measure how successful the sword is at piercing the shield, and how successful the shield is at warding off the sword. But - and this is what is unique about Kwajalein - the shield is also a whetstone against which the sword is continuously honed, and the sword is a forging hammer which hardens the shield. KREMS measures both sharpness of sword and hardness of shield."[83]

In essence, the United States was conducting *an arms race with itself*. The Air Force develops better and better missile technologies; in turn the Army improves its interception technologies - all conducted in an arena which acted as a an impartial judge, 'scoring' the results.[84] USAKA has significantly scaled back from those days, demolishing housing and reducing the American workforce by more than 50%. Now there are only 4 or 5 tests a year.[85] Why does the US remain?

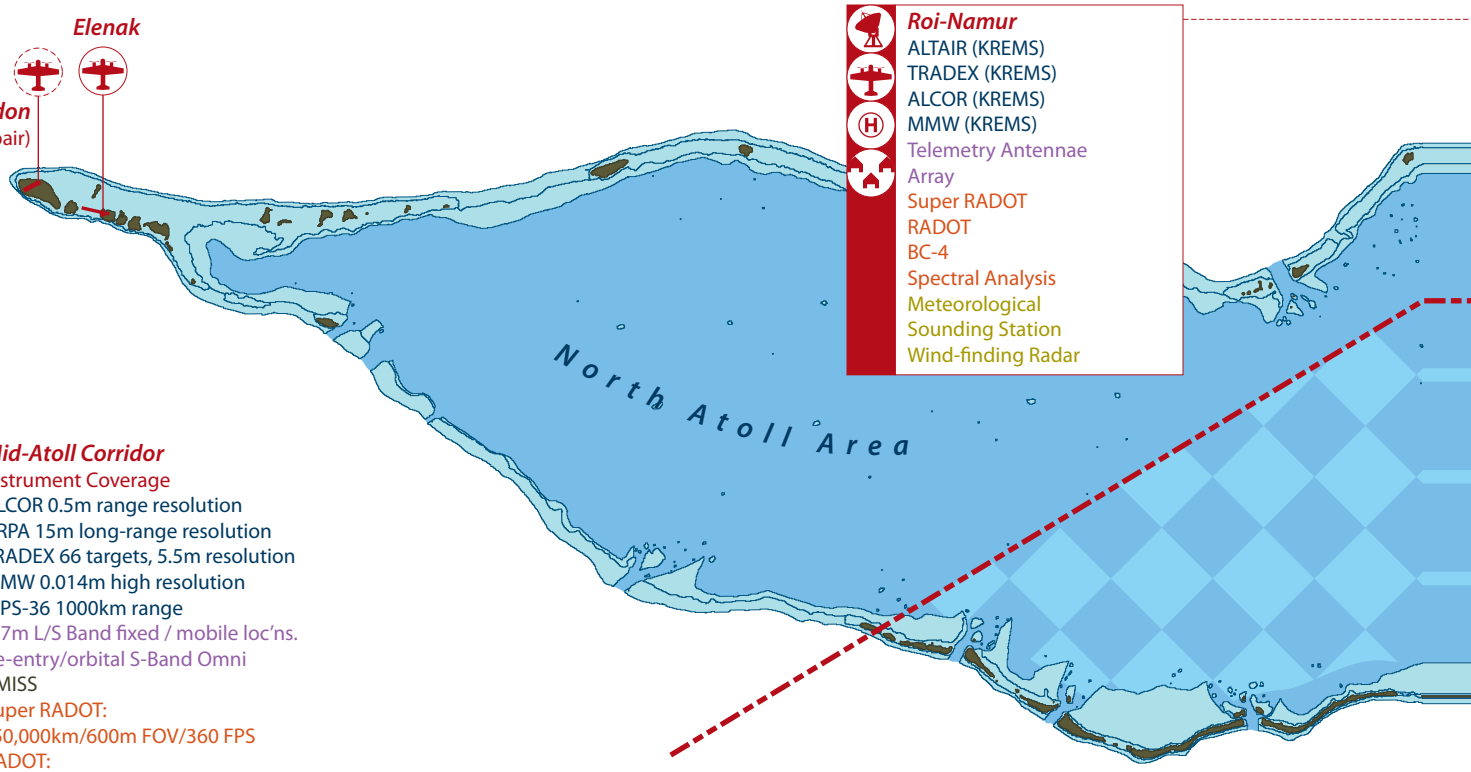
There are a couple of key reasons. First, the missile defense industry is worth *billions and billions* of dollars.[86] The price paid to lease Kwajalein is a drop in the bucket - the price of doing business. The military has a very significant investment in the radar infrastructure, worth more than $4 billion alone.[87] And in recent years, the instrumentation has proven valuable for operations outside of the original design intentions:

83 Wilkes, Frank, Hayes. (1991): p12.
84 Ibid., p13. The whole performance was also an effective deterent - Soviet spy trawlers and subs would sit just offshore - sometimes even entering the lagoon - "listening to the clang of sword against shield and picking up tips on how they can sharpen their own sword and harden their own shield." But today, their are no ears listening.
85 US GAO. (2001).
86 Even back in 1982, military sales of missile systems exceed $5.2 billion worldwide annually. See Wilkes, Frank, Hayes. (1991): p12. The value of the industry exploded in the Star Wars period; still further with the development of Patriot-SLCM-SCUD during the Iraq War; and further still with the contemporary wars in Afganistan and elsewhere. By 2010, the value of arms sales among the top-ten US companies topped $200 billion. See Sauter, Stockdale. (2012). The maker of the Trident missile, Lockheed Martin, had arms sales of $36 billion *and* US government contracts totalling $36 billion in 2010 alone. The army paid Bechtel - the company which manages the Kwaj facility - $626 million for a four-year contract from 2002-2006; this has since been extended to a 15-year, $2.5 billion contract, which gives some idea of the value of these operations. Doan. (2003).
87 US GAO. (2001): p35.

Rising Tides
"I see the change.
When the waves tumble over
places where rocks once were.
Rocks that I once sat on."

Excerpted from the winning entry in the first annual Marshall Islands climate change school competition, from a poem composed by Crystal Kabua, age 9. Wontoon. (2009).

The image shows a 'King' tide (the highest annual tides between December - February) over-topping the Ebeye-Gugeegue causeway. Events such as this are becoming more common. While it may simply seem to be a matter of rising sea levels, there are a number of other factors at work. Most notable is the detrimental effects caused by the connection of islands with causeways and landfill. These inter-island connections prevent the natural tidal flow between ocean and lagoon which absorb the effects of storm-surge and heavy wave action. Where causeways have been built there is increased pressure on islands, with more severe erosion and flooding more common.



Roi-Namur
ALTAIR (KREMS)
TRADEX (KREMS)
ALCOR (KREMS)
MMW (KREMS)
Telemetry Antennae
Array
Super RADOT
RADOT
BC-4
Spectral Analysis
Meteorological
Sounding Station
Wind-finding Radar

Mid-Atoll Corridor
Instrument Coverage
ALCOR 0.5m range resolution
ARPA 15m long-range resolution
TRADEX 66 targets, 5.5m resolution
MMW 0.014m high resolution
MPS-36 1000km range
3-7m L/S Band fixed / mobile loc'ns.
Re-entry/orbital S-Band Omni
KMISS
Super RADOT:
50,000km/600m FOV/360 FPS
RADOT:
50,000km/1400m FOV/360 FPS
Spectral Ballistics Cameras
CCTV
Meteorological Sounding Station
Defense Meteorological Satellite
DWSR-93S (MHR) Radar

Illeginni
Post-impact Telemetry
Fixed Camera Tower
Land Impact Site

Legan
Super RADOT (x2)
BC-4 (x2)
Spectral Analysis

Meck
Fixed Camera Towers
CCTV
ABM Launch Site

USAKA - Kwaj Island
MPS 36 (x2) [metric]
FPN 66 [FAA]
KMRSS Ship Telemetry
Telemetry Antennae (x5)
S-RADOT, RADOT, BC-4, CCTV
Meteorological Sounding
Defense Satellite
DWSR-93S (MHR) Radar
Defense Satellite
Communications Earth Station
International Airport
Mobile Sensors

USAKA Utilization
Ballistic Missile Tests:
- Minuteman-2 and 3 ICBM (Intercontinental Ballistic Missiles)
- M-X DT (Peacekeeper Missiles)
- SICBM (Small ICBMs, ie Midgetman)
- Trident SLBM (Submarine Launched)

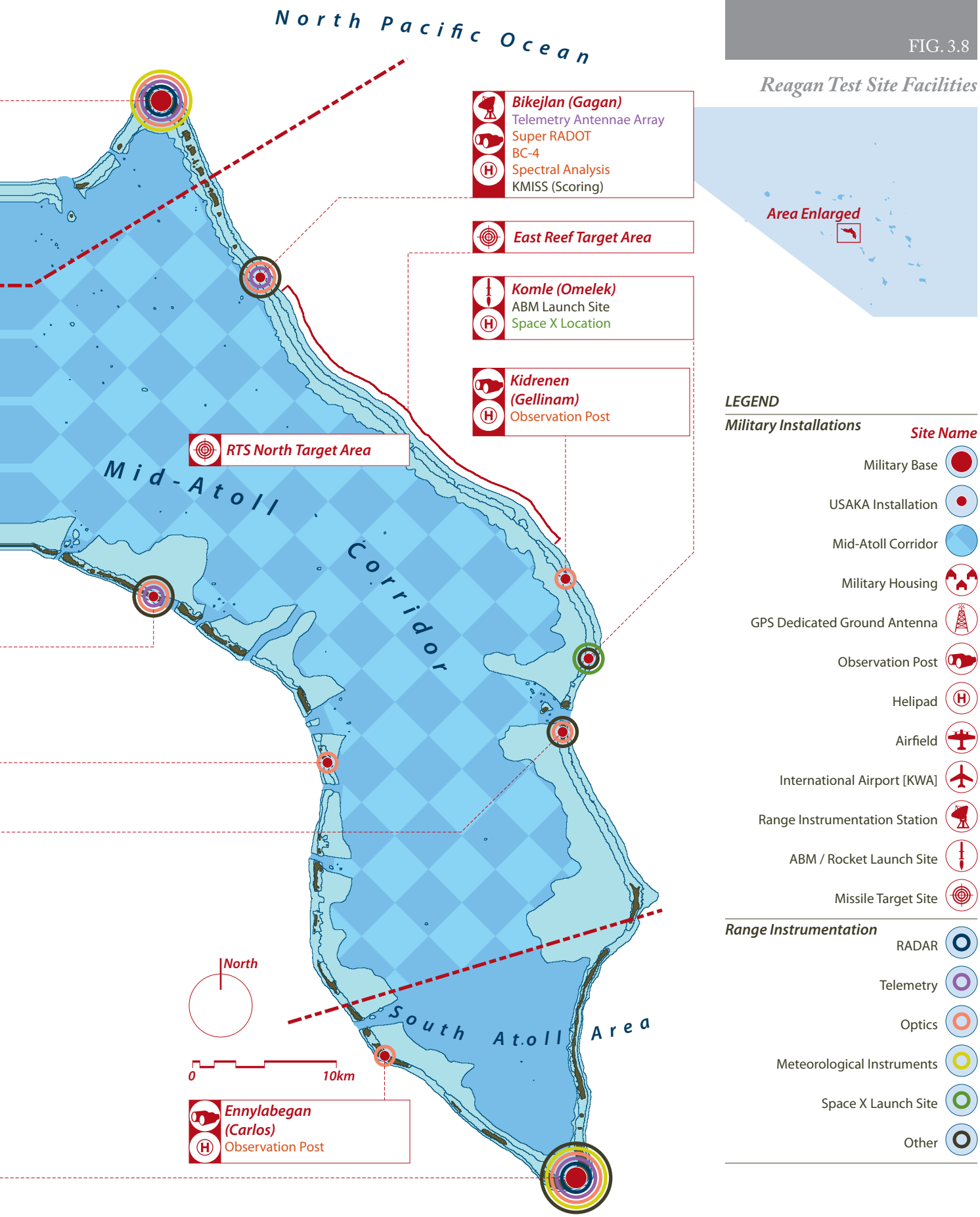
Other Weapons Tests:
- Tomahawk SLCMs (Sea-launched)
- ASAT (Anti-satellite Weapons)
- Aircraft (B-1, E-3A, B-52, F-15)
- ALCM (Air-launched Cruise Missile)
- Harpoon
- SRAM (Short-Range Attack Missile)

Space Exploration & Satellite Launch:
- Titan (Polar Launches to the south)
- Geosynchronous Orbital Launches
- SpaceX (Launch in 2008)

Tracking & Intelligence:
- Space Catalogue Maintenance, SOI (Space Object Identification)
- GPS Ground Antenna Location
- TTI (Tracking, Telemetry intercept) of Soviet ICBM re-entries
- TTI of satellites
- Anti-satellite weaponry

FIG. 3.8

Reagan Test Site Facilities



SpaceX
Liftoff of the SpaceX Falcon 1 flight 4 vehicle from Omelek Island in the Kwajalein Atoll, at 4:15 p.m. (PDT) / 23:15 (UTC), September 29, 2008. It achieved an elliptical orbit of 621x643 km, 9.3 degrees inclination, and carried into orbit a payload mass simulator of approximately 165 kg (364 lbs), designed and built by SpaceX specifically for this mission. What role could space technologies play in the future of the Marshall Islands?

space launches;[88] satellite and space surveillance;[89] meterological measurement; GPS antenna location; even astronomy.[90]

But the importance of Kwajalein goes beyond the economics of the US military-industrial complex; as the Department of Defense put it in 2001 (notably, post-September 11):

> "While DoD currently sees a region largely at peace and free of significant security threats, DoD believes that future uncertainty over security trends in the Pacific makes a continued right to strategic denial in Micronesia essential [...] it would be unwise to assume that the end of the Cold War has lessened the strategic importance of Micronesia to the defense of US national interests in the Asia-Pacific region."[91]

It is not simply the value of the current investment in USAKA which makes Kwajalein an essential tool for maintaining US missile defense superiority; the remote ocean location in a sparsely populated region with an uninterupted 8000km flight path to an even larger investment at Vandenberg makes it a unique and irreplaceable facility. So while the value of strategic denial has certainly changed since the Cold War, the value of Kwaj as a missile testing venue effectively underwrites the strategic value of continued US presence. The question of whether or not the United States will continue to occupy its leaseholdings is effectively resolved; pending drastic changes to American sentiment or a collapse of the US economy, USAKA will remain. The good news is, with the uncertainty of the Compact renegotiations - which clouded the first 10 years of this century - finally over, the Marshallese are in a position to begin to assess new ways in which they might take advantage of their partnership with the United States.[92]

88 SpaceX. (2012). SpaceX upgraded the launch facilities on Omelek Island, and now has the capability to launch polar and geosynchronous Falcon 9 rockets here. In 2008, SpaceX was awarded a $1.6 billion dollar NASA contract to develop its reusable launch vehicle technologies which will replace the space shuttle which retired in 2010. USAKA is an ideal site for geosynchronous orbit missions: its location very close to the equator provides an extra boost to launch vehicles, and launches from here can achieve any orbital inclination.

89 RTS. (2012). The Reagan Test Site (USAKA) is an ideal site for observing new foreign launches; maintaining the near earth satellite catalog; and tracking and surveillance of deep space and synchronous satellites, particularly those in low inclination orbits.

90 Rejcek. (2001). In a bizarre irony, USAKA optics are now being used to track the same astronomical phenomena which first brought many European explorers to the south seas, such as the eclipse of Venus behind the moon. As of 2001, the range had provided more than 32,000 observations of near-earth and deep space objects.

91 US GAO. (2001): p51.

92 USAKA is already an important national resource: it is the largest private employer; it is also the largest source of tax revenues for the RMI government: American's working on the base do not pay US income tax - they pay 5% of their salary to the RMI government. Revenues from the base account for 25% of RMI total tax revenue collections each year. See USSD. (2012): "U.S.-Marshall Islands Relations," and Crismon. (2005): p241.

The ri-Kuwajleen have an unprecedented relationship with the United States military:

> "As a rule, the US government and overseas military personnel deal *only* with national governments and do not negotiate with lower-level political leaders or other regional or local 'foreign nationals.' These other national governments then make arrangements with local people. This is one *very* unique aspect of Kwajalein: Marshallese elites, landowners and the local government are all part of negotiations regarding the use of Kwajalein Atoll and its policies."[93]

The military may continue to deny that it is directly responsible for the conditions on Ebeye, but - whether for humanitarian reasons or to maintain the status quo - it is in the US interest to make concessions to the ri-Kuwajleen to smooth out relations. The USAKA administration has shown some willingness to amend the rules in response to Marshallese pressure. One example of this is provided by the changing policies towards Mid-Atoll Corridor (MAC) access. Before Marshallese independence, no access was allowed. Prior to 2002, landowners were allowed to visit their MAC lands for a total of 126 days per year, in three 42 day blocks. Today, in response to community council lobbying, landowners are permitted to return to their islands for 265 days of the year.[94] There is no reason to suppose that further activism-induced changes to official policy are impossible, despite the seemingly 'set-in-stone' nature of the Compact document. While new construction of housing is still forbidden in the MAC, changes to the frequency and nature of the missile testing in recent years suggest that there may be more flexibility in the future.

Further, there is the question of greater Marshallese involvement in base operations. In the past decade, hundreds of have joined the US military, serving in Iraq, Afganistan and elsewhere.[95] This raises the possibility of Marshallese attaining to more prominent positions at USAKA: for impoverished people of Ebeye, with little access to education, involvement with the military is an attractive option. This may also become more feasible as the nature of US operations changes here in the future. For example, though the recent SpaceX launches at USAKA have been experimental, and SpaceX does not intend to utilize the facility in a permanent manner, the possibility exists that Kwajalein could be an economically attractive location for certain

93 Crismon. (2005): p358.
94 Yokwe Online. (2012): "Ambassador Responds to Questionable Notice." It is also important to point out that the reason there have been no further sail-ins is not due to a lack of will, but rather a concientious tactic on the part of the Marshallese, who realized that the military adminstration responds more favourably to negotiation than protest.
95 Ibid: "Marshallese in US Forces are Deployed in Operation Iraqi Freedom." In 2008, a Marshallese soldier, Staff Sgt. Solomon T. Sam, was killed in Iraq - the first Marshallese casualty as a US soldier. See also USSD (2012): "Marshall Islands / U.S.-Marshall Islands Relations."

types of launch operations which benefit from the equatorial position. Satellite launches could one day be a regular occurence, and would open the door to future opportunities for local involvement. However, the greatest potential - and a significant challenge - is the development of educational opportunities for local people which will give them the option to pursue more lucrative careers at home and abroad.[96]

Arkansas Atoll

The Marshallese are leaving their islands by the thousands. Many follow in the footsteps of one man - John Moody - to a little town in the foothills of the Ozarks called Springdale, Arkansas. While not everyone dreams of moving to Springdale, everyone in Majuro has heard of Arkansas. In 1979, Moody got a scholarship to study at the University of Oklahoma. But his education at home did not prepare him well, and eventually he dropped out of school and ended up working at a chicken plant in nearby Springdale at around the time when the Compact of Free Association came into effect back home, enabling him to remain in the United States indefinitely. He stayed and did well for himself. As the unemployment rate back home climbed from 12% in 1988 to over 30% by 1999, Moody became the first Marshallese homeowner in Springdale. He urged his friends and relatives back home to join him.[97] Soon, there were hundreds of Marshallese in Springdale. They slept on his crowded floor until they had earned enough to find their own places to live.[98] It is unknown how many Marshallese there are in Springdale today, but estimates range upwards from 8000-10,000.[99] And Springdale, though the largest community, is not alone: there are thousands of other Marshallese in the United States, with major communities in Hawai'i, California, Oklahoma and Oregon.

The large numbers of people who have left to pursue work and study abroad represents possibly the most radical change to Marshallese society in modern history. Prior to 1986, there were no more than 300 Marshallese living outside the atolls, most studying at university temporarily before returning home;[100] as of 2010, there were *at least*

96 There are currently only two post-secondary providers in the RMI: the University of the South Pacific, which has a tiny regional campus on Majuro; and the College of the Marshall Islands. While the range of programs is currently quite limited, the organisations have shown a dedication to developing locally-applicable skills. For example, the CMI is involved in developing the Rongelap Pearl mariculture enterprise, and the USP is actively involved in outreach on Ebeye, preparing youth who dropped out of school for Job Corps and post-secondary education. See University of the South Pacific. (2012): "Marshall Islands."
97 Leonard. (2005).
98 Roche, Mariano. (2002).
99 No one is pretending to know exactly how many. The issue is particially confused by US census data, which - when available - categorizes Marshallese simply as "Hawai'ians." See Hezel. (2001); Yokwe Online. (2012): "Marshallese Population Highlighted in Northwest Arkansas Newspaper Series;" and Arkansas Legal Services. (2012).
100 Hezel. (2001): p146.

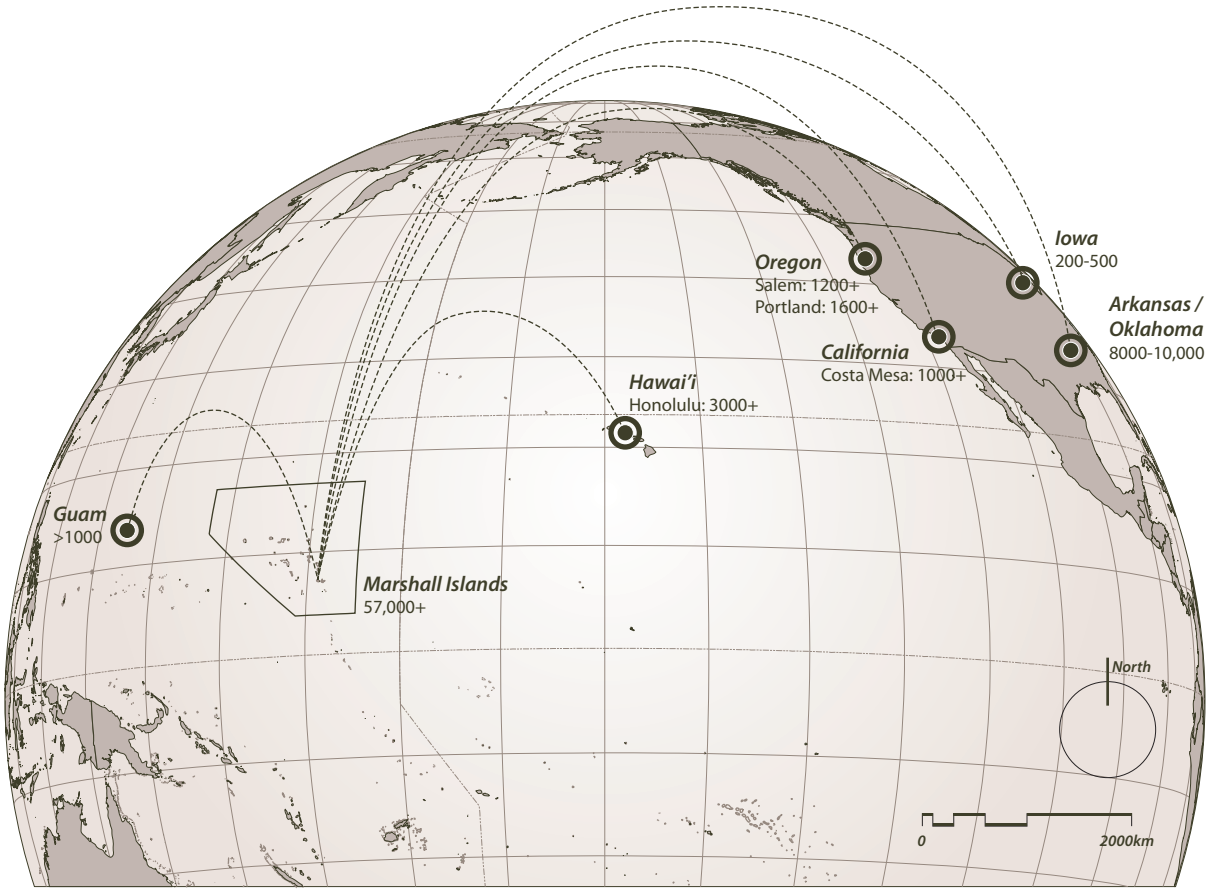
10,500 Marshallese in the United States, some 16% of the total RMI population.[101] This number is fast increasing, as the RMI is losing approximately 2% of its population to out-migration annually - one of the world's highest net emigration rates - slightly outpacing the natural population growth.[102] Some have lamented the damage this is doing to Marshallese culture and the local economy, and sought to lay the blame on the failures of US trusteeship or US policies of strategic denial on the stagnation of the RMI economy.[103] But there is another way of looking at the "Micronesian Exodus."[104] The recent Marshallese émigrés are merely the latest in a long history of islanders who have left their homes, "enlarging their world, establishing new resource bases and expanded networks of circulation."[105] The freedom to migrate negotiated in the Compact makes nonsense of the artificial boundaries which have confined the Marshallese people in the modern period, cutting them off from distant sources of wealth, trade and cultural cross-pollenation which had sustained them in the past. They now move - as their ancestors did before them - within a much larger milieu than single isolated islands such as Ebeye. They have gone seeking education, employment, but most often simply a better life and opportunities for their children.[106]

So ubiquitous is out-migration amongst Pacific islanders[107] and so significant is the value of the remittances and goods they send back home, that academics have coined a term to describe these small island

101 Most estimates put this number much higher: Dvorak. (2007) suggests 15,000 (though the source is uncited); Browne. (2007) estimates up to 20,000 Marshallese in Guam, Hawai'i and the US mainland, based on IMF research.
102 PIPP. (2010).
103 Ibid., p3. RMI Senator Tony de Brum: "This exodus is not just about our citizens taking advantage of a Compact privilege. I think it is an open indictment of the inadequacies of the trusteeship effort as well as a direct effect of the closure of the region and the policy to keep the islands dependent."
104 Ibid.
105 Hau'ofa. (1993): p11. It is important not to overly romanticize this point; Pacific out-migration is not adequately explained - nor is islander motivation given the correct context - by framing it as "an ancient islander characteristic." Goss, Lindquist. (2000): pp397-398.
106 Leonard. (2005). This is especially the case for members of the 'commoner' class: migration to the United States represents an escape from the rigorous traditional caste system. Although the first generation often ends up working menial jobs in the US, their children have access to American education and all the opportunity seen to attend it.
107 Samoans, Cook Islanders, Tongans, Niueans, Fijians and Tokelauans totalling about 170,000 in New Zealand; Fijians, Samoans, Tongans and Cook Islanders for about 85,000 in Australia; Samoans, Micronesians, Tongans and Fijians numbering some 150,000 in the United States; there is a further 17,000 in Canada and 23,000 in France. See Goss, Lindquist. (2000): p398, and Lee, Tupai Francis. (2006): Introduction.

FIG. 3.9

Marshallese Migration



Trans-Nationalism

"In his 'What is Globalization?' (1997), Ulrich Beck proposed the following as counter-aspects to the franchise effect of globalization. First, we are already implicated in social and power relations that are organized at a level that differs from the Modern social unit of the nation-state. Second, the real experience of living and moving beyond the borders of national units is actually now routine. The social system of the Modern nation-state that defined citizens in terms of territory is unable to completely govern multinational corporations, NGOs, worldwide media and other bodies that transcend national borders, while the circulation of people, funds and capital between nations now encompasses us. In encountering and then consuming these phenomena, as in the concrete form of redevelopment, we transform our living environments, and in this way reality has been more or less globalized." Hino. (2011): ¶11.

nations: MIRAB economies.[108] MIRAB is a rather unfortunate epithet, but fitting as it is usually used in a derogatory - or at least cynical - sense. Criticisms generally fall into two categories: those that see chronic out-migration as a threat to the endurance of islander identities in the face of the large and homogenizing melting-pot societies they are joining; and those who are critical of the economic challenges posed by the MIRAB format and suggest that it is not viable in the long-term.[109]

Certainly some migrants never intend to return. But as Francis Hezel writes:[110]

> "Anyone who thinks that Micronesian emigrants abroad simply vanish one day never to be seen again need only scan the departure area of a return flight to the islands to discover that this is far from the case."[111]

Studies of many Polynesian countries, which have had a substantial culture of migration and remittances for several generations, suggest that the diasporic communities remain closely tied to their home islands and to each other in their new home, and that this connection remains strong beyond the first generation of migrants. Available evidence suggests that Micronesians are continuing this trend of "transnational corporation[s] of kin."[112] Marshallese, even from the US mainland, regularly return home to attend funerals, sporting and cultural events, and to reconnect with family. Emigrants send their children home - sometimes for years at a time - to attend school and forge bonds with island life that they will bring with them on their return to the United States; and this process is carried out in the opposite direction too. Goods flow as freely as people: the emmisaries return home with clothes and American foods, and luxuries such as perfume, keyboards, and electronics; and when they leave they carry island foods, artisanal products and handicrafts to relatives abroad. "Goods are exchanged between migrants and their relatives back home just as they would be if all were living on the same island."[113]

108 Goss, Lindquist. (2000): p398. Where *Mi*gration generates *R*emittances, and *A*id funds local *B*ureaucracy to provide the primary sources of income and employment. An even more unfortunate and equally ubiquitous acronym which has come to dominate discussions about insular island states is SIDS - Small Island Development States. The very idea of the SIDS definition is that small islands are somehow handicapped in their ability to 'develop' into modern states by their smallness and geographic isolation, and ignores the more concealed relationships of power which conspire to undermine their success.
109 A nuanced, comparative historical analysis - which is critical of tendancies to over-simplify the trends among islander outmigration - is provided by Goss, Lindquist. (2000). See also Baldacchino. (2011) for a detailed analysis of the politics of vulnerability and an examination of some of the *advantages* of small island economies.
110 Hezel. (2001). This work documents his extensive research among diasporic Micronesian communities.
111 Ibid., p152.
112 Goss, Lindquist. (2000): p398.
113 Hezel. (2001): p153.

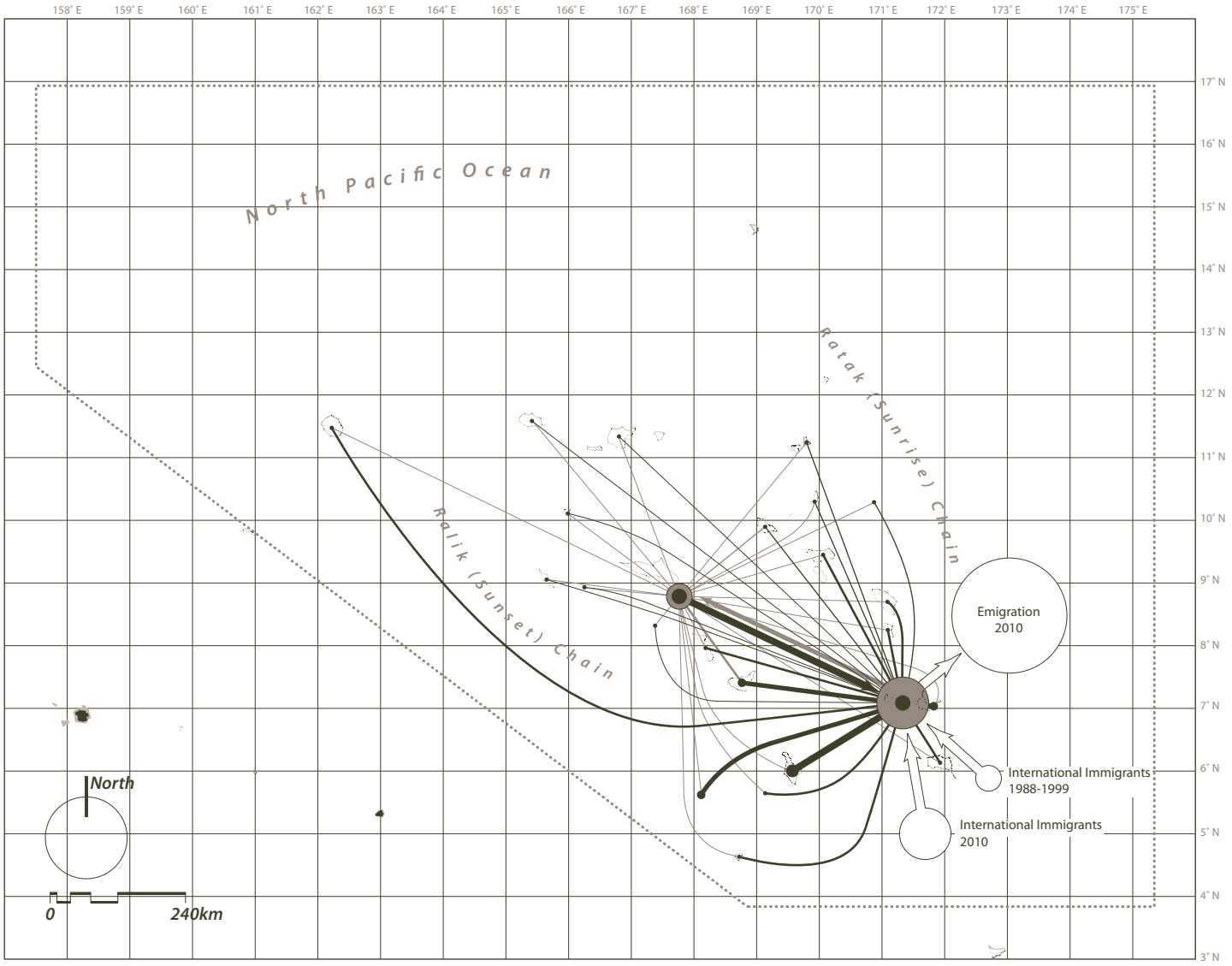
Furthermore, the migrant communities abroad have tended to promote continuing solidarity: Marshallese abroad open churches soon after their arrival, and all of the US communities are tightly knit.[114] The question of the maintenance of cultural traditions and the transition of Marshallese-ness to youth on the continent is taken seriously.[115]

The multi-generational history of emigration in Polynesian countries also suggests that the economic flows of remittances and kinship support are similarly enduring. Several generations into their emigration history, remittances remain a very significant contributor to national income in nations such as Tonga, Samoa and Kiribati.[116] In fact, in general the rate of out-migrations have slowed down or remained constant, while the amount of remittances have increased substantially.[117] Marshallese migrants are still largely in their first generation abroad. There is not yet a significant flow of remittances returning to the RMI from the US.[118] This first generation is largely engaged in menial jobs: working in poultry farms or for low-wage retail and service jobs. But if the Marshallese can be expected to follow the pattern of Polynesians who came before them, their children are likely to be in a much better position to reaffirm connections with the home islands: already stories abound of Micronesian youth in the US studying to be doctors, lawyers, pharmacists and accountants.[119] The migrants are not permanent exiles: in order to have some stake in the future of their islands back home and to maintain title to lands or resources, they will be compelled to continue the cycles of visitation and exchange with friends and family back home. "Kinship, after all, is not bestowed at birth; it is created over time through shared food and presence."[120] Through the processes of "world enlargement"[121] the Marshallese are becoming a trans-national people. The migrants are more than just economic refugees; they are the international representatives of a kinship network which now spans almost half-way around the globe, across the Pacific and beyond.[122] While so far the call of opportunity

114 Ibid., p151.
115 Allen. (1997): p64. This is not true of all communities, and there is criticism amongst emigrant communities over groups which have "gone hollywood" (Americanized).
116 Browne. (2007): pp3-4. Amount of GDP attributed to direct remittances: Tonga - 40% of GDP; Samoa - 25%; Kiribati - 14%.
117 Amuedo-Dorantes et al. (2010). Worldwide, remittance inflows increased from $68 billion in 1990 to $263 billion in 2005, compared with the growth of migrants, from 155 million to 190 million.
118 Hezel. (2001): p152. In fact, the opposite is true: early reports estimate monetary support flows outward from the RMI to communities in California and Oklahoma at rates of 4:1 to 7:1 compared with return remittances. More recent assessments by Hezel of Micronesian remittances suggest the number has grown quickly, and he placed remittances at about 8% of the Federated States of Micronesia's GDP in 2006. No recent numbers are available for the RMI.
119 Ibid.
120 Ibid., p154.
121 Hau'ofa. (1993): p6.
122 Hezel. (2001): p154.

FIG. 3.10

RMI Intersectoral Migration



Inter Atoll Migration (1988-1999)

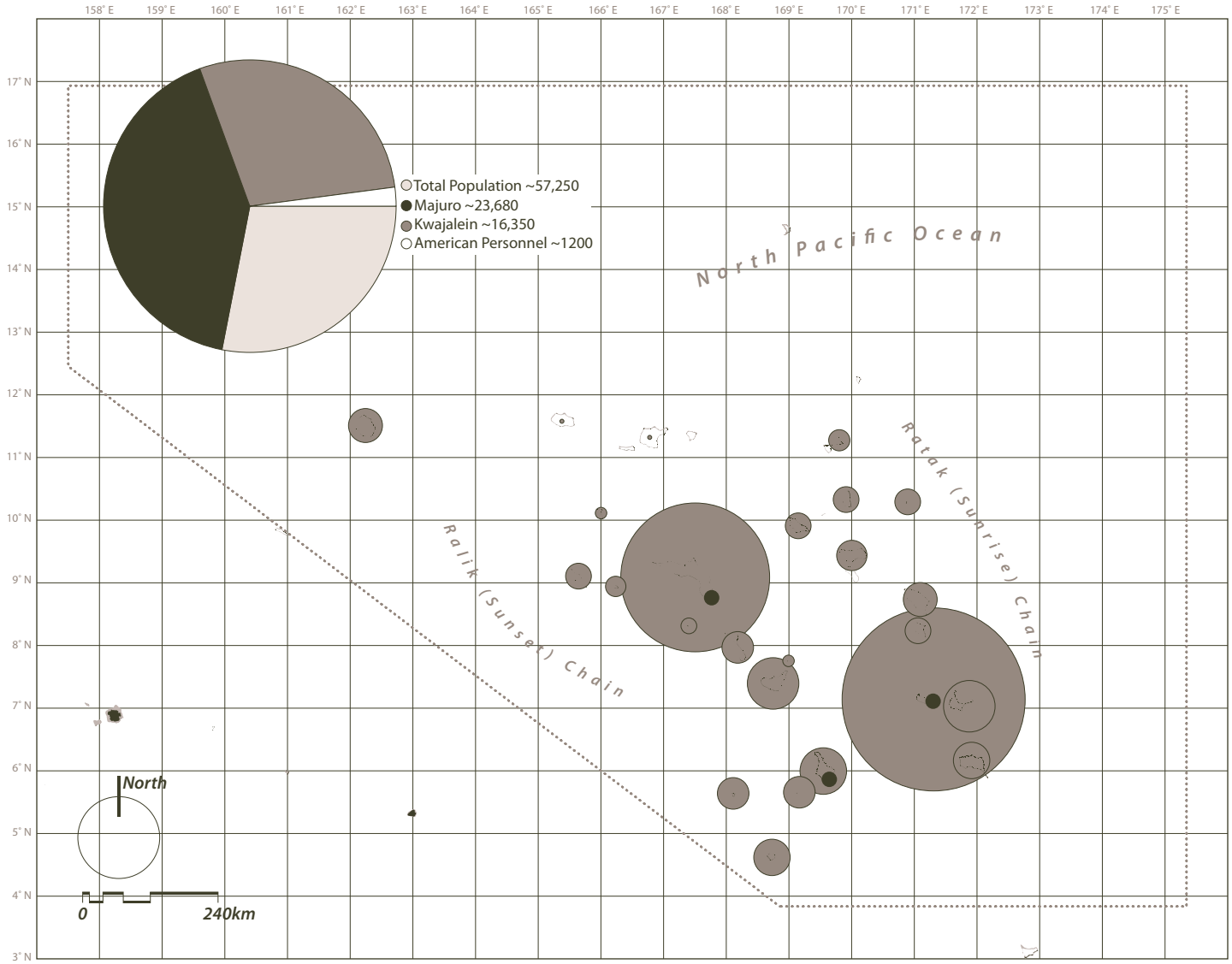
	to Majuro	to Kwajalein
<25 People		
25-50 People		
50-100 People		
100-200 People		
200-400 People		
400-1000 People		

Immigration / Emmigration

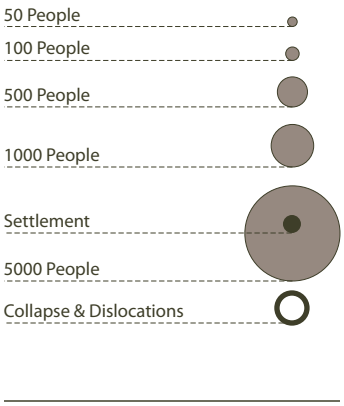
1999 and 2010

International Arrivals / Departures

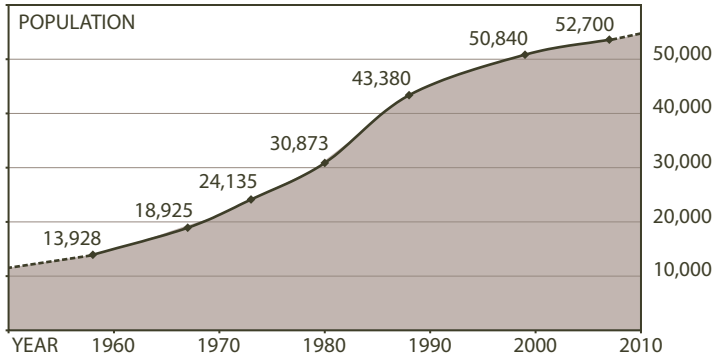
RMI Population Statistics



Population by Atoll 2010(est)



Total Population of the Marshall Islands 1950-2007
(1958-1999 sourced from 1999 census; 2007 projected by SPC)



provided by the United States through the concessions of the Compact have conditioned the directions of their travel, there is no reason to suspect that it will be the limit. Australia has recently signalled its intention to build greater ties with the western Pacific, which may lead to further opportunities for Micronesian migrations. But perhaps the greatest unknown potential lies *within* the Pacific itself: so far the opportunities for Pan-Pacific interconnection have been few, but major developments are on the horizon: oil, gas and foresty in Melanesia, the possibilities of deep-sea mining throughout much of the Pacific, and development projects associated with the military or tourism.[123]

Future Islands?

For the Marshallese people, the questions posed by climate change and emigration are already familiar. A significant proportion of the population has been living in exile longer than the RMI has had independence. Bikinians and ri-Kuwajleen have been telling stories to their children for many years of the bounty and beauty of their lost islands. These groups have already forfeited their resources and been absorbed into a larger polity which does not neccessarily share their interests or wish to argue on behalf of their return. And through the years of their exile, these communities have remained tightly knit, moving together as a group, within the RMI and now abroad. The Bikinians (and the people of Utrik, Rongelap and Enewetak) have maintained their political representation, which is territorially derived from their atoll, in absentia.[124] This represents an interesting jurisdictional fluidity: while the diaspora in northwest Arkansas does not yet have direct representation in the RMI government, the government has established consulates in both the Honolulu community and in Springdale.[125] As the community grows, it raises serious questions of identity and nationality.

Perhaps the most interesting questions raised by the threat of climate change and out-migration are not economic, but legal. Faced with the

123 PIPP. (2010): p4. Australia is dramatically increasing its development and aid activity in Oceania in coming years, and there are other major developments in the works, for example Papua New Guinean oilfield potential. There was a great deal of interest in the 1970's in the potential of deep seabed mining (DSM). Research is ongoing but extraction costs have remained prohibitive. It was DSM which spurred the development of the modern legal definitions of Exclusive Economic Zones, classified by the 1982 UN Law of the Sea. Recent rises in metal costs signal that DSM may have significant importance in the near future. See IOC. Enormous mineral and gas deposits lie on the deep seabed throughout the Pacific, on the abyssal plain under 4000-6000 metres of water. See Bandow. (1983) for a dated but detailed discussion. While DSM remains one of great development dreams for small island governments (it is given significant prominence in government assessments of resources, for example) it is unclear how it might benefit local people, and furthermore the environmental effects are not well known and potentially very serious.

124 Niedenthal. (2012). Bikinians living on Majuro, on Ebeye, and in the United States are all represented in their government by a Senator who is a full-member of the Nitijela. See also RMI government. (2012).

125 RMI government. (2012).

Springdale Marshallese
Workers pack frozen cornish hens at the Tyson chicken factory in Springdale, Arkansas. More than 70% of the Tyson workforce is now Marshallese. Scenes from Carpenter's film *A New Island: The Marshallese in Arkansas* (2012).

International Registries
The RMI has already experimented with forms of revenue generation that call into question the conventional limits and borders of nation states. In 1990, the government partnered with an existing shipping registry to form International Registries Inc. IRI has since become the 3rd largest shipping registry in the world, with more than 2600 vessels worldwide and offices in 18 countries. IRI is unabashedly a 'flag of convenience' - a form of slushy legality in international waters which is often criticized for enabling illicit activity. "Cheap registration fees, low or no taxes and freedom to employ cheap labour are the motivating factors behind a shipowner's decision to 'flag out.'" The International Transport Workers Federation is actively fighting to change laws enabling FOC's, which it sees as exploitative to workers. See ITFGlobal. (2012). An FOC ship flies a flag which is different than the country of ownership; lax or corrupt regulations can be used to launder huge sums of money, traffick in illegal goods or otherwise conceal illegal activity - a form of masquerade which operates with a disposition similar to offshore banks. IRI goes beyond shipping registries; it is also a tax-haven, an offshore business registry generating pseudonyms and aliases for international operators of all kinds. The RMI government offers tax free havens for corporations seeking to operate under its legal umbrella, in exchange for concessions. See Lowtax. (2012). Shady activity is cloaked in legitimacy: RMI corporate law is borrowed directly from its American partners. The consequences made possible by FOC's are well illustrated by the most famous Marshall Islands flagged vessel - the Deepwater Horizon, the oil rig which caused the largest oil spill in history in 2010. See Wikipedia: "Deepwater Horizon oil spill."

loss of their sovereign territory in the coming century, the government of Kiribati has recently entered into talks to purchase land on Fiji, in preparation for the climate-induced evacuation of its population in the coming decades.[126] "This unprecedented situation raises the question: what would be the legal status of an I-Kiribati or Maldives [or Marshall Islands] population on the run from rising waters?"[127] In the traditional format, land is a key component of nationhood. This is uncharted territory, and questions abound. Could the Marshallese state continue to exist? Or would the Marshallese people have to be 'absorbed' into other states? What becomes of the oceanic resources contained within the RMI's existing ocean-holdings?[128] It also raises the question of blame: among global nations small island states contribute the least to greenhouse emissions and yet are most at risk from the effects of climate change.[129] The future of "climate refugees"[130] has opened up entirely new debates about the nature of statehood and the question of international responsibility.

Ultimately, perhaps what is most important is that the Arkansas community has provided a sense of hope in Majuro and Ebeye. Springdale is a problematic solution in many ways: the jobs on the poultry farms taken by many of the emigrants are dangerous and low-paying; they face racism, often lumped together in the minds of locals with the legal and illegal hispanics with whom they share jobs and socio-economic position; and for many, they have simply traded poverty in the Marshall Islands for poverty in the United States. But for most, the good outweighs the bad. The RMI government, besides opening a consulate, has partnered with the Arkansas government at the local, state and federal level to open a health clinic to serve the new community - which is also open to Arkansans.[131] The local community is strong and gathers frequently for many religious, community and sporting events.[132] As John Moody, the original Marshallese Arkansan puts it: "Life over here is everybody's dream. It's hard to explain. Life over here is better."[133] Most emigrants acknowledge that they are unlikely to return home; but back in the islands, some see the children of Springdale as the future for the RMI: "the Marshall Islands is just a little dot, floating around in the ocean. But I tell them that something

126 BBC. March 8, 2012.
127 Kelley. (2011): p56.
128 The current law of the sea has never had to account for the 'disappearance' of land, by which Exclusive Economic Zones are defined.
129 Sem. (2009): p5 & 12.
130 See for example Roy, Connell. (1991): "environmental refugees." A 2010 film documented arguably the first "climate refugees" of the Pacific - the Carteret Islanders. They have been forced off of there home atoll, which has grown too precarious to support human settlement in the traditional manner. See Redfearn. (2010).
131 Yokwe Online. (2012): "Marshall Islands' President Attends Arkansas Health Clinic Dedication."
132 Carpenter, Dale. (2012). Carpenters recent film documents the Springdale community in detail.
133 Walden. (2011). John Moody, the original islander in Springdale.

can come out of this white sand and blue water."[134] The children from Arkansas may one day return, with new plans, new energy, and a dedication to their homeland fostered through continued and energetic connectivity. As imperfect and improbable as it is, Springdale represents a tiny and modest utopia for the 'lost generations' of Majuro and Ebeye that has restored to them what the poet Eduardo Galeano has called "the right to dream - the right to delerium."[135]

* * *

134 Leonard. (2005).
135 Galeano, in an interview with Enzo de Leon. (2011).

"We would, however, point out one aspect of the way in which Micronesian navigators conceptualized their navigational environment which highlights the confidence with which they work. The European, at sea in a small vessel, tends to envisage his situation as one in which his craft moves towards, passes by, and then away from fixed islands. The islands are secure and he is in motion. But Galdwin describes how the Puluwat navigator, once on course, inverts the concept and in his navigational system considers the canoe to be stationary and the islands to move towards and past him. Such a vision seems to reflect a high level of security and confidence in the self-contained little world of craft, crew, and navigational lore.

We accept that the risks and dangers of the sea which seem to weigh heavily in the minds of continental men are not given such emphasis by island navigators today. And we may surmise that a western Pacific islander in the past might well sail east or south or north in search of new land, confident in the belief that, as usual, islands would rise over the horizon to meet him."[1]

- M. LEVISON, R.G. WARD, and J.W. WEBB

1 Levison, Ward and Webb. *The Settlement of Polynesia*. (1973): p17.

Future Systems?
Members of a community group on Arno atoll participate in the installation of a biorock™ reef project - in collaboration with Thomas Goreau and the GCRA - in 2010.

It is now possible to speculate on some tentative answers. The design proposal attempts to frame the problem of how to approach a modernizing future in the atolls in terms of the parallel but independent paradigms laid out in the introduction: the *technical* issues which must be resolved in order to develop a format for inhabitation in the atoll environment cannot be separated from the *social* issues which neccessarily accompany them - and condition their success or failure. The participation, decision-making and priorities of local people will be an insurmountable obstacle if they are ignored, but also represent the most valuable resource for developing change if they can be addressed and harnessed.

In approaching the technical issues (ie. what forms of urbanism or inhabitation are appropriate and sustainable in this environment, and how might islanders engage and manage their landscape effectively?) it is useful to begin by making note of some emerging technologies which may have the capacity to radically transform life in Oceania in the near future.

The first of these 'future systems' has already been mentioned briefly in the context of Hilbertz' work: OTEC. Ocean Thermal Energy Conversion is not a new technology in the sense that proposals to utilize the temperature differential between deep and surface ocean water to generate electricity have been around since the 19th century; however, until very recently a number of serious technical difficulties have prevented further development of the concept.[2] The technology required to make large scale OTEC energy generation feasible on an economical scale has only recently become available. Today, several groups, including the US military,[3] have large OTEC projects in the works which the potential to radically transform the geo-political situation of island nations. The benefits of OTEC are manifold: first

2 Finney, K.A. (2008): p17.
3 Ibid. The major players in OTEC development are currently a Japanese initiative run out of Saga University by the Science and Technology Agency of Japan, and various research projects run by the US Department of Energy - in Hawai'i, Puerto Rico and Guam.

and foremost, it makes an enormous reserve of very cheap, clean energy available for tropical coastal communities; secondly, OTEC systems can simultaneously act as desalination plants, producing fresh water for drinking and irrigation on a large scale; third, the cold water brought to the surface in the tropics is rich in nutrients, and could be used to develop highly-productive mariculture operations.[4] With the looming oil crisis and criticism of non-renewable or dangerous (ie nuclear) forms of energy production, island nations in the tropics might one day have the conditions necessary to attract large-scale manufacturing or other industries which require cheap energy for their facilities.

Along the same lines are a number of other renewable energy sources which may have advantageous effects on the economies of small island states. One example is the recent development of kite-sail systems for large container ships.[5] A post-carbon global economy may radically transform the routes and economies of scale in the global shipping industry. While today the vast majority of ships ply the shortest-distance routes across the north Pacific between Asia and North America, a return to wind-power utilization may bring shipping routes into the tropics. In combination with OTEC plants, island nations might in the future become important transhipment hubs, waystations powering up cargo ships which combine electric motors with wind power and route optimization to lower shipping costs - and increase sustainability - to unprecedented levels.

Another emerging energy source which may soon be important in this regard are algal biofuels. There has been a massive campaign in recent years in the race to develop biofuel facilities which can compete with or even outperform in the long-run the traditional methods of oil extraction.[6] Even the US military - the largest buyer in the world energy market - has shown a progressive interest, releasing a request for proposals in 2012 that would grant a $7 billion contract to help the military become petroleum-free by 2040.[7] While much of the early research into biofuel production facilities has focussed on land-based operations - usually in arid regions where they can take advantage of optimal solar access - a Spanish company, Algasol Renewables, has developed a 'floating bag' system for industrial scale micro-algae

4 Ibid., pp21-22. OTEC offers up a plethora of other potential advantages, including uses such as refrigeration, air-conditioning, cold-water agriculture (the growth of temperate plants in tropical environments made possible by running cold-water irrigation pipes through the soil) and many other potential advantages.
5 See Skysails GmbH. (2012) for a good introduction to the current state of the technology; Skysails is the current leader in this technology.
6 The US Department of Energy for example, has invested an enormous amount of money in research and development focussed on replacing the $1 billion dollars a day the US spends on imported oil. They have R&D programs exploring bio-diesel, jet-fuel, gasoline, and how to replace petroleum products with biofuel products. See US DoE. (2011).
7 Daly. (2012).

production on the sea surface.[8] The atoll environment could be one of the best environments for deployment of Algasol style biorefinery: seawater is at an optimum warm temperature; reefs create protected environments to protect bags from storm events; and huge portions of the lagoon environment are biological deserts - fields of coral sand with quite low diversity of life, and will be largely unaffected by a loss of solar access.[9]

These and other 'future systems' are compelling arguments to be hopeful that the peripheral economic and geo-strategic position contemporary island nations now find themselves in may soon be a thing of the past.[10] However, these future technologies raise as many questions as they answer, and as always, while the potential benefits to island governments and wealthy elites are obvious, it is unclear how these types of projects might benefit or engage with local people. Any proposal which considers a dreamed-of future for the Marshall Islands is dealing in a kind of utopian vision - whether that vision is far-fetched, revolutionary, and reliant on untested technologies, or modest and based in grass-roots action, it will be attended by a whole host of effects and relies upon vague assumptions about a not-as-yet revealed future world which will dictate its validity. It is important in this sense to caution against a vision for the future which is teleological - one which has a pre-determined end-condition in mind. It is impossible to speculate what the future will bring: it will no-doubt be as unlikely as the recent past.

This proposal takes the position that making use of existing technologies - both traditional and contemporary, imported from successful examples abroad - it is possible for the Marshallese to begin working immediately on the transformation of their land and sea-scapes to construct a new and unique system of inhabitation and livelihood production. Successful outcomes can be achieved by starting small, working locally with modest groups of people, cheap

8 Williams. (2012). Essentially, plastic bags filled with fresh water are floated on the sea surface. Sea-based algae farming has several important advantages over other photo-bioreactor designs: surrounding sea-water acts as a temperature control buffer - while land based PBR's would require a cooling system which would add to energy consumption; secondly, wave action automatically mixes the algae in the bags, a process which is usually achieved by mechanical means on land based PBR's; thirdly, floating oceanic locations provide optimum solar access at industrial scales, which takes up enormous space to duplicate on land.
9 See Williams. (2012), and Algasol Renewables. (2012).
10 Several other future potentials are worth brief mention. As noted in the last chapter, Deep-seabed mining represents an enormous avenue for development, and the RMI - like other Pacific island nations - has enormous mineral reserves which might become important industries in the future. Another interesting technology is the development of VLFS's - Very Large Floating Structures. Several projects have demonstrated the potential of constructing massive structures which float on the ocean surface, and might one day provide ideal investment opportunities. Paired with OTEC, VLFS's could provide the space required for large-scale industrial or manufacturing in the atoll environment. See Watanabe et al. (2004) for discussion of current technologies and design.

and easily implemented technologies, and the creativity, experience and innovativeness fostered by involvement in the production of a personal stake in ones future. The design does not propose a final condition, but suggests an array of systems, techniques, and livelihoods which - considered together - will empower local people to experiment and develop a format for inhabitation which is sustainable in the long-run, provides a better quality of life than the contemporary urban conditions offer, has as many of the perceived benefits offered by both traditional and western ways of life, and is adaptable to the vagaries of change to come.

Two recent developments illustrate this way of working. The first, a program called The Micronesian Challenge, is "a commitment by the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, Guam, and the Commonwealth of the Northern Marianas Islands to preserve the natural resources that are crucial to the survival of Pacific traditions, cultures and livelihoods."[11] The challenge is an inter-governemental initiative with a number of partners - including US agencies, NGO's, other governmental organizations, and private enterprise - developed with the goal of conserving and protecting 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia by 2020. The Challenge has engaged in a wide array of activities, including re-establishing traditional vegetation regimes, research, documentation of existing resources, and working with governments to develop legislation which is capable of acknowledging and protecting these resources. One of the more well-known outcomes has been the announcement in 2011 that the RMI had declared the entirety of its territorial waters a shark sanctuary - the largest in the world.[12] But, perhaps most importantly, the Challenge has initiated large-scale outreach and education programs promoting sustainable fishing practices, teaching traditional subsistence techniques, and educating local people about how to obtain resources and manage their local environments to provide for their communities.

The second example is related: in early 2010, Thomas Goreau and the GCRA - funded by the German government Task Force for Humanitarian Aid - collaborated with local community leaders and the Pacific Aquaculture Cooperative[13] to install the first biorock™ projects in the Marshall Islands. Three reefs were installed in separate community locations on Majuro and Arno atolls - one each powered

11 Micronesia Challenge. (2012): "About the Challenge."
12 Black. (2011).
13 The PAC is a "global aquaculture business enterprise whose primary mission is to provide strategically engineered aquaculture solutions to the world aquaculture industry as a modus operandi of economic and environmental sustainability to SIDS (Small Island Developing States) and developing countries for economic development, environmental sustainability, and sustainability of the global food chain from the bottom up." See PACI. (2006).

by wind, solar, and wave power - and involved the local community in training, facilities construction, and future planning.[14] Goreau sums up the goals and motivations of the projects:

> "The results of these pilot demonstration projects dramatically demonstrate that local communities can use their own vast and untapped sources of sustainable energy to grow back their coral reef and fisheries resources and protect their islands from erosion by global sea level rise. There is a critically urgent need to replicate this example on a large scale in all low-lying island nations and coasts before global sea level rise accelerates."[15]

Both of these projects are noteworthy here not so much for the radical change they have achieved - they are both far-sighted projects which will take time to have an effect - but rather for the combination of government support, stakeholder participation, and long-range vision they demonstrate. These projects clearly attest to the willingness and capacity of local groups to participate in open-ended experimentation if they are included in the discussion and planning of their own future.

Kininwatne

In the Marshallese story-telling tradition, there are certain stories called *inoñ* which are not terribly serious in nature but nevertheless convey through myth-motifs essential facts about historical and social reality. The Jebro and Letao myths introduced earlier are good examples. To signal to the listener that this is such a story, the *bwebwenato*[16] opens the narrative with the word *kininwatne,* and ends the story - often abruptly, with the words *jirib inon*, meaning simply 'the end.'[17]

The title of this chapter refers to another such kininwatne story, and one which is in fact almost universal among Polynesian and Micronesian cultures, hinting at an ancient antiquity and the pervasiveness of the voyaging seafarers who shared these stories over past millenia. It is a creation myth, perhaps best known in its Hawai'ian incarnation in which Maui fishes the Hawai'ian islands out of the sea.[18] The story appears in many different forms throughout Oceania, and in these different incarnations it hints at the similarities and divergences between the cultures who tell them. The Marshallese version of the story is curious for its matter-of-fact tone: in these stories it was not gods but men who brought the islands into being, raising them from

14 Jormelu, Hagberg & Goreau, PhD. (2010).
15 Ibid., p2.
16 TRANS. story-teller, myth-teller MAR.
17 Tobin. (2002): p187.
18 Nunn. (2003) provides a fascinating survey of the geography of origin stories amongst Pacific islanders and the relation of these stories to the location of cultural groups. He contrasts the two fundamental forms of these stories - 'fishing up' vrs. 'throwing down' myths - and notes the relationship between these stories and the local geological histories of various island groups.

the sea and populating them with all the plants and animals which have sustained the people since antiquity.[19] Of course these stories are not meant to be interpreted literally; yet they reflect the all-pervasive historical fact that the archaic Marshallese completely transformed the terrestrial ecology of these islands to suit their needs; in many ways it is true that they brought them into being - with all of the technologies and cultural practices they carried with them and developed along the way.

The proposal builds on this idea, conceptualizing a mode of life in the atoll environment which recognizes that islanders have always 'raised' their islands out of nothing, and theorizes that this process might continue with the adoption and adaptation of new technologies and practices. The proposal also involves looking at the environmental condition in ways which will not be unfamiliar to island people: rather than measuring in terms of land area and rainfall to determine the capacity of the terrestrial landscape, the proposal considers the marine landscape as an inseparable and essential component in the capacity of the atoll to support human endeavour. The process describes the possibility of quite literally 'raising islands' from the reef shelf. Through the productive labour of a generation of people, motivated by the possibility of bequeathing an enduring legacy to their children - a powerful incentive - the littoral environment is transformed into a landscape of islets and productive mariculture facilities. This is not about 'reclaiming' land in the usual sense it is meant in the west, but rather a response to the natural systems which already exist: the system is a catalyst to which the natural processes respond, with the ultimate goal of producing new atoll islets.

The basic concept of the proposal is to utilize mineral accretion technology - biorock™ - to construct a marine infrastructure on the intertidal reef-flats of the atolls, in support of a variety of aquaculture enterprises. This infrastructure doubles as a framework to encourage the natural processes of sedimentation: it proposes to act as a transformative landscape generator, which over time will enable local people - acting in small, incremental ways, with cheap and lightweight components - to manipulate the marine and terrestrial environments in useful ways. The reef-flat infrastructures are paired with a number of activities which take place on adjacent islands and within the near-shore lagoon, including the installation of artificial reefs, the cultivation of seaplants and mangroves, and the rehabilitation of the terrestrial landscapes with the reintroduction of traditional food-crops - and the introduction of new ones.

19 The story is related as part of the origin myth related by Tobin. (2002): pp11-25, and appears under another guise in the origin story of Mile Island, p315.

The system is as much a social proposition as it is a landscape design: the manufacture, installation, maintenance and utilization of the system is reliant on the perceived benefits it can provide to local stakeholders. While there is no specific requirement that ownership and utilization take any rigid format, the intention and advantage of the design is that it is made up of components and systems which are cheap and could be readily fabricated and installed by local groups with a minimum of training. Furthermore, the growth and propagation of the system is open-ended and incremental, such that local stakeholders - individuals, families, or community groups - could organize ownership and share the economic rewards produced by the system. The installation of additional components and the shift from one stage to the next in the development of the system is contingent on the economic success of the stakeholders: ie, the initial investment is small enough to be manageable by local groups, and further investments into the system - additional components, power sources, and equipment such as boats and dive gear to access these systems - will be made only when the system has produced sufficient profit to merit it. The process seeks to engage with the disenfranchisement of the ri-Kuwajleen which has occurred as a result of the exile from their land.

The proposal is organized into three sections. The first section describes the prototype reef-flat site: the typical characteristics found throughout the intertidal environments of the Marshall atolls. There is a great deal more variety than is represented here, but the prototype site embodies the 'ideal' condition: a flat site, not far from adjacent islands, in an area of productive natural reefs but away from the full violence of the north-east reef front. The second section introduces the various systems and techniques which comprise the proposal. All the systems involved represent existing technologies; some are already present in the Marshalls to various degrees, others represent new introductions. The final section projects the proposal fifty-years into the future, and examines the stages of development which will comprise the activities and deployment of systems in this time.

There is no conclusion to the process: it is a stochastic vision which acknowledges the degree of experimentation and adaptation which will be involved, and the future potentials are open to interpretation.

Prototype Site
The reef flats between Ebeye and Kwaj. A shallow intertidal environement, exposed at low tide, but periodically subjected to fierce storms and currents.

The proposal begins with the choice of a suitable prototype location. From a bio-mechanical standpoint, the system can be installed on any reef-flat - one of the most common natural environments in the Marshall atolls. For the purposes of understanding the relationship of activities and progression of the system over time, this proposal examines this singular site only; however, it should be noted that many of the productive activities involved would benefit greatly from the economies of scale which would be provided if multiple sites were developed simultaneously. Thus, the development of this site should be imagined in the context of a cluster of neighbouring sites spread across the atoll - a network sharing resources, building up the infrastructures required for packaging and export, and allowing the mobility of people within the atoll itself and beyond.

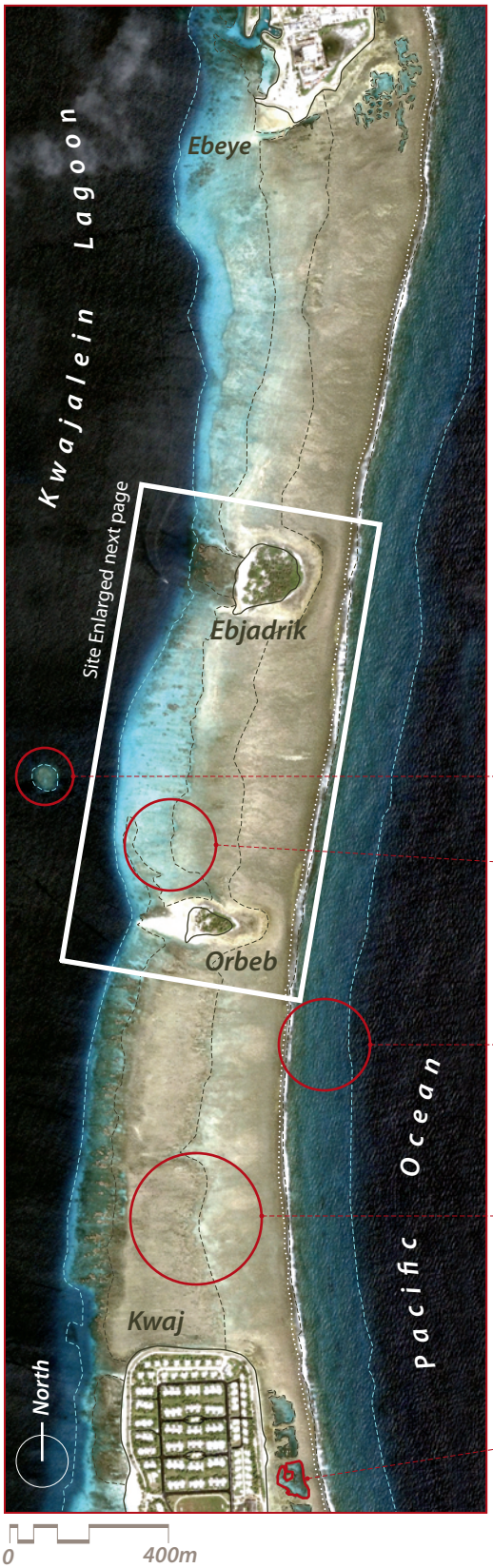
The reef-flat site is a complex and variable intertidal environment. When considering the effects of erosion on the movement of sediment, tidal action is the most powerful and regular erosive force, but the effects of localized currents, ocean swells, and exposure during storm events must not be underestimated. The tidal regime is semi-diurnal: that is, there are two high and two low tides daily; typically one of the two tidal events is significantly larger than the other each day. This asymmetry is most pronounced during "sping" tides (when the sun and moon are in syzygy during full/new moons). Twice each day, an enormous flow of water overtops the reef crest and spills into the lagoon, rushing with localized currents approaching 10 knots; hours later, as tides recede, the flow reverses as the surrounding ocean level drops below the water level in the lagoon.

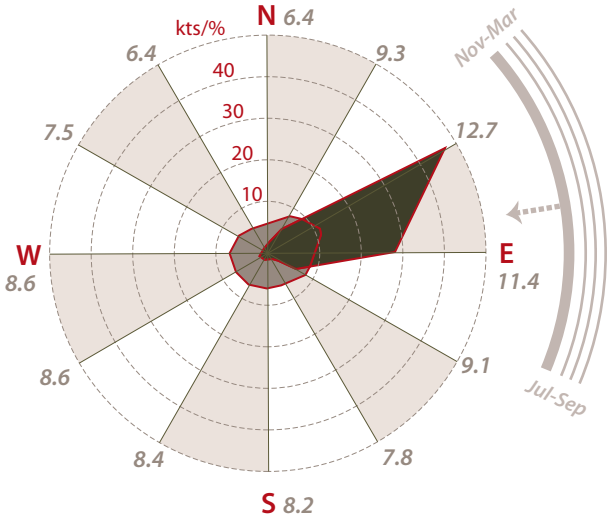
Other significant erosive forces include: powerful longshore drift (littoral currents) which move parallel to the shore, created by the deflection of ocean swells along the reef front; localized currents created by wave interactions with islands and reef outcrops; and powerful and unpredictable effects created by singular storm events, which may overtop atoll islands, and in extreme cases have completely scoured entire islands from the reef shelf, or created new ones overnight.

The site consists of an 800 metre long section of reef flats, approximately 200 metres across, 100-150 metres from the wave crest and forereef. It is characterized by a broad, relatively flat intertidal back reef consisting of sand, coral rubble, and living corals which form thousands of 'micro-atolls'. The reef flat slopes gently towards the lagoon, where the hard-scoured reef limestones are gradually replaced with sediments and beds of sea-grass. Most of the reef flat is completely submerged during normal high tides, which have a maximum variation of *ca*. 1.8 metres, but on average vary by about 1.2m. During extreme low-tides it is possible to walk between Ebjadrik and Orbeb.

Kwajalein has a large tidal range compared with many Pacific atoll islands - the actual conditions vary within localised areas. The most severe tidal ranges can be observed along the north-east reef ridge from Bikej to Namur; this is due in part to the angular geometry of the atoll rim which causes complex current interactions and in part to the onshore pressure created by the predominant northeastern swell. Along the southern coast of the atoll the swell generates a powerful littoral drift from north to south on the seaward face of the reef shelf. Additional currents vary with tide and weather conditions, but there is a southward trending longshore current on the lagoon slope, with a focus on the harbour of Kwajalein Island to the south. These currents, in combination with a large reef fetch (length of living reef to the north) suggest that sedimentation will occur here quickly and predictably on both lagoon and seaward interfaces.

Prototype Site - Location





Coral head
One of literally thousands of reef outcrops in Kwajalein's enormous lagoon.

Back-reef
The lagoon / reef flat interface is a diverse ecotone, containing reefs, sandy flats, rubble, and sea grass beds.

Fore-reef
Living reef seaward of the reef crest; highest productivity & species diversity; high wave energy environment. The reef face quickly drops off from sea level down to several thousand metres depth. Living reef occupies only the top 50 or so metres.

Broad reef flats
The seaward reef flat in this area is >400m wide and partially exposed at low tide. This zone is composed of coral sand, broken coral rubble, living corals, and mud; generally protected from high wave action, it is periodically subject to high wave turbulence during storm events.

Tidal Pools
Adjacent to many of the inhabited islets are excavated tidal pools, typically 1-4m deep. Created as a result of land reclamation efforts; dynamited rubble was removed to build up adjacent islets.

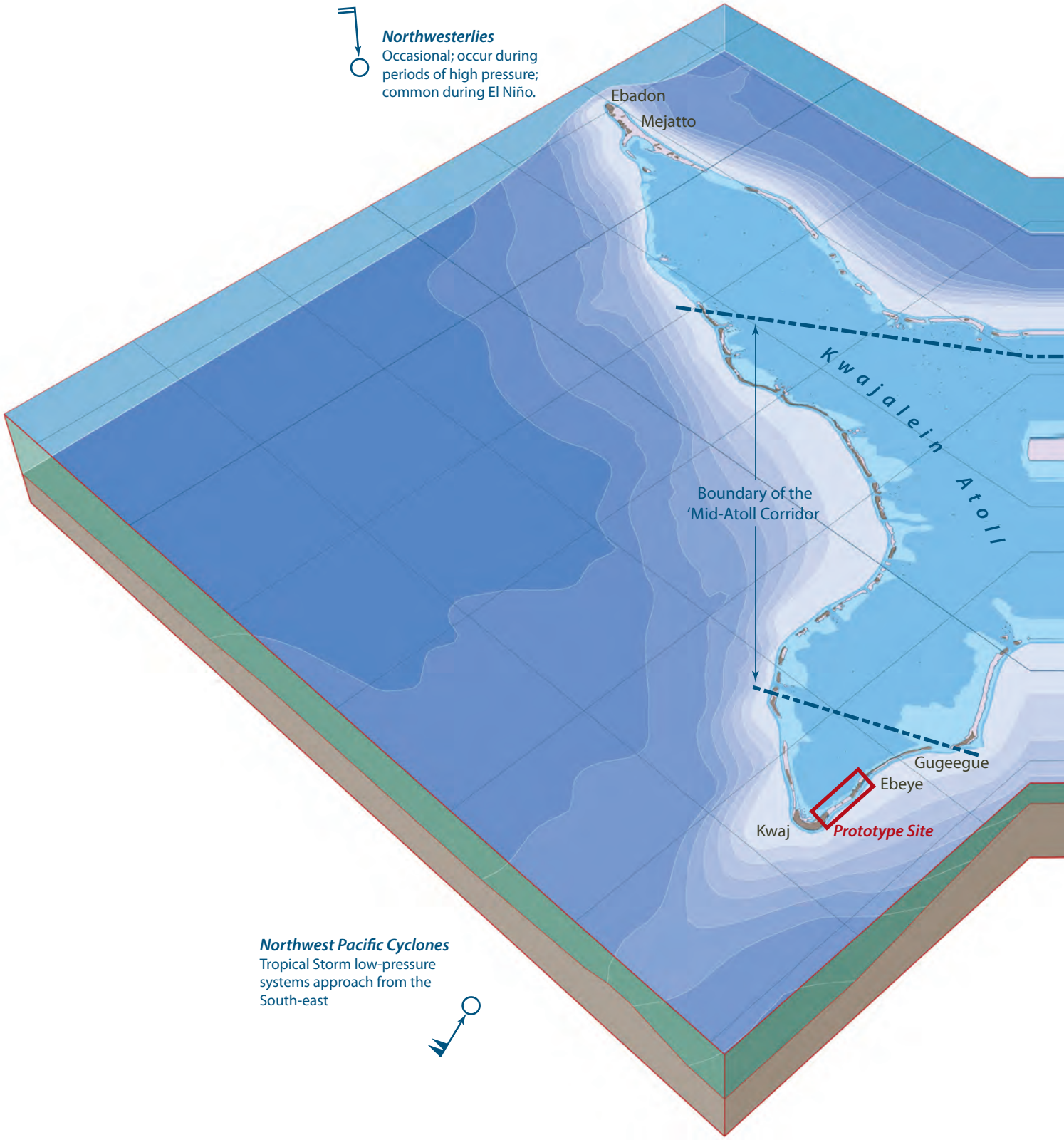

Northwesterlies
Occasional; occur during periods of high pressure; common during El Niño.
Ebadon
Mejatto
Kwajalein Atoll
Boundary of the 'Mid-Atoll Corridor
Gugeegue
Ebeye
Kwaj
Prototype Site
Northwest Pacific Cyclones
Tropical Storm low-pressure systems approach from the South-east

FIG. 4.2

Kwajalein Atoll – Reef Flats

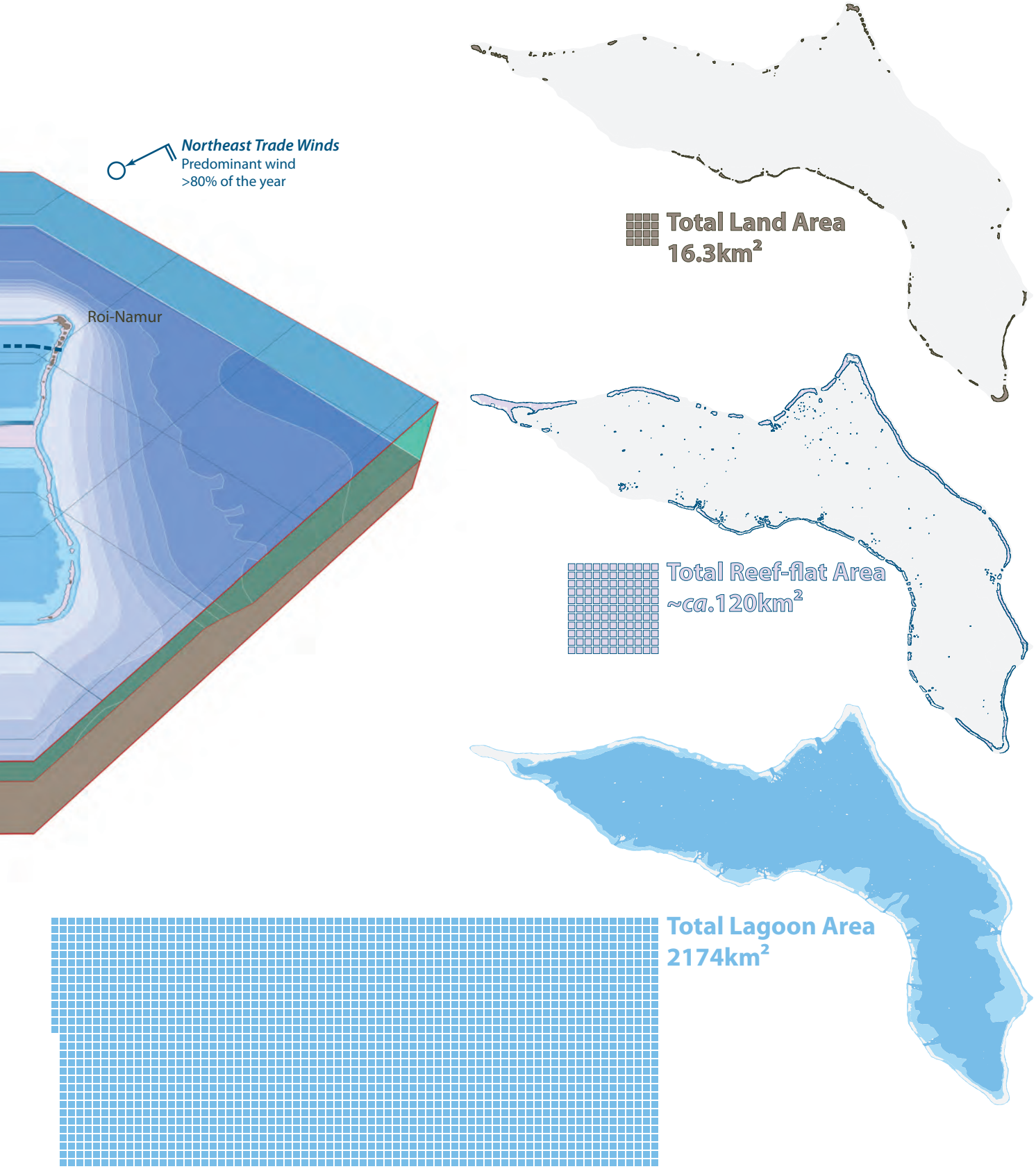
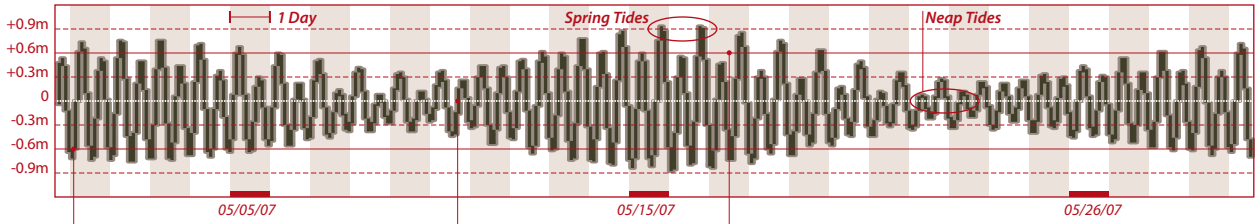


FIG. 4.3

Site Characteristics

Tides & Sea Level

Tide chart for a typical month in the southern portion of Kwajalein atoll (May of 2007).



MLLW
Mean Lower Low Water

MSL
Mean Sea Level

MHHW
Mean Higher High Water

Sediment plumes & scouring

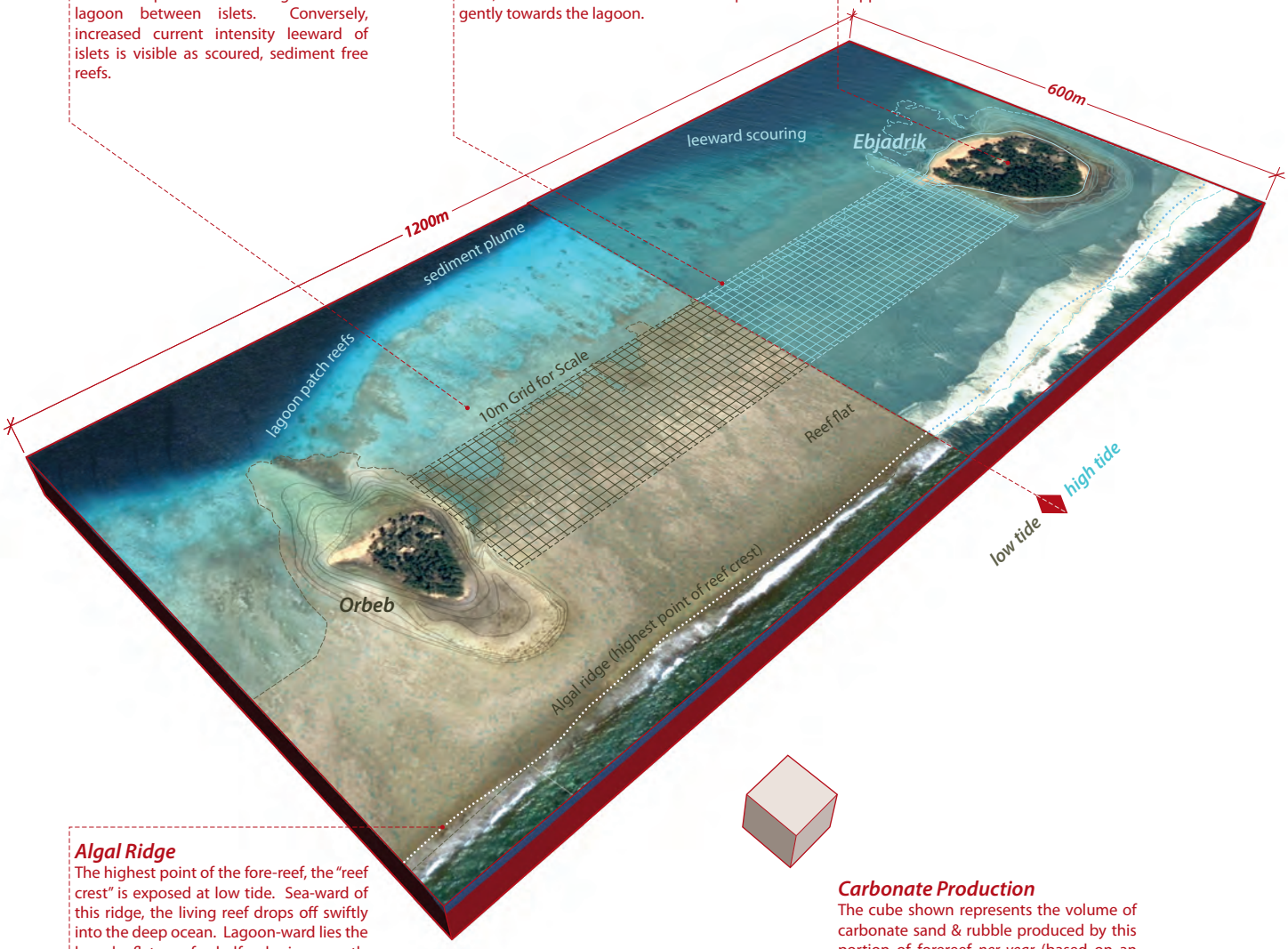
Refraction interactions between two atoll islets create low-energy current conditions ideal for sedimentation, visible as sediment plumes extending into the lagoon between islets. Conversely, increased current intensity leeward of islets is visible as scoured, sediment free reefs.

Prototype Site

The site is approximately 150x900m, characterized by relatively flat intertidal reef flats made up of sand, scoured coral beds, and raised micro-atolls which slope gently towards the lagoon.

Micro-islets (Motu)

Ebjadrik & Orbeb are typical *motu* (sand islets) which, despite dense palm & pandanus vegetation, are too small to support a reliable fresh water lens.



Algal Ridge

The highest point of the fore-reef, the "reef crest" is exposed at low tide. Sea-ward of this ridge, the living reef drops off swiftly into the deep ocean. Lagoon-ward lies the broad, flat reef shelf, sloping gently towards the lagoon.

Carbonate Production

The cube shown represents the volume of carbonate sand & rubble produced by this portion of forereef *per year* (based on an average rate of 4kg/m^2/year).

The prototype site is located adjacent to the most at-risk population in the RMI - the people of Ebeye. This site is a contested space, the border territory between the Marshallese governed islands of Ebeye - Gugegue and the US Army airbase on Kwajalein Island. On the one hand, occupation and successful utilization by Marshallese people of sites such as this, and elsewhere in the contested outer islands of Kwajalein atoll, is an essential step away from dependence on American aid. On the other hand, a location between RMI and US administered islands, and visible to every incoming flight to Bucholz Army airfield, engenders the site with a symbolic importance, an emblem of Marshallese / American partnership and a shared future.

As Fig. 4.2 demonstrates, the area of intertidal reef flat sites on Kwajalein atoll is about 10 times the available dry-land area: at more than 120km^2 it represents an enormous potential resource. However, about 70% of this area is contained within the Mid-Atoll Corridor. This does not neccessarily preclude this area from consideration; but access to this area for the purposes described will require the co-operation of the military. Furthermore, the marine resources of Kwajalein atoll are not free for the taking: the reefs, reef-flats, and other submarine features are the property of the clans which once lived on the adjacent islands. The utilization of any of the territory within the atoll would have to be negotiated with the traditional owners.

Mangrove Cultivation
Men tend to mangrove seedlings in Indonesia.

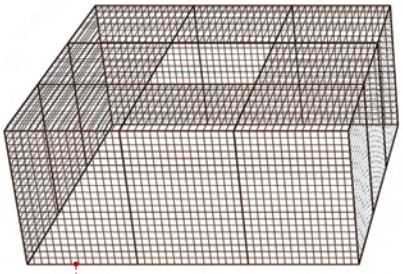
The systems and components which comprise the design proposal are presented in the following section. They are organized chronologically: in order of appearance in the design sequence.

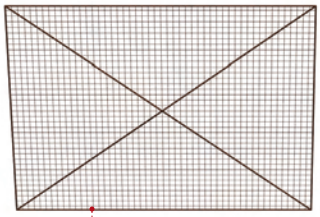
- Component Assembly
- Mineral Accretion
- Power Units
- Artificial Reefs
- Reef Seeding & Coral Mariculture
- Sedimentation Array
- Pearl Farming
- Construction Components
- Aquaculture
- Seaweed
- Mangrove Cultivation
- Garden Planters
- Living Machine
- Dune-Stabilizing Vegetation
- Housing & Cisterns

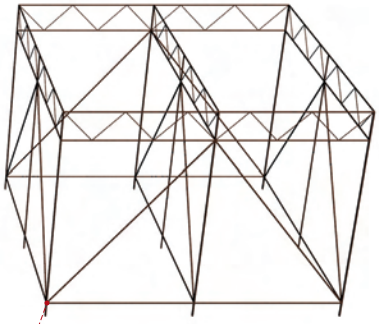
Component Assembly
Central to this proposal are a number of components made from accreted minerals. These components are all constructed from the same simple, cheap, and easily assembled materials: plain steel rebar and welded wire mesh of various gauges. The frames are assembled first from lengths of rebar, bent and cut to shape and welded together. Rolls of wire mesh are then laid over the frame and spot welded at joints. All the components required for the subsequent processes are small enough to be assembled and manipulated by a small group of people, and are designed to be mobile: after assembly, groups of components are rolled into the lagoon. One by one they are floated out using flotation devices, and are then sunk in shallow water at a suitable accretion location. The completed rebar frames are flexible and highly porous to water flow, allowing them to be installed in dense groups without obstructing tidal floes in the lagoon.

This assembly location - what will become a veritable mineral accretion factory at times - is simply the lagoon beach of the settlement island. The only requirements are that there is a power source for running a small-scale welding machine, suitable access for the delivery of loads of rebar and rolls of wire mesh, and a nearby lagoon location of sufficient depth and area for the accretion processes. The assembly events could be sporadic, occurring only when needed (perhaps once every several years at the early stages in the process). Alternately, component assembly could be centrallized for a larger area - an entire atoll, for example - and one location could become the supplier of components for similar enterprises dispersed around an atoll. In either case, expensive welding equiptment and skills can be shared by larger groups of stakeholders than one small settlement such as this.

Component Assembly



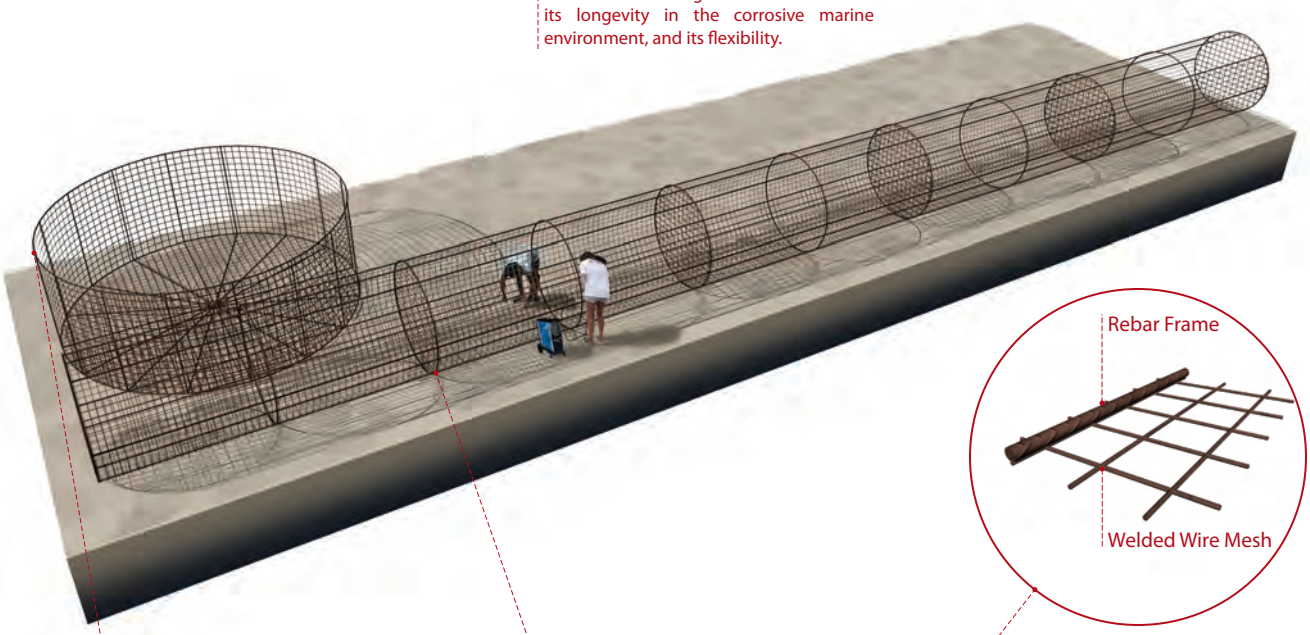




Reef Frame
The reef frame shown here is a simple square, but any form is possible, as shown in the biorock section described earlier.

Construction Components
Biorock does not lend itself well to precision components - the process as carried out in open water has too many variables. However, very simple construction components - grid frames, simple catenary beams, posts, tubes, and tank forms - could provide a more attractive alternative to the currently favoured concrete block / steel roof vernacular. The material is advantageous in terms of both its longevity in the corrosive marine environment, and its flexibility.

Platforms
Intertidal platforms will be essential for many of the seaweed and other mariculture activities in this proposal. While these structures are commonly constructed from bamboo in insular southeast Asia, biorock structures with lashed connections could be the local solution in a landscape with very little timber to spare.



Pens
The round, open-topped pen has multiple uses in this proposal. It is the basic anchor unit which makes up the sedimentation array, it is used as an exclosure pen for reef based mariculture, and it can be used to construct land-based aquaculture tanks and garden pens. They are 4m in diametre, 1.5m high; light enough to be rolled into position with a small group - even with a coating of aragonite.

Spars
The spars - which span between the pens in the sedimentation array - are 20m long and 1.5m in diametre. Once accreted, they form a rigid structural connection between anchor points. They can also be used to build other structures such as groynes or piers to reinforce the shorelines of existing islands.

Materials
All biorock components are constructed from ordinary construction-grade rebar and welded wire mesh. The most costly elements in the process - power sources and anodes - can be re-used many times.

install use

Mineral Accretion

Following assembly, design components undergo a process of mineral accretion in nearshore lagoon locations. They are floated into position and anchored to the lagoon bottom in clusters which allow many components to undergo the accretion process using a small number of reusable anodes. Choice of location is determined by several factors: proximity to the assembly location; areas with sandy bottoms away from fertile beds of sea-grass or lagoon reefs; and water of sufficient depth that the components can be anchored below the low-water mark where they are protected from wave and tidal currents. In the early stages, when only a few components are being created at any one time, they can simply be allowed to rest on the lagoon bottom in shallow water. Later, larger, more complex assemblies can be established at permanent locations in deeper water, requiring dive equiptment and expertise to access and work on them, but where better results can be achieved. The nearshore lagoon location allows the accretion to be carefully controlled and monitored from nearby islets, and provides an economy of scale where large "batches" of components can be constructed at once.

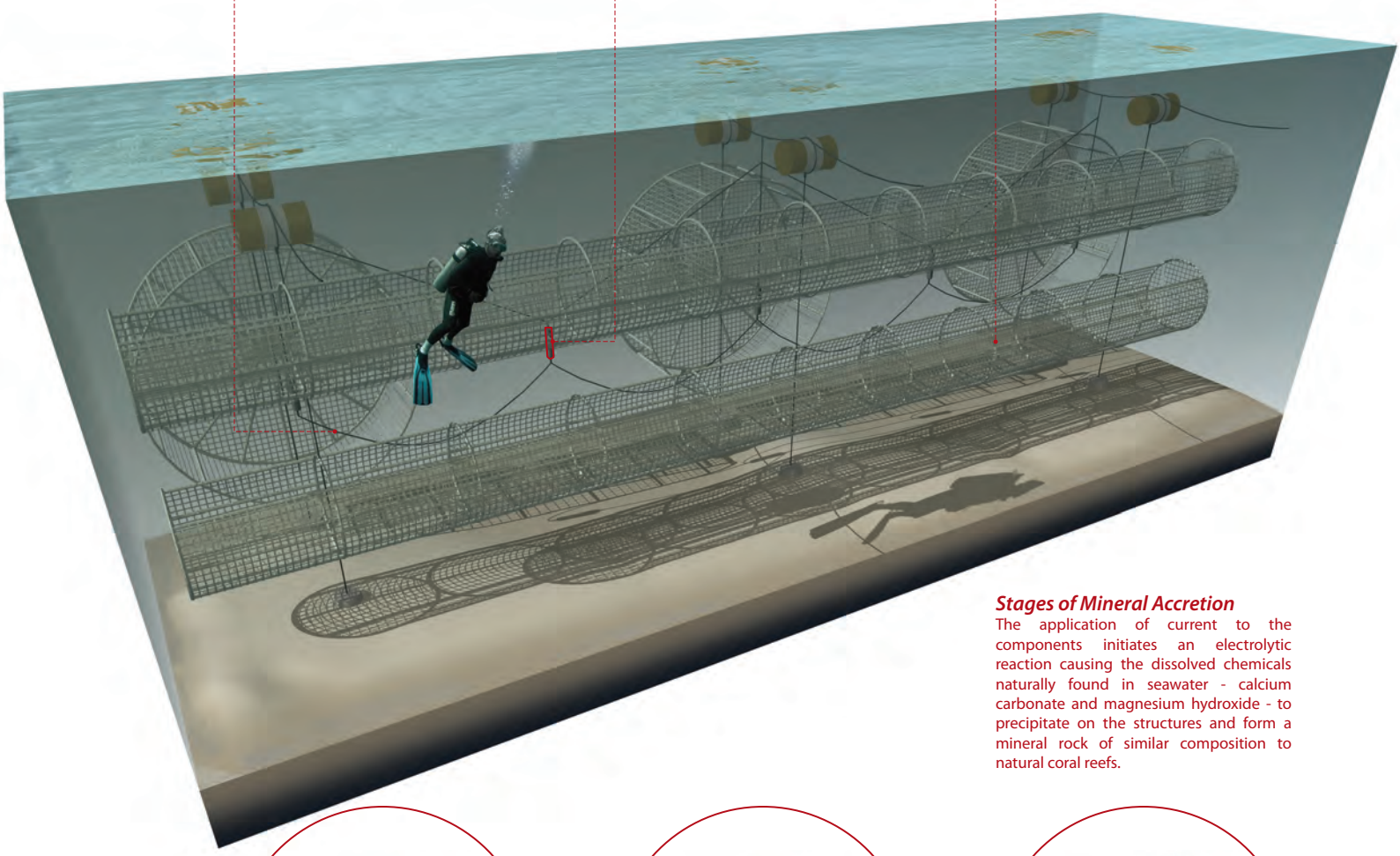
Wave generators provide the low voltage current required to initiate the mineral accretion process; they are anchored at the surface adjacent to the accretion site. Power is administered by running a negative charge to the biorock elements, and a positive charge to regularly spaced anodes, every four or five meters along the array, to form a galvanic cell. Components will be left in position for varying amounts of time, depending on intended purpose. Artificial reef components need undergo no "initial accretion" stage, and can be deployed directly after assembly to final locations. The spar / pen components undergoe accretion for several months to develop a thin coating of biorock which protects them from corrosion in the harsh intertidal environment - these components undergo further accretion after deployment, discussed in the installation diagram. Biorock construction components might require in excess of a year to achieve structural integrity (ie structural components for building of platforms and housing).

Mineral Accretion

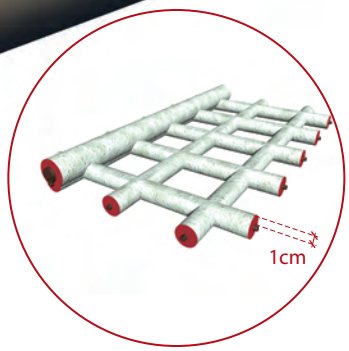
Power Supply
The accretion process requires a supply of low-voltage direct current, though this need not be continuous. The power source should be nearby as it is inefficient to transport low-voltage current long distances and high voltage lines are dangerous. Power is administered at a voltage of between 2 and 16, and from 30 milli-amperes to 3 amperes per square meter of cathodic material. Power consumption is very reasonable: approximately 2 kilowatt hours per kilogram of accreted material.

Anodes
Current is administered by effectively turning the frame into a giant battery: the frame becomes the negative terminal (cathode), with the positive anodes suspended within to form a galvanic cell. Like the wave generators, the corrosion resistant and expensive Anodes can be reused many times, moved from one location to the next.

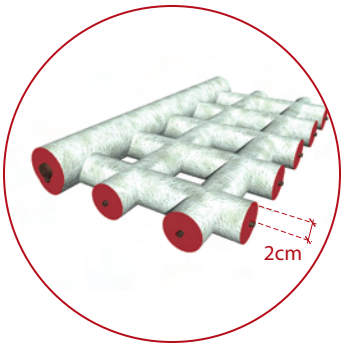
Biorock
The biorock process creates structures composed of accreted Aragonite - a very hard and dense mineral with strength comparable to concrete. Furthermore, the accreted rock coats all steel surfaces and protects them from corrosion, and the biorock process increases the rate of coral growth 3-6 times.



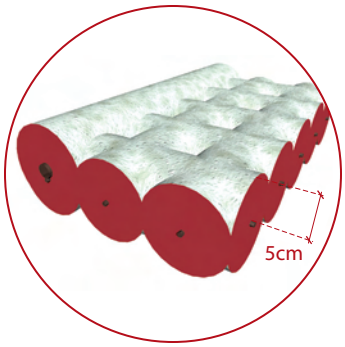
Stages of Mineral Accretion
The application of current to the components initiates an electrolytic reaction causing the dissolved chemicals naturally found in seawater - calcium carbonate and magnesium hydroxide - to precipitate on the structures and form a mineral rock of similar composition to natural coral reefs.



1-2 months of accretion



4-6 months of accretion



Maximum accretion, approximately 12-18 months under power

Power Units
Currently, urban areas in the Marshall Islands (Ebeye, Majuro) rely almost exclusively on large-scale diesel generators for local energy production. Efforts to reduce dependance upon aid and foreign imports must focus upon replacing these inefficient and expensive power sources with a capitalization on abundant natural sources of power. For example, Ebeye and the associated islets to the north are reliant on a single generator, now approaching 30 years of age. The plant has a capacity of 3.6MW, but demand is on the order of only 1.8MW, and the plant consumes approximately 3000 gallons of fuel per day.[20] At current costs of US$2.08/USG[21] wholesale in the RMI, the existing plant costs approximately $2.3 million/yr on fuel costs alone. For comparision, a commercial scale wind generator which satisfies this demand might cost roughly $3.5-4 million installed.[22]

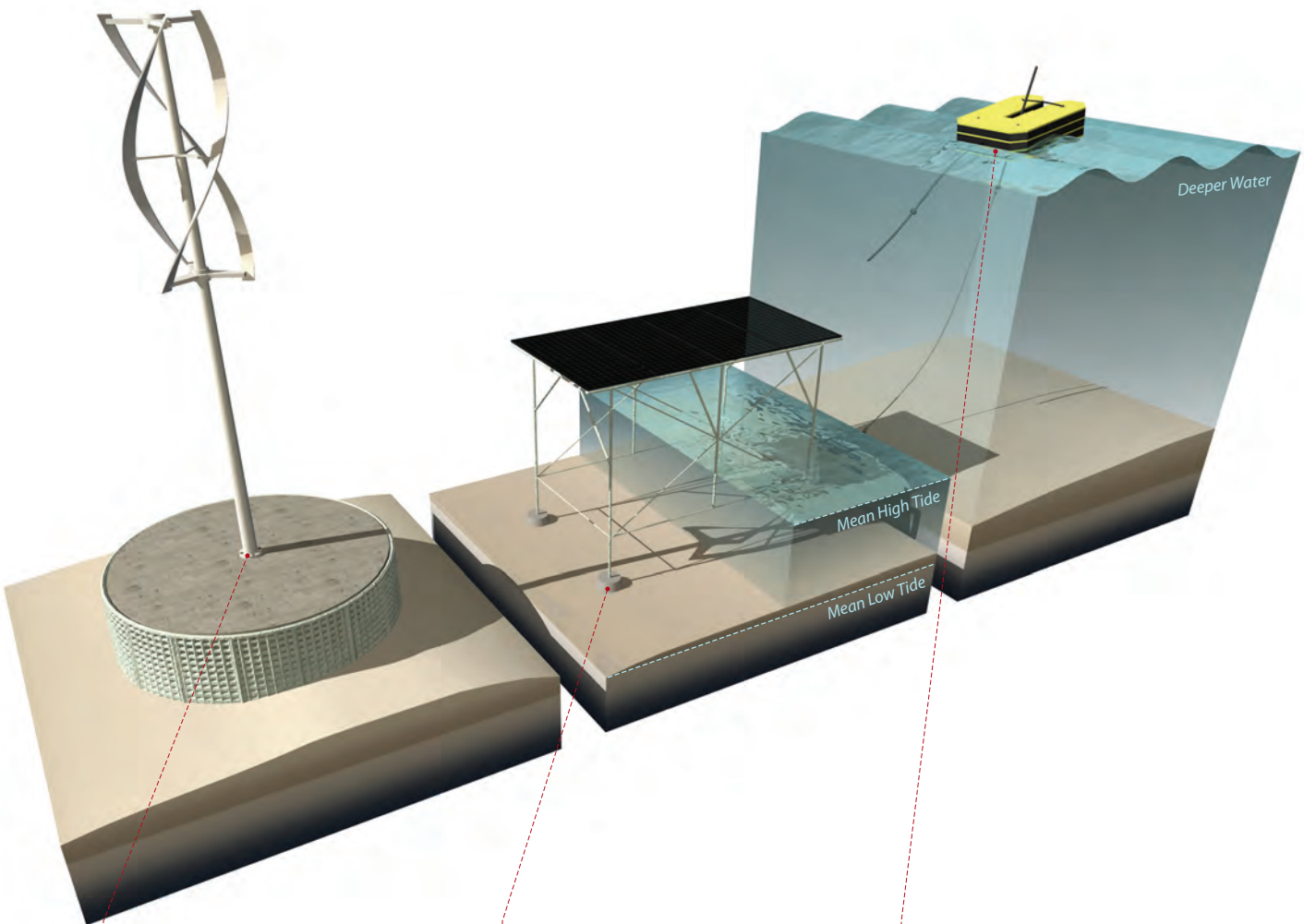
Wind Turbine
The RMI is an ideal location for local wind power production. The northeast trade winds blow steadily through most of the year, with averages for most months on the order of 10-15 kts, and long periods of time where a constant 20+ kt wind is available. Smaller scale wind generators have significant economies of scale, and would allow the dispersion of settlements to smaller islets and outer island (rural) atolls, while maintaining or improving quality of life.

Solar Cells
Sunlight hours, especially in the more arid northern atolls, is excellent in the RMI. Small scale solar cells could provide an important local energy source where a community is too small to afford a wind generator. Solar units are also ideal for powering the reef-mounted sedimentation array, as demand is low and can be intermittent. Lightweight solar cells on aluminium frames could be re-used throughout this proposal, moved as the array progresses across the reef.

Wave Generators
The new generation of small scale wave generators is a promising source of mobile, renewable energy in remote island locations. These units cost less than $1000, and could even be manufactured locally. They are utilized throughout this proposal as the primary energy source for the biorock™ reefs and mineral accretion processes, but could power small settlements in significant enough concentrations. There is no shortage of wave energy here.

20 USA-CE. (2010): pp36-45.
21 PIFS. *Pacific Fuel Price Monitor* (2005): p3.
22 Windustry. (2012): "how-much-do-wind-turbines."

Power Units



Wind Turbine

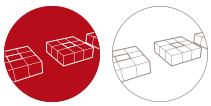
The primary power source for settlements, providing affordable high voltage energy for lighting, work and living systems. Shown here is a multidirectional Vertical Axis Turbine (VAWT), which functions at high efficiency with variable wind directions.

Solar Array

The primary power source for biorock mineral accretion processes on the reef flat based sedimentation array. Solar arrays are ideal in this situation as access to wave power here is too distant to function efficiently; the arrays are mounted on a mobile lightweight aluminium frame which can be moved as demand requires, and can be placed in 1-2 metres of water at high tide.

Small Scale Wave Generator

These small units (1-1.5m across) are placed in 4-5m of water in locations where significant tidal action ensures constant wave action. These units are used throughout the proposal to provide low cost energy for submerged, low-voltage applications. They are less useful human use as voltage is limited and transport of energy reduces efficiency, but might provide an important bridge for small communities that cannot yet afford a wind turbine.



Artificial Reefs

The sister component to the sedimentation array installed on the shallow reef flat are submerged artificial reefs located in shallow lagoon waters adjacent to the sedimentation site, or in natural or excavated tidal pools on the reef flat itself. The sedimentation array requires a source of sediment; all of the sediment which makes up atoll islands is derived directly from the living reefs which surround them. The highest carbonate productivity occurs along the oceanward forereef - on the order of 4-8 kilograms of carbonate per square meter of reef per year. Where lagoon reefs exist, carbonate production is significantly lower, on the order of 0.5-1 kilogram per year, and much of the backreef is devoud of living reef outcrops. The biorock™-based artificial reefs compliment the existing reef ecosystems: they can be used to spur the growth of existing reefs, help to repair damage caused by climate change and pollution, and create new reef ecosystems in locations which are not naturally suitable for their growth. The artificial reefs grow significantly faster than natural reefs, and readily recover from environmental stresses. The addition of artificial reefs significantly increases the influx of sediment to adjacent islands and shallows.

Like the sedimentation array, the reef armature is assembled on the beach from rebar and welded wire mesh; however, after assembly these components are deployed directly to sites chosen for enhancement. While the form shown here is a simple square frame, there is no advantage to this and in fact the reef frame can take any manner of shape. The important aspects for the frames are: stability, such that they will remain in position and not roll over or become top-heavy; and elevation, providing young coral installed on them an elevated position with preferential access to nutrient streams in passing currents. Power is provided to the frames by surface based wave generators. After several weeks of mineral accretion, during which a thin coating of aragonite coats the frame, the frames are ready for the installation of young corals.

Power Supply

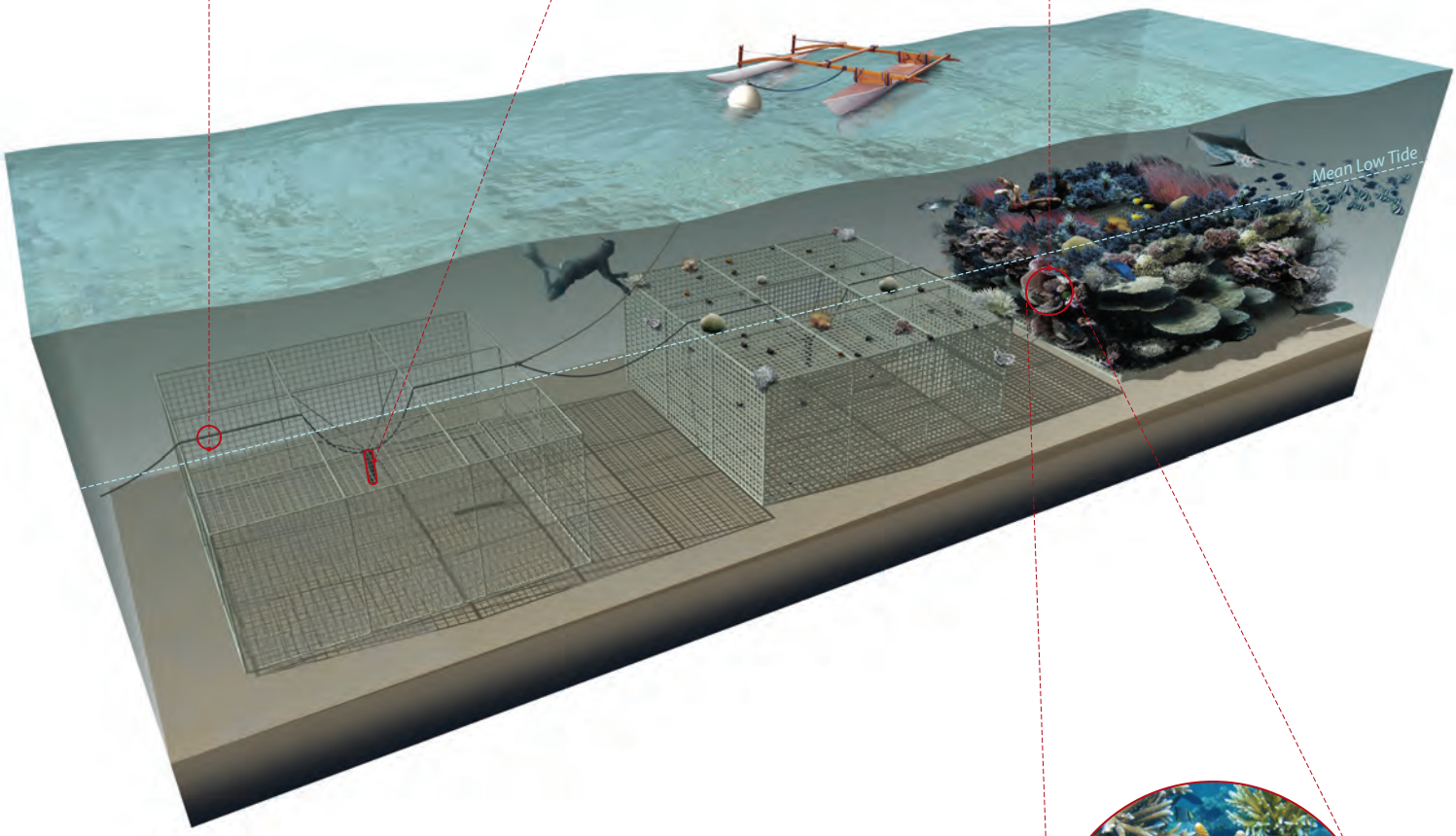
The accretion process requires a supply of low-voltage direct current, though this need not be continuous. The power source should be nearby as it is inefficient to transport low-voltage current long distances and high voltage lines are dangerous. For the submerged reefs, mobile wave generators are anchored directly to the reef components. Electric current lowers the acidity of the seawater, causing dissolved limestone to crystallize in proximity to the steel frame. While under normal conditions, coral polyps must expend their own energy to create these conditions, on the biorock reef polyps can spend all of their energy on growth, reproduction and recovering from environmental stresses.

Anodes

Current is administered by effectively turning the frame into a giant battery: the frame becomes the negative terminal (cathode), with the positive anodes suspended within to form a galvanic cell. Like the wave generators, the corrosion resistant (and relatively costly) anodes can be reused many times, moved from one location to the next.

Biorock & Coral Growth

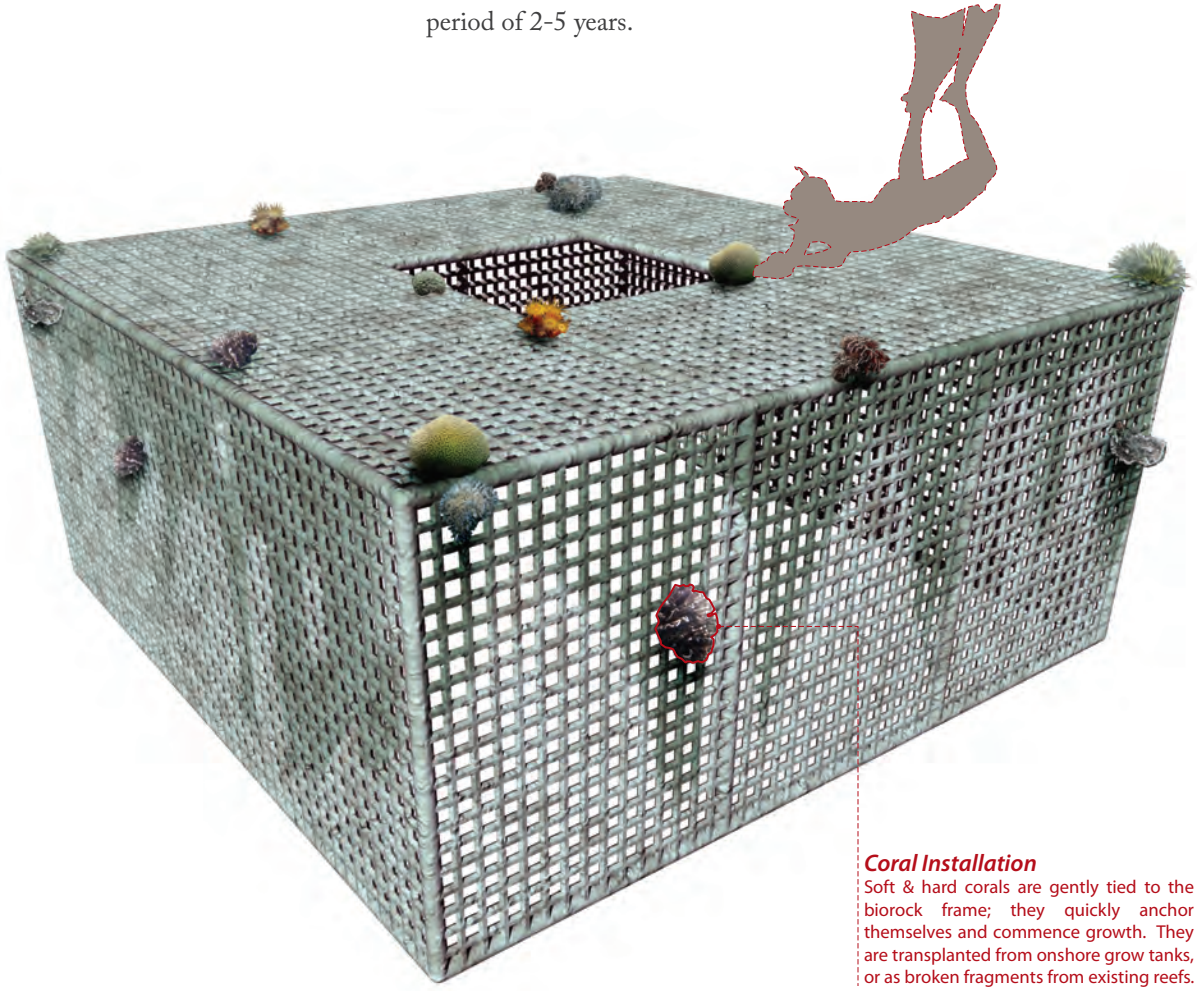
Unlike artificial reefs which utilize synthetic materials, reefs constructed from biorock are composed of Aragonite - a form of limestone on which living corals prefer to settle. The biorock frame spurs coral growth: first because of environmental factors (the coral is raised above its surroundings, protecting it from sedimentation and providing access to food); and secondly because of the electrodeposition process itself. Because of these beneficial effects, corals growing on the biorock reefs grow at greatly accelerated rates, 4-6 times faster than under natural conditions.



Reef Seeding

The next step in creating the artificial reef is the installation - by hand - of young corals, either broken pieces gathered from the living reef, or farmed in tanks onshore. In shallow, calm water this can be done by snorkelling; deeper or turbulent water requires dive equiptment. The installed coral benefits from the mineral accretion process, growing 3-6 times faster on the artificial reef than in normal conditions. Coral growing on the artificial reefs is also more resistant to bleaching from higher water temperatures, as the low-voltage current actually replaces the corals natural symbiotic relationship with zooxanthella (algae) and allows it to recover from more drastic shifts in temperature or the stresses induced by nutrient pollution.

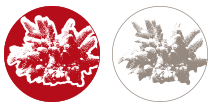
Seeded corals quickly bond to the biorock™ frame; the frame is slowly converted to a pseudo-natural reef by the reproduction of this coral, as well as invaders from the nearby living reefs. The coral continues to grow and propagate at higher than typical rates as long as the voltage is applied. Once the micro-ecosystem is stabilized, the anodes can be removed and used to seed another cluster of artificial reef frames - a period of 2-5 years.



Coral Installation

Soft & hard corals are gently tied to the biorock frame; they quickly anchor themselves and commence growth. They are transplanted from onshore grow tanks, or as broken fragments from existing reefs.

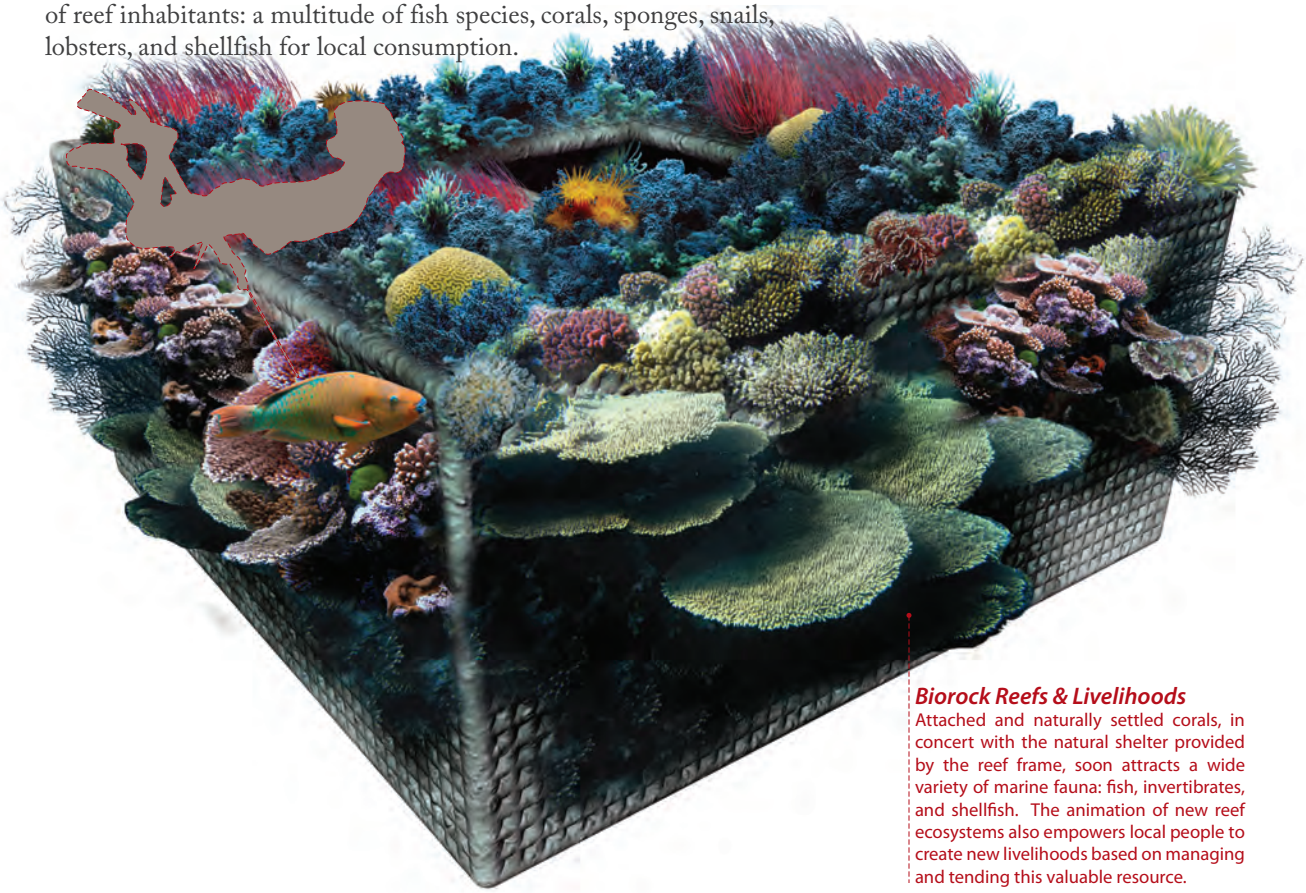
Coral Mariculture



After several years of growth, the frame has become completely colonized by living coral. With the power system removed, coral growth stabilizes, and the frame becomes a haven for reef fish. Pounding surf during storms and the natural predation of beaked, coral-eating fish (ie parrotfish, etc.) break down the mature coral and the artificial reef begins to function in a completely natural manner, despite its synthetic foundations. Products derived from the artificial reefs can provide significant incomes through export for the aquarium trade (hard & soft corals, giant clams, and reef fish), foreign and domestic seafood markets (reef fish, lobsters & shellfish), and the pharmaceutical industry (soft corals, sponges and sea horses).

Artisanal Fishing

These synthetic reef ecosystems will become a valuable resource for artisanal fisherman. The location and morphology of these reefs will facilitate harvesting much more readily than much of the existing natural habitats: they are located in shallow water, proximal to inhabited islets, and largely protected from the violence of the wave-thrashed forereef, while at the same time more productive than the existing reef flats. With the use of simple traditional technologies such as spear-fishing and netting, local fishermen will be able to harvest a broad range of reef inhabitants: a multitude of fish species, corals, sponges, snails, lobsters, and shellfish for local consumption.



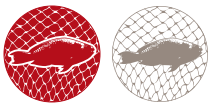
Biorock Reefs & Livelihoods

Attached and naturally settled corals, in concert with the natural shelter provided by the reef frame, soon attracts a wide variety of marine fauna: fish, invertibrates, and shellfish. The animation of new reef ecosystems also empowers local people to create new livelihoods based on managing and tending this valuable resource.

install use

Sedimentation Array

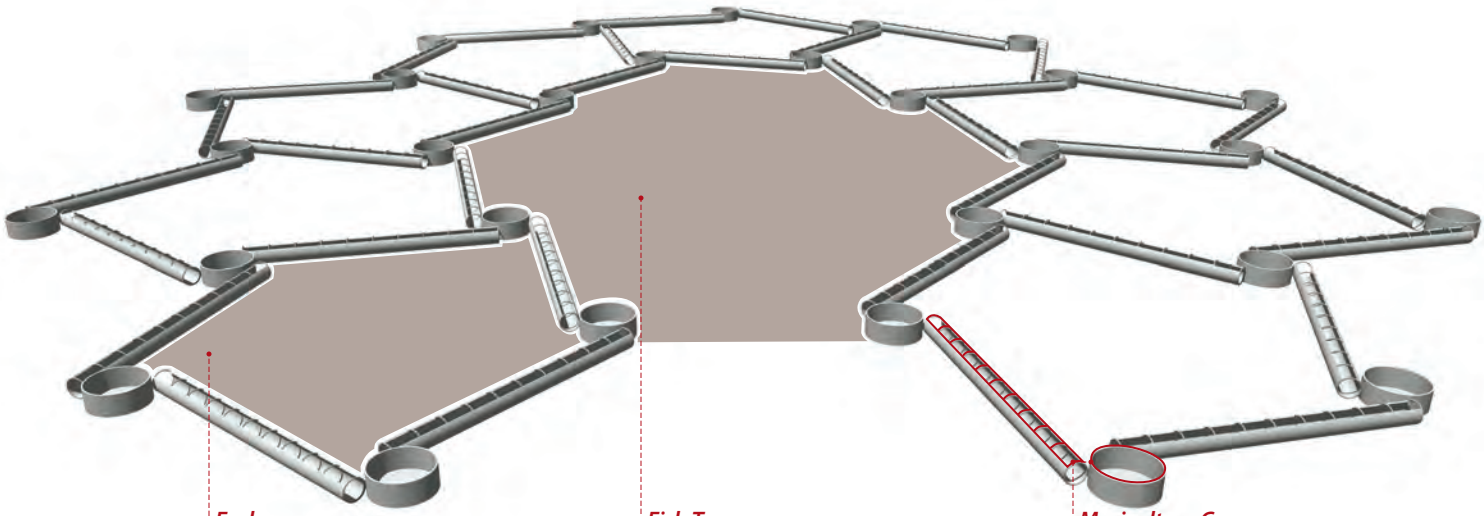
The 'sedimentation array' is composed of two basic elements: round 'pens' which form the nodes or anchor points, and tubular 'spars' which span between the pens. The array is designed to be installed on shallow intertidal reef flats, where the system is submerged at high tide and partially or wholly exposed at low tides, and forms an infrastucture ideal for various forms of mariculture, fish trapping and seaweed farming. The components act as exclosures - cages which allow the cultivation of various marine flora and fauna, and provide protection from predators. Pens - 4 metre diameter cages, 1.5 metres in height - are installed first. The cages are anchored either mechanically by drilling into the reef surface, with stakes in sandy locations, or by placing heavy coral rocks in them. Biorock™ accretion continues: the electrochemical process actually causes the components to sink into the surface of the existing reef rock and bond to it - within months, pens are permanently fused to the reef surface. At this point, the spars - 20 metre tubes, open on top and forming multiple compartments - are floated into position at high tide, and then lashed with steel wire to the pens. The continuous accretion process bonds the spars to the pens, forming the completed infrastructure. The installed array is now corrosion resistant and strong but still highly permeable, allowing the powerful waves and currents of the littoral environment to pass through it. The framework can be left at this level of accretion indefinitely if desired; the modular nature of the components allows the system to progress as resources allow and needs demand. The frames will become completely impermeable within 1-2 years; this process also fuses the biorock™ infrastructure to accumulating sediment, forming layers of hard calcium carbonate platen. Accretion on the frames occurs assymetrically as the frames are not exposed to seawater equally from top to bottom; they become bottom heavy as they accrete a thicker coating of biorock at the base while the top remains open and permeable. Littoral currents will deposit vast amounts of sand within and around the units, and tidal flows will be modified by a slowly emerging island landscape.



Fish Traps

The array mimics the design of indigenous fish traps which are found throughout the Marshall's, though most have fallen into disuse. Fish are directed through a narrow, ocean-ward facing aperture at high tide; as the tide recedes, the trap is harvested by drawing a net across the opening, or by hand-netting or spearing fish trapped in the shallows of at low tide.

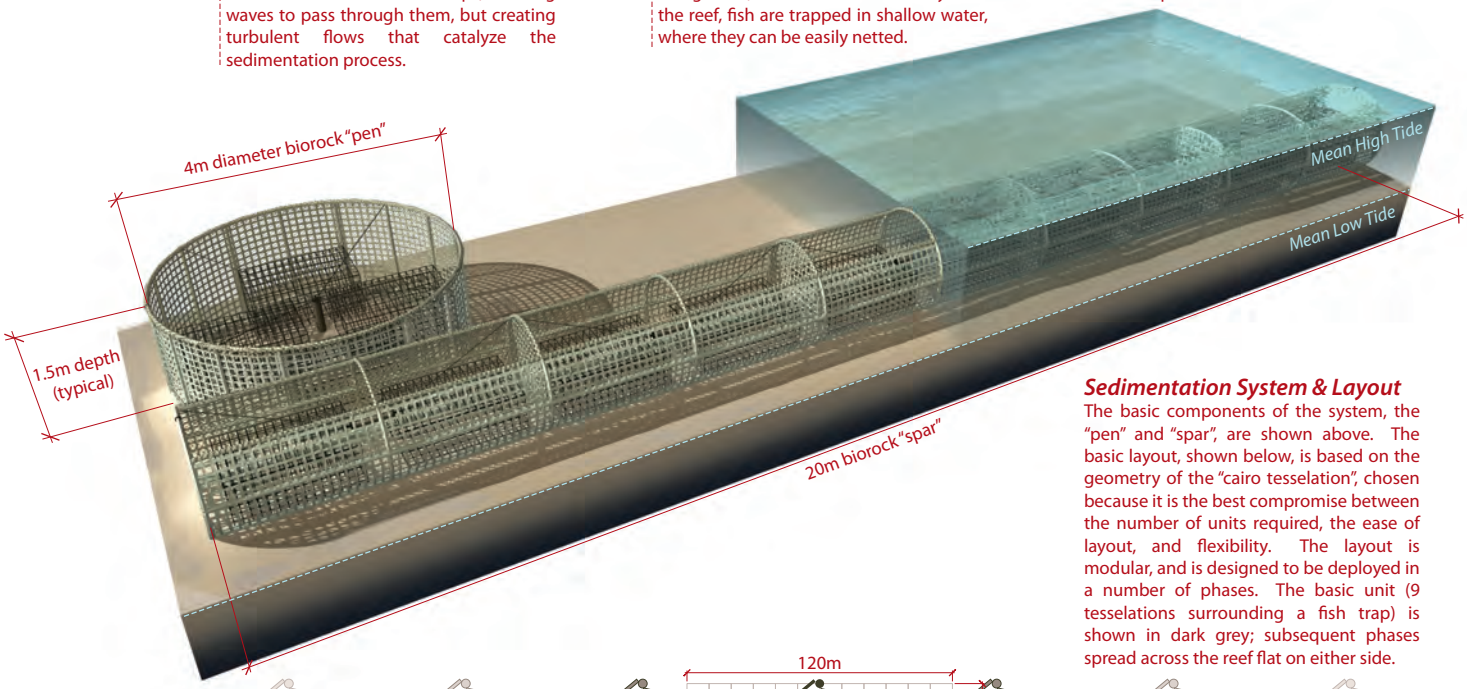
Sedimentation Array



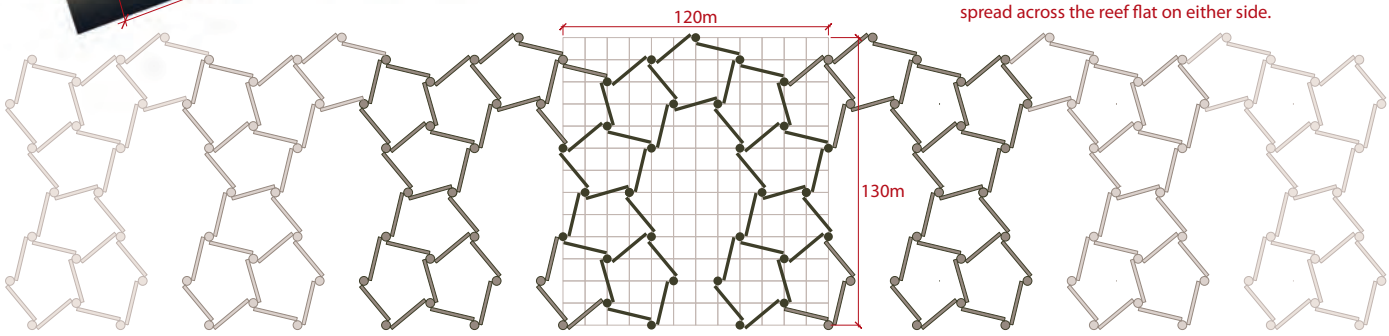
Exclosures
The deployed array creates a number of 'exclosure' areas, protecting cultivated seaweed from herbivorous fish. These areas also act as sediment traps, allowing waves to pass through them, but creating turbulent flows that catalyze the sedimentation process.

Fish Trap
The geometry of the exclosures creates a natural fish trap at the centre of the array. The trap functions by allowing fish to enter at high tide; as the tide recedes away from the reef, fish are trapped in shallow water, where they can be easily netted.

Mariculture Cages
The "spars" and "pens" are essentially multi-purpose mariculture cages, and can be used to cultivate a wide array of different products.



Sedimentation System & Layout
The basic components of the system, the "pen" and "spar", are shown above. The basic layout, shown below, is based on the geometry of the "cairo tesselation", chosen because it is the best compromise between the number of units required, the ease of layout, and flexibility. The layout is modular, and is designed to be deployed in a number of phases. The basic unit (9 tesselations surrounding a fish trap) is shown in dark grey; subsequent phases spread across the reef flat on either side.



install use

Pearl Farming

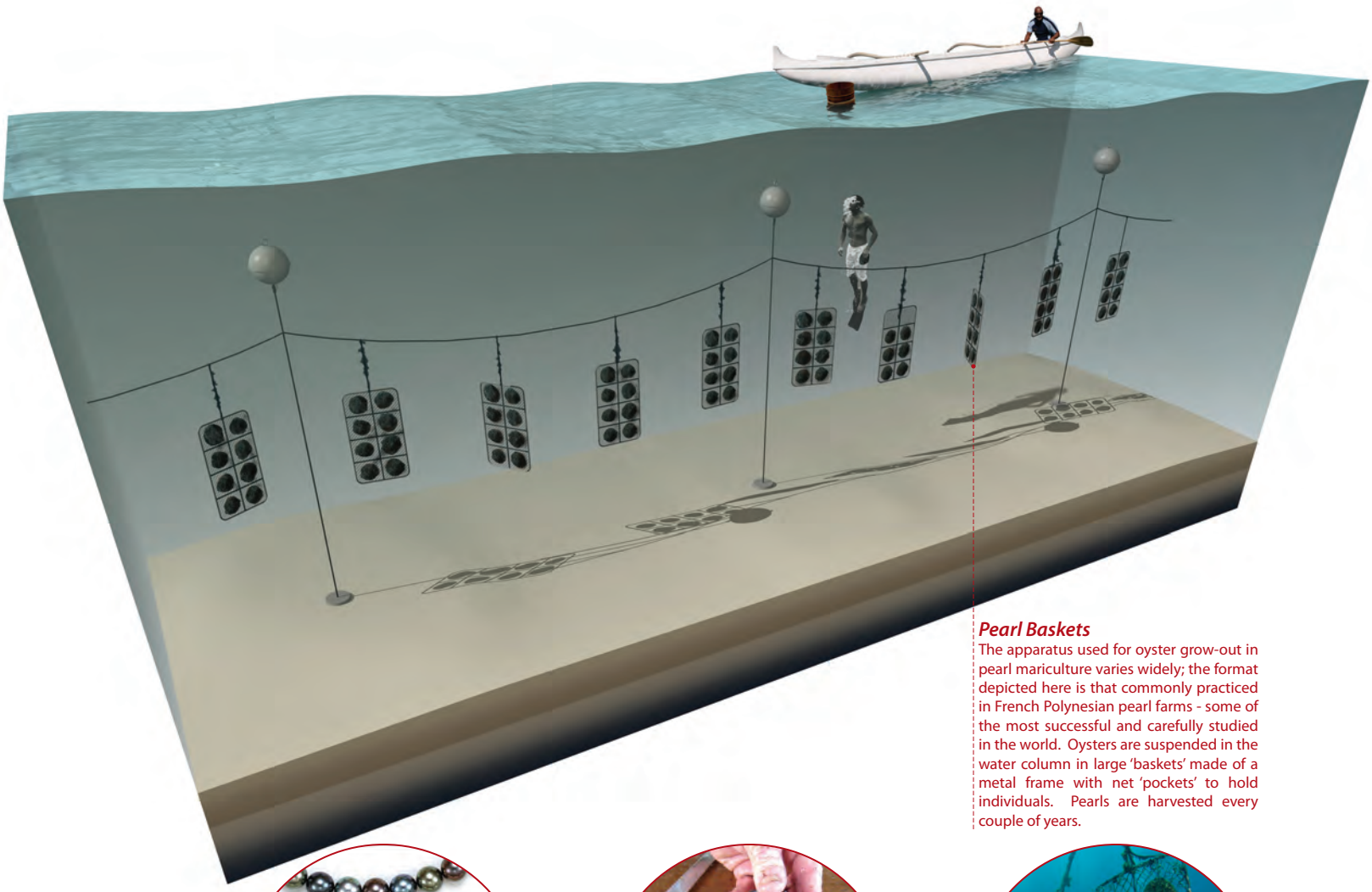
While pearls occur naturally in some Pacific oyster species, they are exceptionally rare. The modern pearl market is supplied almost entirely by cultured pearls produced in pearl farms (natural pearls make up less than 0.01% of those sold).[23] This market is dominated by large-scale Chinese operations producing freshwater 'pearls' from several mussel species. The 'true pearl' market (ie those sourced from saltwater oyster species) is also dominated by commercial operations, primarily in China, South Korea, Japan, Vietnam and India. However, the industry is uniquely suited to small-scale initiatives in remote island locations, as it is only in these pristine environments that the most prized pearl oyster species can be cultivated. Two species in particular are important to sustainable development initiatives in remote Pacific island locations: the White-lipped Oyster *Pinctada maxima* (the traditional source of giant 'South Seas' pearls), and the Black-lipped Oyster *Pinctada margaritifera* (which has enabled the development of a very significant industry in several south Pacific island locations, most notably in the Tuamotus, producing the famed 'Tahitian Black' pearl). *P. margaritifera* culturing in French Polynesia has grown into an enormous industry, beginning in the 1980's, which now produces on the order of 6 metric tons (roughly US$200 million value) annually - note that this is greater than the entire GDP of the Marshall Islands.

'Marshallese' black pearls have already begun to develop their own niche market, due to their unusual green colouration and lustre.[24] Oysters grow by filtering large quantities of seawater to extract organic material - microalgae, protozoans, microzooplankton and detritus - on which they feed. Pearls are formed by artificially implanting a bead (a small piece of mother-of-pearl) in the gonad of a live oyster. The oyster is then placed into its habitat for a grow out period of several years, during which the pearl slowly forms as a cyst around the foreign object.

Pearl farming requires several procedures and infrastructures, but very little material input besides the oysters themselves which can either be gathered wild or bred in captivity. The pearl farming infrastructure consists of four separate components: oyster spat collection cages; aquaculture pens for growing juvenile oysters; workshops suitable for the implantation procedure; and grow-out baskets in the lagoon. First, oyster spat must be collected. Spat collection trays (either trays manufactured specifically for the purpose, or assembled from recycled materials, such as 2L pop bottles) are placed in cages on the reef flat. Spat are harvested and placed in aquaculture pens. When the juvenile oysters reach a suitable size, they are collected and brought to a workshop where seed beads are surgically implanted. The oysters are then manually placed in net baskets suspended in 3-8m of water in the lagoon, as shown. A grow-out period, of 18-36 months follows, after

23 Pearl Paradise / Pearls of Joy. (2011).
24 Ibid.

which the oysters are harvested, and returned to a work area where pearls are extracted, sorted, and packaged for sale prior to export.

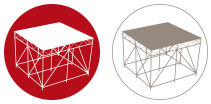


Pearl Baskets
The apparatus used for oyster grow-out in pearl mariculture varies widely; the format depicted here is that commonly practiced in French Polynesian pearl farms - some of the most successful and carefully studied in the world. Oysters are suspended in the water column in large 'baskets' made of a metal frame with net 'pockets' to hold individuals. Pearls are harvested every couple of years.

Pearl varieties - black Akoya (*P. imbricata*), white 'South Seas' (Australian *P. Maxima)*, black 'Tahitian' (*P. margaritifera*), and giant 'Golden' (*P. Maxima)*.

Pinctada margaritifera Black-lipped Pearl Oyster

Tuamotu-style pearl baskets



Construction Components

In addition to artificial reefs & the sedimentation array system, there is a third application in this proposal for biorock - as a construction material. This prospect is attractive for several important reasons. Firstly, there are few naturally occurring materials suited for construction in the atoll environment. Traditionally, people lived in huts constructed from the wood of several tree species - including pandanus, mangroves, palm and *Pisonia grandis*. But there is a limited supply of wood for construction, wood buildings do not have a long lifespan in this humid, salty environment, require constant maintenance, and are often damaged in major tropical storms. In recent times, wood huts have begun to be replaced with concrete and steel; the new vernacular Marshallese house is a rectangular 1-storey building made from concrete blocks on a poured slab, with a corrugated steel roof. But these materials have no local source - even concrete blocks must be imported, making them very expensive. While they last longer than wood, these materials are not particularly well suited to the construction of dwellings or workspaces in a tropical climate. Concrete block / steel buildings swelter under the tropical sun, they are impermeable to airflow, and thermal mass retains heat into the night.

Despite the perishible materials, there was a lot of wisdom embedded in the traditional Marshallese hut. Often raised on posts, stored foodstuffs were out of reach of rats and other pests. Typically, they were open on two or more sides, allowing air to flow freely through; and the high ceiling under a roof thatched with pandanus kept heat away from ground level. Finally, they were easy to assemble without specialized skills or tools. It is to these attributes which the proposed use of biorock™ as a construction medium aspires.

Construction components as proposed take two fundamental forms: trabiated systems: discrete posts, spars and beams made up of accreted biorock on a steel member (rebar); and membrane systems: in which biorock is accreted onto a metal mesh to form sheet goods, which can be simple rectangular forms, or bent into catenary shapes. The first type is more straightforward, and can be used to create simple forms such as posts / spars, from a single piece of accreted rebar (useful as stakes in the seaweed farming enterprises, for example). More importantly, integrated trusses can be easily manufactered, en masse. Welded rebar frames can be used to produce scaffold-like frames for the construction of platforms or walls, roof trusses, and wall structures. Accreted welded-wire mesh, in rectangular or curvilinear forms can be used to produce rigid structural grid panels that have the advantage of allowing air flow through them.

Monocoque forms can be produced with biorock as well; a fine mesh is used in place of discrete members or large wire mesh, folded or bent into shape. Once accreted, the mesh behaves like fibre cement panels, and can be used to create cladding, catenary structural forms, and

simple objects such as the 'reef balls' used in mangrove culturing. It should be noted that this technology is much more difficult to control, and requires careful monitoring and management of the conditions to ensure that structural skin forms achieve uniform coverage and density. These types of forms would require carefully controlled accretion environments, such as those which could be achieved in immersion tanks on land. Tests undertaken by Alvaro Ortega in the 70's and early 80's were very promising, showing that structural shell forms could be accreted quickly; however, further research is required.[25]

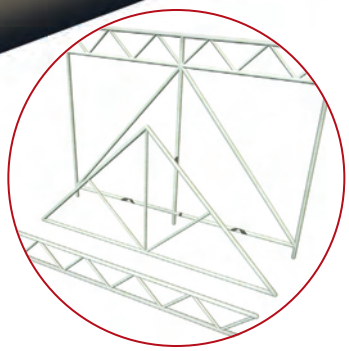
25 Ortega. (1989).

Components

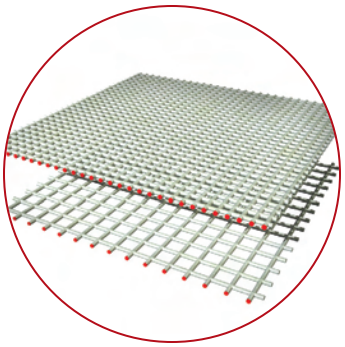
The building shown below is made up of simple, repeating elements. The primary structure is a truss frame, lashed together with strong cord. A roof truss is clad in traditional materials, such as pandanus thatch, as shown, or corrugated steel. Walls can be left open, clad in a biorock grid frame, as shown, to allow airflow and light, or clad in solid panels, wood, or other materials. Floors can be constructed from simple planks of palm or mangrove wood, sheet goods, or slabs can be poured over catenary forms spanning between the primary truss members.

Platforms and Drying Huts

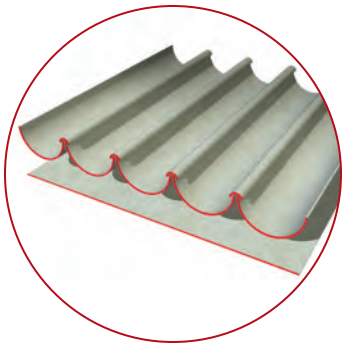
While platforms are sufficient for small drying operations, in the hot, humid Marshallese climate cover is required to provide shade for workers sorting and tying propagules, and to prevent sun bleaching of the product. Fresh seaweed is layed over racks inside the hut, and allowed to drip-dry over a period of days, before being bagged and transported to market.



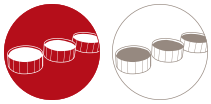
The basic truss forms: platform structures, framing and roof trusses.



Structural grid frames, which can be used to produce walls, floors and industrial components such as cages or grates.



A simple catenary roof form, made up of folded shell structures.



Aquaculture
Open water based mariculture operations (ie fish farming in floating cages) produces a great deal of nutrient load on the local environment, and can have serious detrimental effects in reef ecosystems. This proposal focuses on small-scale, land-based mariculture practices (ie cage rearing of fish & shellfish). The most expensive component in a land-based operation is the infrastructure - ponds or raceways filled with seawater, usually constructed from concrete, or large plastic tubs. In this scheme, biorock replaces concrete. The pens, constructed in the same manner as the reef pens, need only a thin layer of biorock to protect them from corrosion; they are then made water-tight with a plastic liner. Salt water is pumped from the lagoon into the tanks; wastewater from cultured fish is filtered in successive stages by passing it through tanks containing filter feeders such as shrimp or molluscs in an integrated-multitrophic approach (IMTA).[26] Final filtering is achieved with micro-algae in settling tanks before water is returned to the ocean. A multitrophic system using locally sourced organisms might include: herbivorous fish such as rabbitfish, sea cucumbers, clams, trochus, oysters, hard & soft coral species, sponges, lobster, and marine plants & algae.

Giant Clams
One of the easiest species to cultivate, juvenile clams are raised in onshore in tanks before being placed in offshore exclosure cages. All species are valuable for the aquarium trade, including *Tridacna gigas* (true Giant clam), *Tridacna derasa* (the huge Southern Giant Clam), and Tridacna maxima (Maxima clam); they can also be cultivated as a food resource; once installed in reef pens, they need essentially no maintenance and will achieve marketable size in a few years.

Trochus & Ornamental Shells
A number of endemic sea snails and shellfish species are valuable for export, for example Tectus niloticus, much sought after for producing mother-of-pearl buttons and ornaments. Cultivation is similar to the Giant Clams, with grow-out following land-based tank rearing.

Sea Cucumber
Of the 1200 species of Holothurians worldwide (variously known as beche-de-mer, trepang, or sandfish), about 12 are considered to have commercial value,[27] of which at least 3 are naturally present: *Holothuria nobilis* (black teatfish), *Actinopyga mauritiana* (surf redfish), and *Holothuria atra* (lollyfish), which have been overfished here in the past in a boom/bust cycle. These are good candidates for tank based operations.

26 Neish. "Tropical Red Seaweeds as a Foundation for Integrated Multi-trophic Aquaculture (IMTA)" (2009).
27 Smith. (1991): pp48-50.

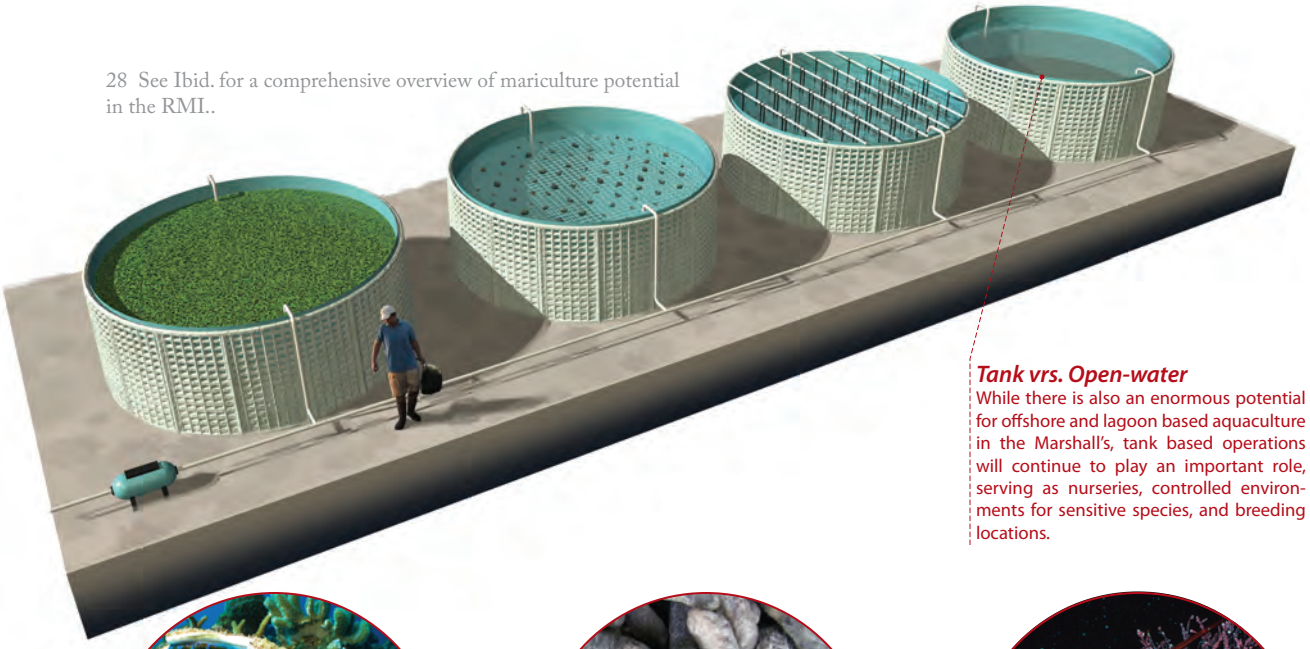
Lobster

Notoriously difficult to cultivate in captivity, lobster hatcheries on the east coast of the US have recently developed techniques to tank-rear cannibalistic juveniles, which are then carefully released in their natural habitat to bolster the wild stocks which have been overfished. This process is untested with Pacific lobster, but may become economically viable as economies of scale are realized with regard to fisheries exports to Asia. Marshallese species such as *Panulirus penicillatus* and *P. versicolor* have the potential to be a valuable fisheries resource, both locally and for export.

Fish

While there is currently no shortage of reef & pelagic fish in the RMI, a greater reliance on local resources for food will put significant stress on populated atolls. Tank-based cultivation of *Chanos chanos* (Milkfish) has been paired successfully with seaweed mariculture in southeast Asia, and proven imported species such as this are one option. There has been little research into tank-rearing of reef fish which occur in the Marshall's, but one possibility which has been suggested is *Siganidae* (Rabbitfish), which occur here in abundance.[28]

28 See Ibid. for a comprehensive overview of mariculture potential in the RMI..



Tank vrs. Open-water

While there is also an enormous potential for offshore and lagoon based aquaculture in the Marshall's, tank based operations will continue to play an important role, serving as nurseries, controlled environments for sensitive species, and breeding locations.

Tridacna gigas Giant Clam

Dried *Holothuriidae* Sea Cucumber (Trepang, beche-de-mer, sandfish)

Panulirus penicillatus Pacific Pronghorn Spiny Lobster

Seaweed Mariculture

Grassroots farming based on the Red Seaweeds (*Eucheumatoideae* and *Kappaphycus*) is an outstanding example of sustainable development that evolved from simple agronomic methods refined and adapted to local environments primarily by farmers themselves, in the field. Small scale projects have proliferated throughout insular southeast Asia, with benchmark projects in the Phillipines and Indonesia effectively transforming local economies from those based on high volume, destructive reef-fishing practices into economies based on environmental stewardship where local people have a personal stake in the health of the marine ecosystem. The commercial success of *Eucheuma/Kappaphycus* stems from the fact that these species produce propagules which are large enough to be handled and 'planted' individually; this is different on a fundamental level from the many other smaller types of macroalgae (for example, the *Chondrus* varieties) which are propagated in 'agitated slurries' in controlled ponds - which lend themselves more to large-scale commercial operations than to small stakeholder based enterprises.[29]

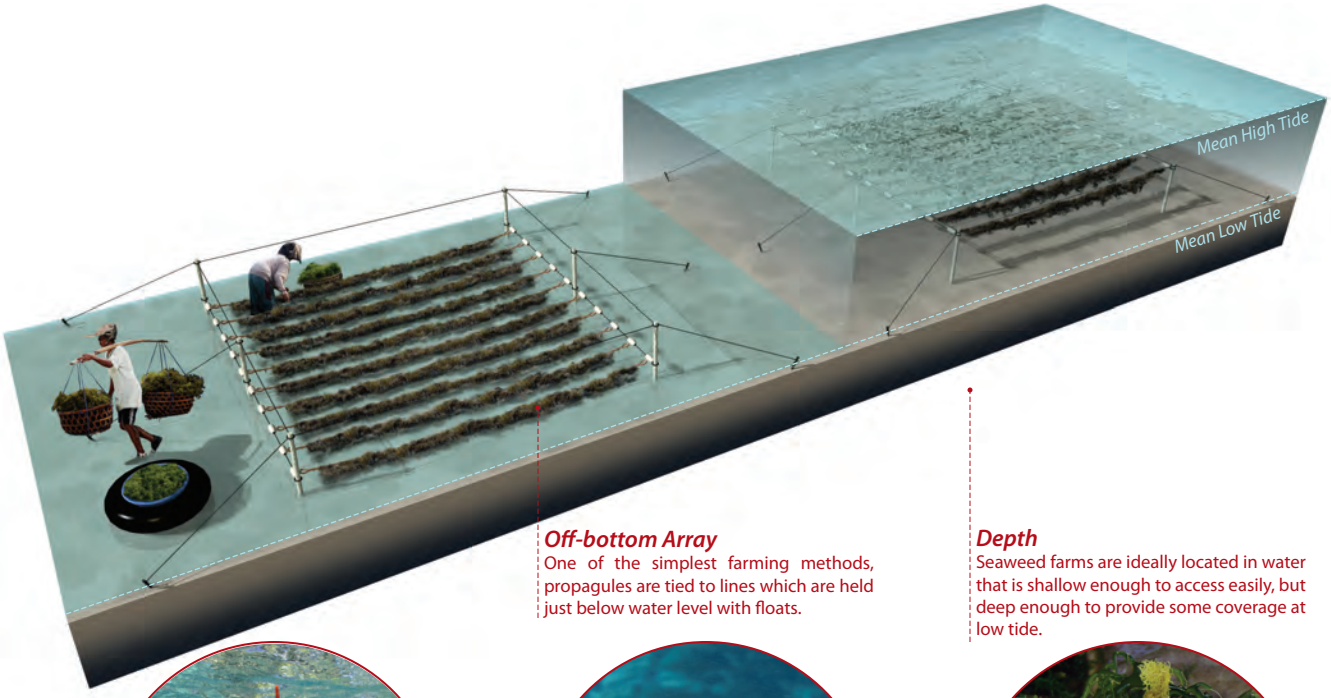
Farming is carried out in shallow intertidal waters, on hard, rocky or sandy bottoms, in areas with moderate water movement. Propagules (vegetative *thalli*) are tied to 6mm nylon lines, 5-10m in length, which are held off the bottom by tensioning them between stakes, or attaching floats to the lines. These species grow incredibly fast: *Kappaphycus* species in Hawai'i - where they are considered a noxious marine weed - have been observed to double their biomass in 15 days.[30] In practice, the lines are harvested every 5-6 weeks. They are gathered by hand and transported immediately to a protected area where the mature plants can be hung to dry - the first step in preparing them for export for the carrageenan and food industries. Typically, this is achieved either by transporting the fresh plants to locations on shore, or by constructing platforms adjacent to the growing beds. The drying area must be clean (free from sand, etc.) and shaded, to prevent bleaching in the hot sun - and also to protect the workers who will now gather the best samples from the grow-out to collect propagules for the next crop. These propagules are stored in seawater until the farmer is ready to restock his plot.[31] The fresh plants can also be sold locally for food.

There are a number of major challenges to be overcome in developing seaweed farm enterprises in the Marshall's. There are several local species which graze on these seaweeds, such as rabbitfish and urchins, which have been known to devastate entire crops in Kiribati and French Polynesia. There are questions to be raised about marine property rights, as large scale seaweed farming has the potential to alter the existing balance of species in the lagoons and reefs, with potentially

29 Neish. "Good Agronomy Practices for Kappaphycus and Eucheuma" (2009): p6.
30 University of Hawai'i Botany Dept. (2011).
31 Niesh. "Good Agronomy Practices [...]" (2009): pp38-46.

detrimental effects. And of course there is the potential for introduced seaweed to spread as a noxious weed species - although based upon early efforts in Majuro lagoon, which were destroyed by schools of rabbitfish, this seems unlikely.

The sedimentation array begins to address some of these questions. First, the array acts as a large exclosure system which will keep out at least some of the larger grazing species. Secondly, it raises the potential to combine the seaweed mariculture with harvesting of the grazing species themselves, as well as their predators. The array acts as a giant fish trap - herbivorous fish are attracted by the seaplants, and in turn larger predatory species follow them into the traps. Finally, with regard to property rights, in the Marshallese tenure system, historic rights to fishing & hunting grounds are typically connected to clan ownership of islands. The sedimentation array allows local stakeholders to participate in the creation of new marine and terrestrial territories, to which they will be empowered to stake claim through occupation and use. This will certainly be a major challenge, as it will neccessitate rethinking both traditional rights and modern laws.



Off-bottom Array
One of the simplest farming methods, propagules are tied to lines which are held just below water level with floats.

Depth
Seaweed farms are ideally located in water that is shallow enough to access easily, but deep enough to provide some coverage at low tide.

Heterocentrotus mamillatus Red Pencil Urchin

Siganus vulpinus Foxface Rabbitfish

Eucheuma denticulatum on monoline

install use

Mangrove Cultivation

While the sedimentation infrastructure begins the process of island formation, this process is greatly accelerated with the cultivation of mangrove forests. Natural atoll islets in the Marshall's are the product of thousands of years of erosion and deposition. It is a constantly dynamic and unpredictable process in which reef-derived coraline sands build up over many years, shifting across the reef into the lagoon at the whim of currents and swell patterns around existing landforms. These islands of sand are constantly migrating, shifting: new islands might form or be erased overnight by storm events - part of the natural atoll cycle.

Mangroves do not occur naturally in the Marshall Islands; however, they were evidently brought here by Marshallese peoples in antiquity. Most of these forests have long since disappeared, being cut for firewood or to make way for urban development. Only a few small stands exist in the modern Marshall's, growing in the intertidal zone on a few islands, and in inland saline depressions on a number of other islands. While several species have been recorded in the atolls, only the true mangroves - of the genus *Rhizophora* - are suitable for cultivation in the intertidal reef zone. *Bruguiera gymnorrhiza*, the Tree Mangrove, which dominates the extant populations in the atolls, seems to occur only in protected inland depressions. *Rhizophora apiculata* and *Rhizophora mangle* or Red Mangrove are the most ideal species. Of these, only *apiculata* is found in the Marshall's.

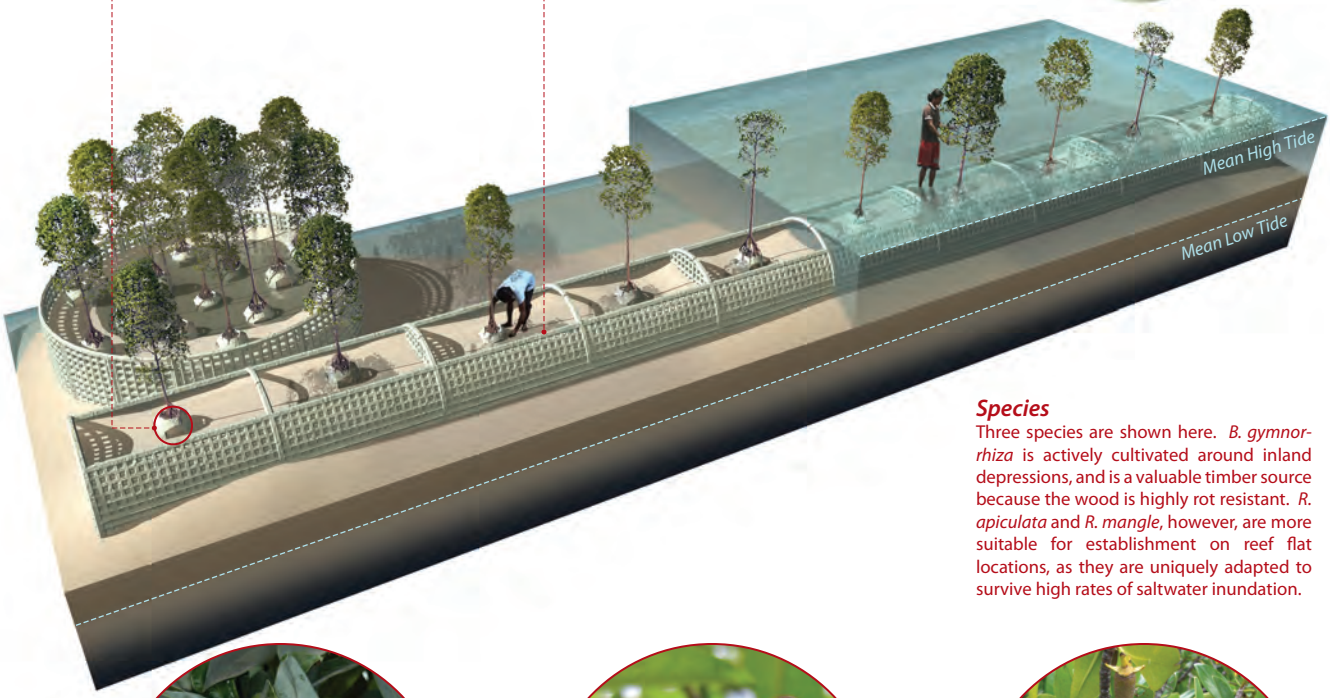
Seedlings are first cultivated in small pots in protected locations, where they undergo grow-out over the course of 12-18 months; these pots are then transferred to 'reef balls' - heavy armatures made from accreted biorock that retain moisture at low tide, raise the seedlings to the correct depth just below the mean high tide mark, and prevent them from overturning until they become established. *Rhizophora* species grow quickly, and will greatly increase the rate of reef flat sedimentation, colonizing new ground through self-propagation. after several years of growth, it will be possible to sustainably harvest annually; the wood is ideal for construction, firewood, and for use in the seaweed cultivation as stakes.

Mangrove Cultivation

Reef Balls
Mangrove seedlings planted below Mean High Tide level require special care to enable them to become established. The seedlings are first cultivated in small pots in a protected location, and then these pots are installed in a "reef ball" - essentially a porous biorock armature that holds the pot upright, helps retain moisture at low tide, and anchors the young seedling against currents and waves. The reef balls, made using the biorock process, or simply from concrete in a reusable mold, are filled with soil and wood chips and installed into the sedimentation infrastructure as shown.

Sedimentation
Open on top, and progressively less porous from top to bottom, the spars & pens of the sedimentation array function as sediment traps, accumulating sand at a faster rate than the surrounding reef flats. When the exclosure pens reach a state of sedimentation that makes seaweed cultivation unproductive, mangrove seedlings are planted throughout the array in the separate compartments of the spars and pens.

Seedlings
Young mangroves on an exposed reef flat environment are not self-sufficient, and require a fair degree of stewardship to become established. The seedlings must first be grown in pots in a protected nearshore location for 12-18 months. At this stage the seedlings can be moved to the reef, where they are placed into the protective "reef balls," shown below.

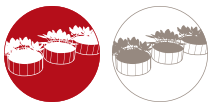


Species
Three species are shown here. *B. gymnorrhiza* is actively cultivated around inland depressions, and is a valuable timber source because the wood is highly rot resistant. *R. apiculata* and *R. mangle*, however, are more suitable for establishment on reef flat locations, as they are uniquely adapted to survive high rates of saltwater inundation.

Bruguira gymnorrhiza Tree Mangrove [Joñ]

Rhizophora apiculata / mucronata Red Mangrove subspecies [Būļabol]

Rhizophora mangle Red Mangrove



Garden Planters
The cultivation of edible plant species is fundamental to the development of sustainable independance in the Marshall Islands. Much can be gained simply by looking to the past: traditionally, the Marshallese utilized a complex system of forest management and curation, partnered with intensive cultivation of foodcrops in the few small areas where this was possible. This agroforestry involved cutting, burning, planting of crops transported from distant lands, harvesting, and other activities which largely replaced the existing dense but resource poor natural *Pisonia grandis* forests. However, much of this carefully cultivated landscape has been lost, replaced from the late 19th century by coconut plantations, and more recently built over on urban atolls.

Agricultural production is threatened by rising sea levels, changing weather patterns - which bring more frequent storms and draughts - and erosion exacerbated by urbanization and the cutting of dense forests. Furthermore, it is important to understand that traditionally, these agriforestry techniques were only suitable to the largest and widest islands - which are the most contested spaces. To adapt these principles for use on smaller islands, or emerging environments such as those generated by this proposal, several additional technologies are required. First, the production of nutrient rich soil through the use of living machines for sewage treatment, composting of seaweeds and aquaculture waste products will be essential. Secondly, because small & low-lying islets are periodically subject to overwash (inundation with salt-water during storm or flood events) garden pens are necessary to provide food security, protecting delicate crops from salt intrusion.

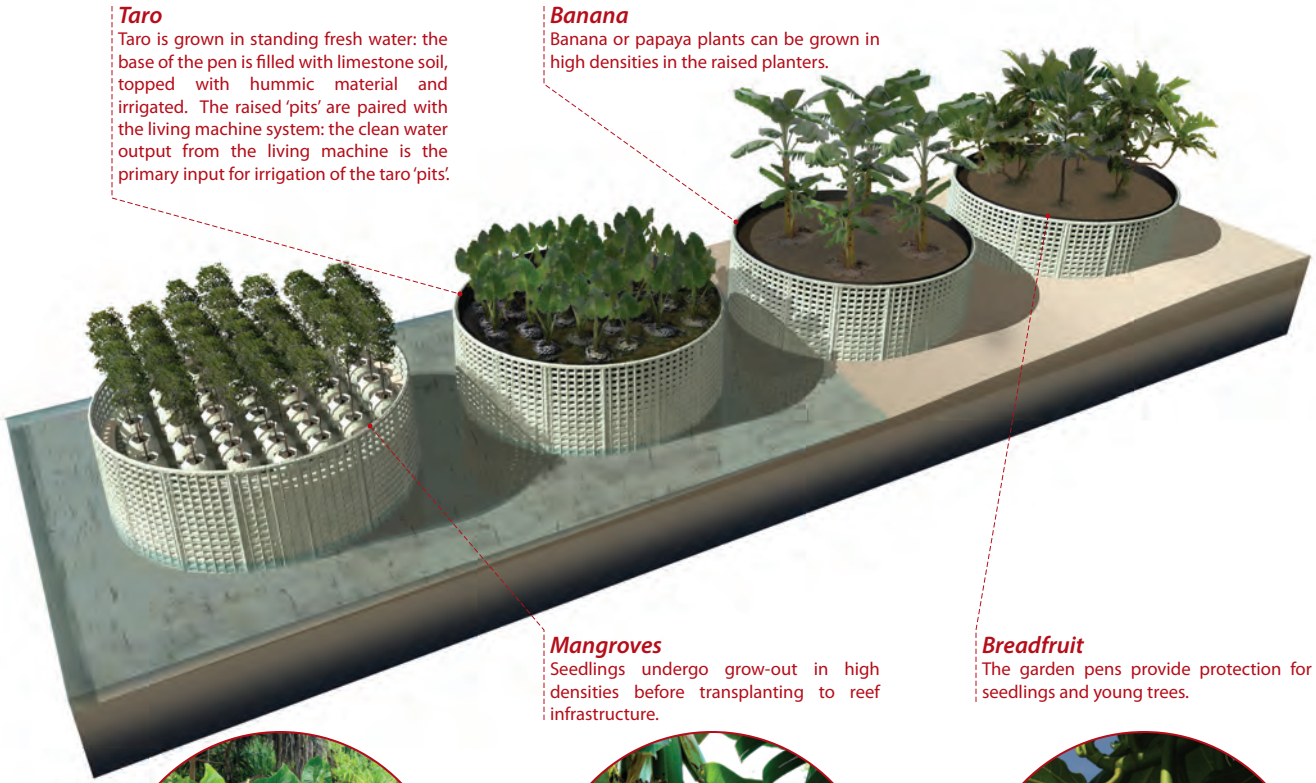
Breadfruit - Mã
The most important food crop for traditional atoll subsistence farming. Not only did Breadfruit trees produce food (the breadfruit), wood, and medicinal ingredients, they also protected more delicate crops such as taro and fruit trees from the salt winds. Breadfruit is a large, starchy food, eaten roasted, baked, fried or boiled. Traditionally, surplus crops were fermented in large pits, producing a strongly flavoured paste which could be stored for a year or more.

Swamp Taro - Iaraj
The tubers of this giant taro plant (it can grow 20 feet high or more, with enormous leaves) made up the bulk of the traditional Marshallese diet. Taro is farmed for its large 'corm' - an enormous tuber which is cooked, pulped, and usually mixed with coconut milk or breadfruit paste for flavor. As with breadfruit, the Marshallese developed techniques to allow storage of taro for years. Taro requires intensive

cultivation practices: it was grown in deep pits dug into the centre of the widest islands, where it was protected by dense stands of Breadfruit and Pandanus trees from salt-laden winds. However, most of these pits have not been maintained; they are also more frequently flooded with seawater, which has destroyed entire harvests on outer islands.

Fruit Trees

As with taro, fruit trees require the protection of the managed forest and vigilant cultivation to grow successfully in the Marshallese environment. It is unclear when they were introduced, but both Banana - Keeprañ - and Papaya - Keinabbu - are widespread on both urban and outer atolls in the RMI.



Cyrtosperma chamissionis Swamp Taro [Iaraj]

Musa acuminata Banana [Keeprañ]

Artocarpus mariannensus Breadfruit [Mā]

install use

Living Machine

One of the major threats to the health of the reef ecosystems in the Marshall's, as with other urbanizing nations of the Pacific, is the nutrient pollution created by the discharge of sewage from urban islands. For example, the sewage treatment facility on Ebeye has fallen into disuse, and has not been operating since at least 2005.[32] The lack of sanitary treatment is also a major health risk for people living on urban islands, and has contributed to the outbreak of infectious disease epidemics in the crowded conditions of Ebeye. In the current condition, raw sewage is discharged directly into Kwajalein lagoon; this has led to high *E. coli* measurements along the lagoon beaches, and threatens the surrounding reefs. High nutrient load can also be a factor in the formation of "red tides" - the explosion in growth of phytoplanktons or dinoflagellates in the water column, such as *Gambierdiscus toxicus* which causes Ciguatera poisoning. Ciguatera poisoning can destroy a fishery by making many reef and lagoon fish inedible to humans.

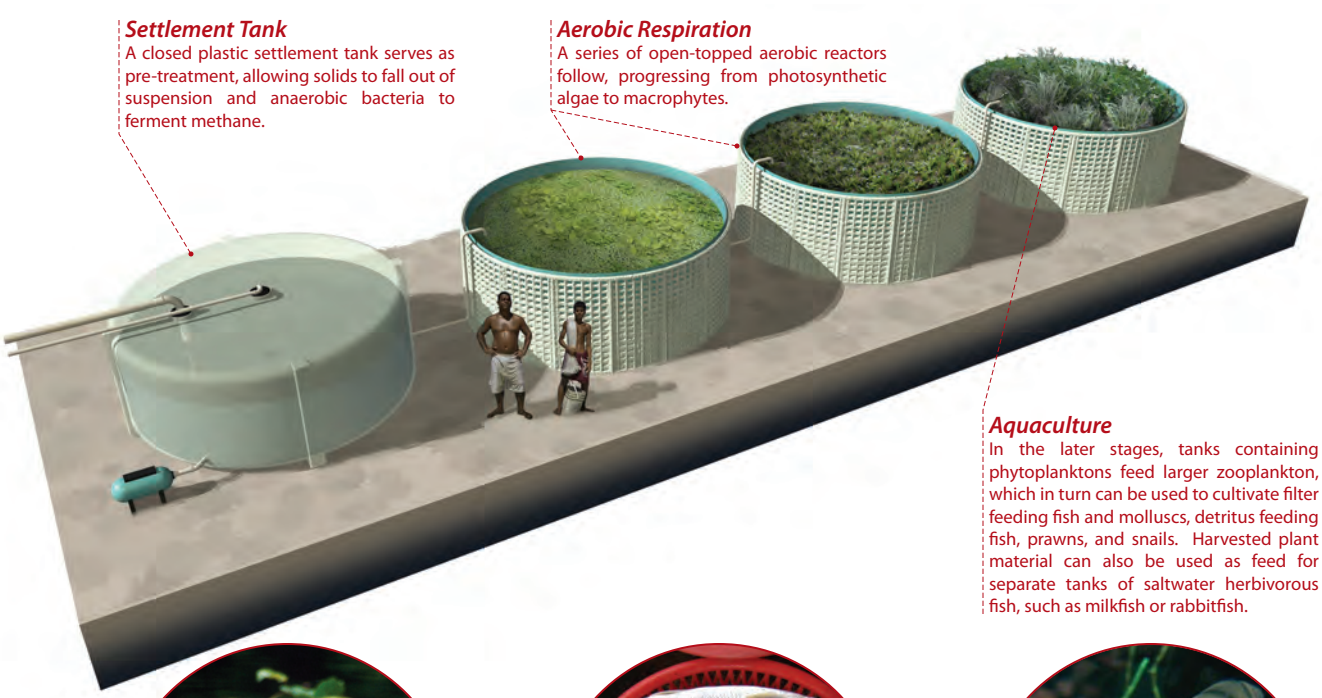
One promising technology which can be implemented at a grassroots level with reasonable initial investments, and numerous potential outputs, is the 'Living Machine' system. A living machine utilizes a sequence of wetland & aquatic plants, anaerobic & aerobic bacterias, algaes, plankton, snails and other organisms to create a system of intensive bioremediation which cleanses wastewater, produces soil, and generates food for other organisms. The system is integrated with the other systems of aquaculture and intensive agriculture, producing biomass for herbivorous fish and filter feeders, nutrient rich humous, and fresh water for gardens.

The primary components of the system are a series of biorock tanks (the same design as the reef pens, although size can easily be modified to suit different species), plastic settlement tanks, and PVC piping for water circulation. Input can include: blackwater from toilets; greywater from washing; and nutrient waste collected from washing down aquaculture tanks. The sequence includes: anaerobic settling tanks; a biofilter, composed of bark or coconut husks; a series of open-top, aerobic reactors, in which photosynthetic algae and microbial communities restore oxygen to the turbid water; and macrophytes with dendritic roots such as *Eicchornia crassipies* (Water Hyacinth) which are grown in tanks stocked with phytoplanktons. Because there is no existing standing fresh water in the RMI, there are no existing freshwater snails, fish, or crustaceans to employ in late stage tanks. Plants grown in the living machine can be fed to tank based saltwater fish, or it may be possible to import breeding stocks of freshwater species of prawns, fish and snails.

32 USA-CE. (2010): pp10-18.

Freshwater Prawns, Shellfish & Snails

Paired living machine / aquaculture systems have been successful in the west. One of the most important species in this regard is the freshwater Duck Mussel, *Anodonta anatina*. Native to Europe and Asia, a single individual can filter up to 40 litres of water per day; a comparable analogue would have to be found which performs similarly well in a tropical environment. One possibility is the Malaysian Giant River Prawn, *Macrobrachium rosenbergii*, which is an important commercial prawn species, and has been successfully cultured for years in insular southeast Asia in comparable conditions to those found in the Marshall Islands. It could provide a valuable food resource as growing populations and a mandate for self-reliance will continue to put greater stress on local resources. One advantage of utilizing imported freshwater species is that there is no danger of escapees forming invasive populations, as there is literally no suitable habitat for them to colonize here.



Eicchornia crassipies Water Hyacinth

Chanos chanos Milkfish

Macrobrachium rosenbergii Malaysian Giant River Prawn

Dune-stabilizing Vegetation
As dune formations begin to appear, mangroves are slowly buried under sediment - they may also be selectively harvested to make way for the planting of new species. There are many species which share similarities enabling them to survive in these harsh conditions: many are non-woody, with fleshy leaves and salty sap; they produce seeds which can float in saltwater for long distances; and they are highly tolerant to salty air and poor soil. Important species which can be used to stabilize emerging dune formations include: *Scaevola taccada* -Kōṇṇat - a succulent shrub; *Triumfetta procumbens* - Atat - a low-growing ground cover; *Tournefortia argentea* - Kiden - a small tree with numerous medicinal uses; and *Cordia subcordata* - Kōṇo - another tree which produces fine timber for carving and boat-building. There are numerous others.[33]

Mangrove Forest
Over a period of several years, mangrove seedlings implanted in the sedimentation array become established; their arching roots spread out from the high ground of emerging dunes which form around the biorock components into the surrounding shallows. As they propagate, new mangrove seedlings accelerate the process of sedimentation and alter the patterns of water movement across the reef flats. The roots bind together the loose sand; they encircle areas of shallow water, forming enclosed ponds which become brackish after heavy rains or supersaline at low tide as they evaporate; and they drop organic material - dead leaves, seeds, and the remains of insect and bird life - into these now enclosed lagoons, where it will decay and feed cyanobacteria and algaes. The forest will form a unique ecosystem which is extremely rare in the atolls, and will be colonized by aquatic species, birds, and insects, making it a rich hunting ground.

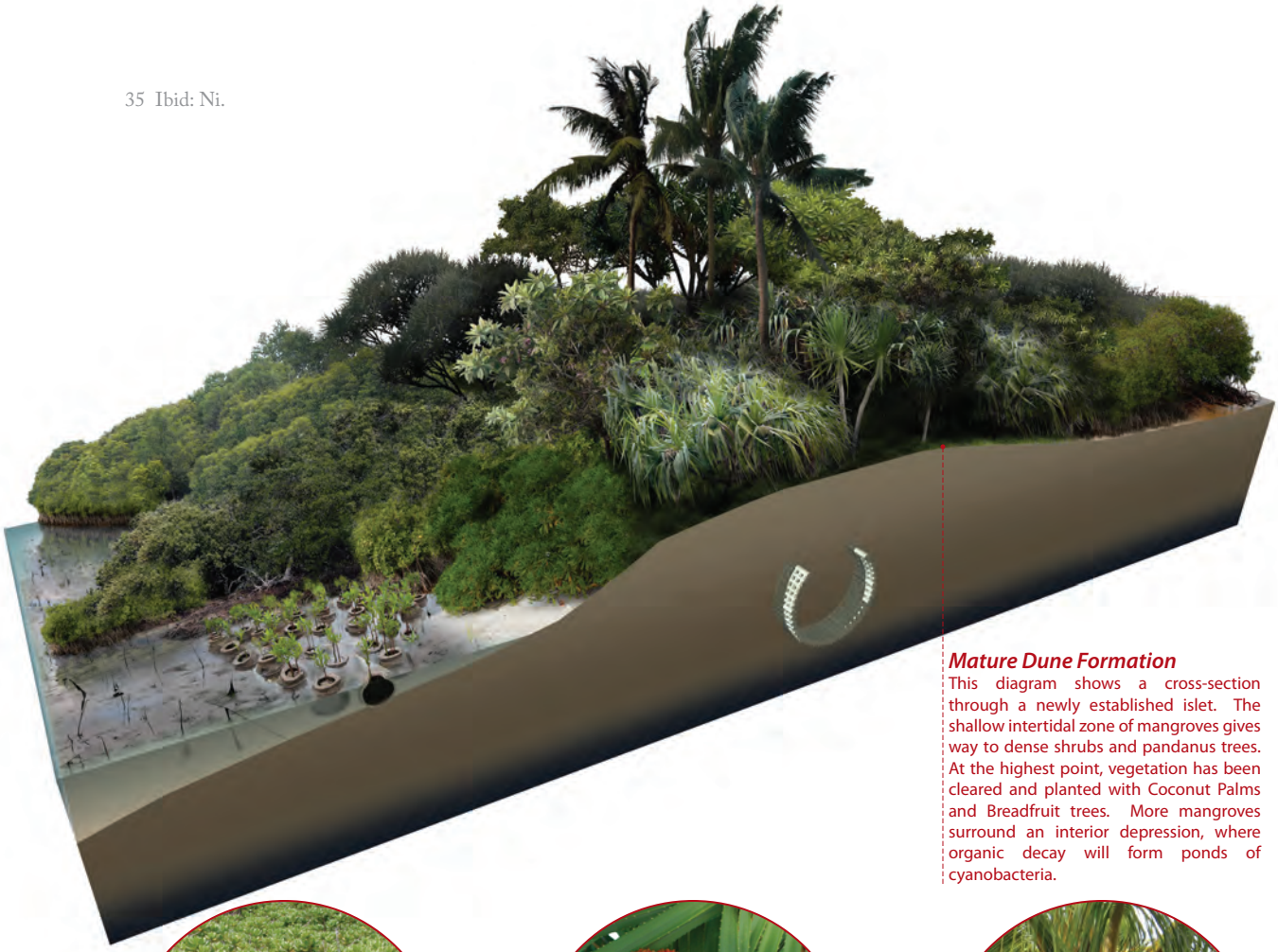
Pandanus tectorius [Bōb]
Of all species which grow in the exposed ocean strand environment, the most important plant is the Pandanus. It has been cultivated for millenia by the Marshallese, who have names for as many as 100 varieties. The tree forms enormous aerial prop-roots, enabling it to survive periodic inundation (similar to mangroves), and produces a large, fibrous fruit which is consumed fresh, and is also fermented into a paste which can be stored for long periods, and was an essential food for long distance ocean voyaging. Establishing stands of Pandanus will be an essential step in catalyzing mature islands, as its dense fronds provide a degree of protection for more delicate plants.[34]

33 Merlin. (2011).
34 Ibid: "Bōb."

Coconut Palm [Ni]

Cocos nucifera probably has more applications than any other plant in the world, with more than 300 recorded uses amongst Pacific islanders. It provides food, drink, building material, fronds for weaving, thatch, oil, alcohol, firewood, natural torches, sweeteners, jewelry, and containers, among others.[35] Palm seedlings must be encouraged by clearing of other vegetation as they will only grow in full sun conditions. Once established though, they are highly resilient and can grow quickly to great heights, forming the backbone of the atoll forest.

35 Ibid: Ni.



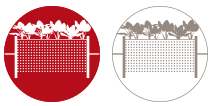
Mature Dune Formation

This diagram shows a cross-section through a newly established islet. The shallow intertidal zone of mangroves gives way to dense shrubs and pandanus trees. At the highest point, vegetation has been cleared and planted with Coconut Palms and Breadfruit trees. More mangroves surround an interior depression, where organic decay will form ponds of cyanobacteria.

Scaevola taccada Beach Naupaka [Kōṇṇat]

Fruit of the *Pandanus tectorius* Screwpine [Bōb]

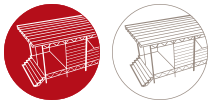
Cocos nucifera Coconut palm [Ni]



Cisterns

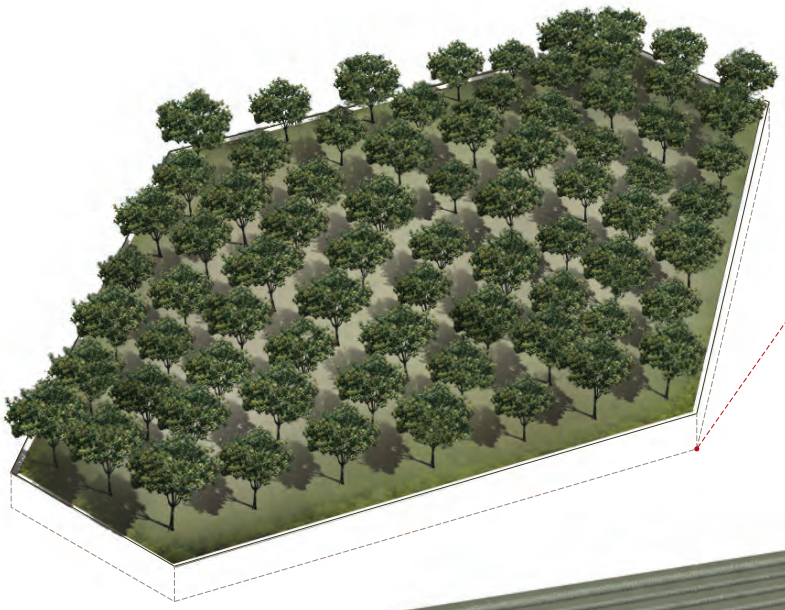
The most serious impediment to be overcome in the colonization of marginal atoll islets is the establishment of secure, reliable sources of fresh water. The simplest technology to achieve this aim is the collection of rainwater. On a small scale, rainwater collection in the form of storage tanks adjacent to buildings will be sufficient to supply local need for drinking water, but may not be adequate to supply irrigated crops. To supply the needs of a larger settlement, and to increase resiliance to storm events, one option is to construct large open-topped cisterns. Because fresh water will float on top of the underlying strata which is permeated with brackish water, the construction of a cistern would involve building a horizontally impermeable barrier to prevent rainfall from diffusing out from the centre of an island. This could be achieved in a number of ways; essentially, the area which will become a cistern is isolated by digging a perimeter trench, which is then filled with an impermeable material - either a geotextile or a solid wall of concrete or biorock™.

Housing



New forms of inhabitation, such as the particular form of maritime urbanism presented in this proposal, will require rethinking housing typologies and construction. Perhaps the ultimate potential for biorock™ as a construction material is for its potential role in the creation of a new vernacular housing - cheap, constructed from locally sourced materials as largely as possible, which is simple for local people to construct. The currently favoured vernacular construction format - concrete block homes, on poured concrete slabs, with corrugated steel for roofing - has largely supplanted traditional housing forms on urban atolls. But this practice relies heavily on imported materials and specialized skills (masonry and working with sheet steel), which make these modern homes expensive. Furthermore, they are not well adapted to the tropical climate, being hot, humid, and provide no protection to inhabitants or possessions in the event of flooding. A step towards a solution is proposed here: biorock trusses and catenary roof forms are used to construct houses which combine some of the advantages of the modern concrete block dwellings (corrosion resistance, durability, and protection from tropical storms) with the logic and wisdom embodied in traditional construction forms (floors raised above-ground for flood protection and to reduce pest infiltration, light-weight, operable walls to allow ventilation, locally sourced materials, and simple construction methods such as lashing and thatching).[36]

36 Ortega. (1989).



Cistern
At the end of the sedimentation process, a trench is excavated around the central cell (what was once the fish trap). The trench is lined with an impermeable material or wall, which is extended vertically well above the high tide line, creating a protected zone within which will become a catchment basin for rainfall.

A New Vernacular
Biorock construction elements, used in combination with locally sourced materials such as pandanus wood & thatching, enable the possibility of a new vernacular construction which is locally produced, simple to construct, durable, and climatically suitable.

Weaving wall panels from Pandanus leaves.

Raising Islands
An atoll motu emerges from the sea. The dynamic processes of the reef flat are eternally in motion.

In this final section, the assembly of systems and components are deployed into a fifty-year projected future, to an open-ended conclusion in 2066 - the end of the current USAKA lease, and a suitable time to reflect upon the future of life in the atolls.

- **Stage 1** : 1-2 years (to 2014)
- **Stage 2** : 1-2 years (to 2016)
- **Stage 3** : 3-4 years (to 2020)
- **Stage 4** : 3-4 years (to 2024)
- **Stage 5** : 3-4 years (to 2028)
- **Stage 6** : 3-4 years (to 2032)
- **Stage 7** : 5-8 years (to 2040)
- **Stage 8** : 5-8 years (to 2048)
- **Stage 9** : 5-8 years (to 2056)
- **Stage 10** : 7-10 years (2066 and beyond?)

A loose timeline is provided to aid conceptualizing the scale of the natural processes and growth rates involved in the proposal - both terrestrial and marine. But this is uncharted territory, and it is impossible to say exactly what is possible in a given frame of time. Experimentation will no doubt yield both successes and failures which will condition the development of the proposal more than the quantities and exigencies of the present.

FIG. 4.19

Proposal Stage 1

P+

1-2 years (2014)

In this phase:

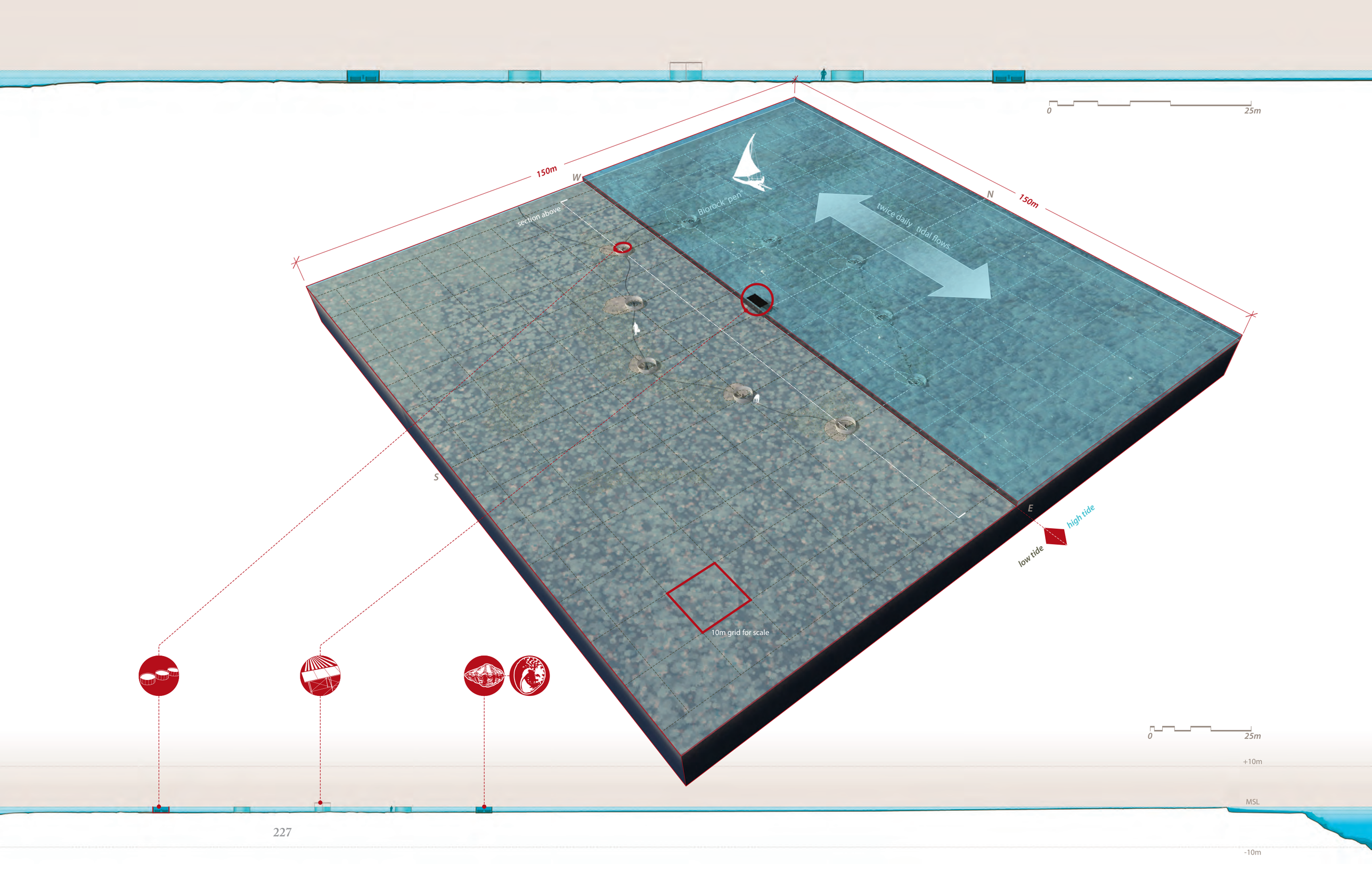
- A biorock workshop is set up on a nearby island.
- Biorock exclosure pens are assembled on the beach, and then floated into position at high water and anchored to the reef shelf, roughly halfway between the two islets.
- Low-voltage current is supplied by solar panels mounted above high-water, either on a steel frame with accreted minerals to protect it from corrosion, or a lightweight aluminium frame;
- Alternatively, the pens can be powered by a small wave power unit, anchored on the lagoon shore.
- The exclosure pens can now be used to protect various reef products which can be grown in the intertidal zone: Giant Clams, Trochus and other ornamental shells.

As the exclosure pens accrete aragonite, they are fused to the reef shelf, forming strong 'anchor' points for subsequent construction. The initial accretion process only takes a few weeks; however, power can be maintained for a longer period as desired, as current supply increases the growth rate of the molluscs.

Input / Outcomes:

This initial deployment requires the labour of a small community group - 8-10 people. Material requirements include rebar & welded wire mesh for the reef pen components, as well as associated tools such as a propane torch, metalworking tools, etc. It also requires the purchase of a power unit. These initial expenses could be significantly offset by a larger scale of operations: if a number of prototype sites were set up simultaneously, all of the specialized equiptment could be shared amongst a larger group. A key to the success of the project from the beginning will be the availability and skill to utilize canoes. Throughout the life of the project, canoes will be required daily for access and transport of people and products.

With the reef pens in place, experimentation can take place to determine which species produce the best yields - also contigent on whether the products produced will be consumed locally or exported.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Biorack "pen"
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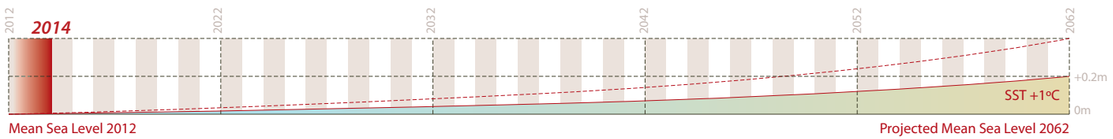
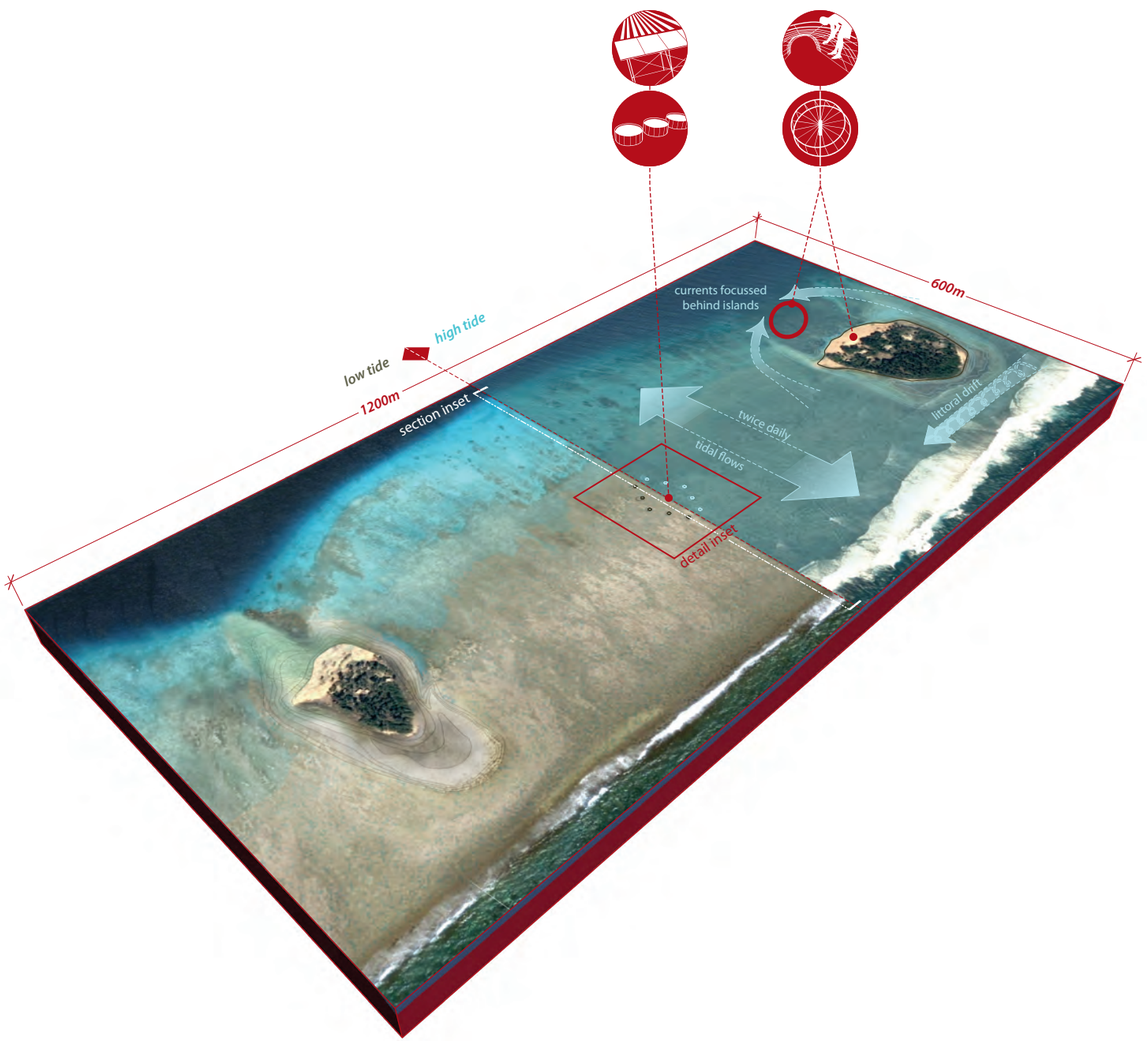
FIG. 4.20

Proposal Stage 2





1-2 years (2016)

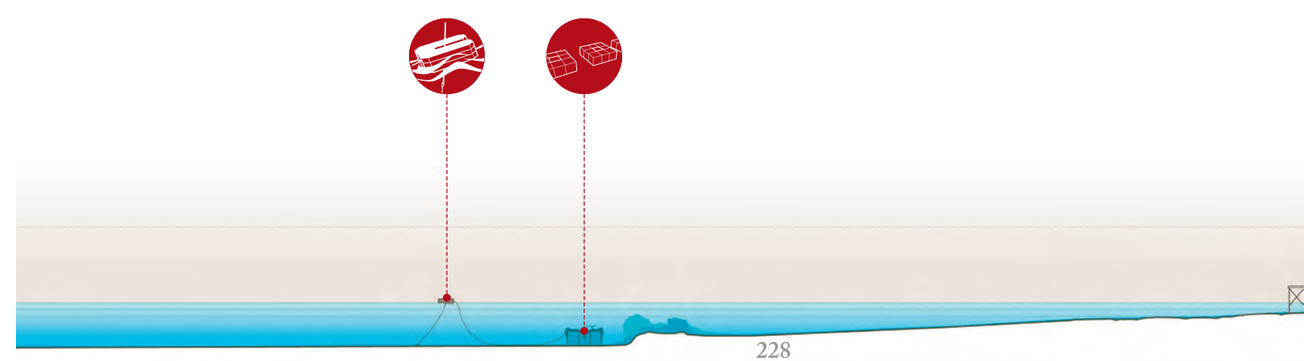
In this phase:

- Component manufacture continues.
- 'Spars' - which form the connecting elements in the sedimentation array - are manufactured.
- 'Pens' of various sizes are also constructed, for both terrestrial and marine use: exclosure pens, artificial reef frames, land-based garden planters, and mariculture tanks.
- After accretion, biorock elements are deployed. The spars are anchored to the pens on the reef flat to form a fish trap.
- The first artificial reef is installed, in the lagoon shallows adjacent to the fish trap. Coral fragments are collected from the forereef and installed.
- The first platforms can now be installed in the protective lea of the fish trap.
- In preparation for settlement on the island, selective clearing and planting of a dense Pandanus windscreen to protect future foodcrops can take place.

Input / Outcomes:

At this point, a larger number of stakeholders can become involved. The component assembly could take the form of a training facility, with this prototype location acting as a catalyst for other sites in more distant locations around the lagoon - perhaps with the involvement of the University of the South Pacific, the College of the Marshall Islands, an NGO, or even corporate investment. Productivity of the fishtrap will be tested, to determine if alterations to the design can provide larger catches. Similar experimentation will be required in the collection of oyster spat, in preparation for establishing pearl operations.

The end of this phase is a suitable goal in itself: a working fishtrap and reef shelf mariculture facility to be shared amongst the initial group of stakeholders.



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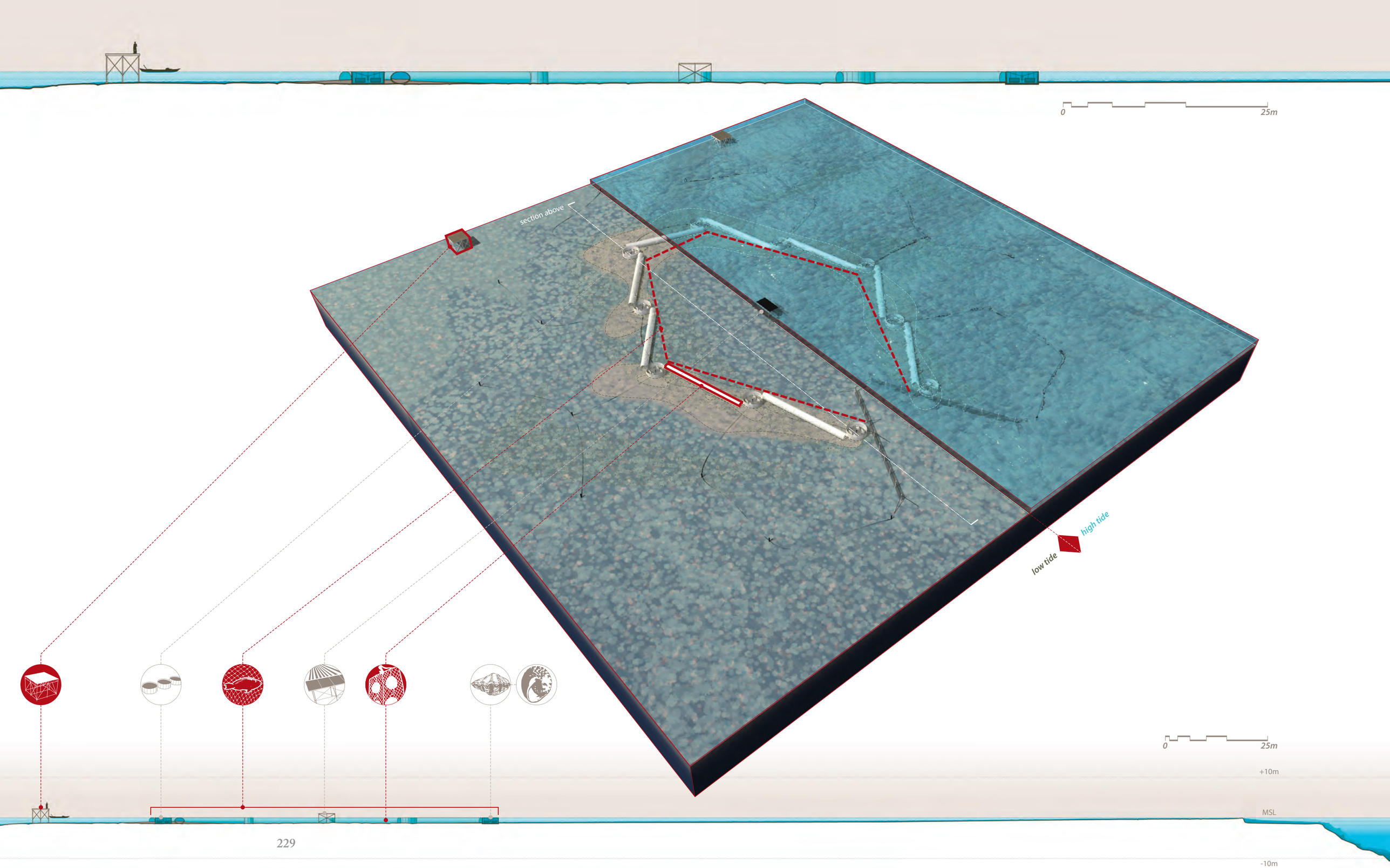
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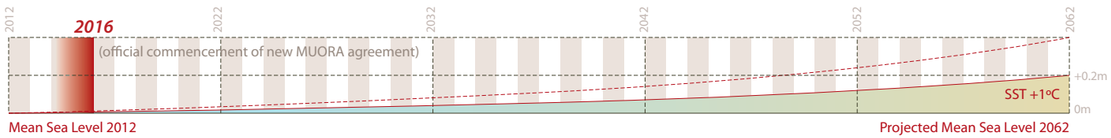
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(official commencement of new MUORA agreement)
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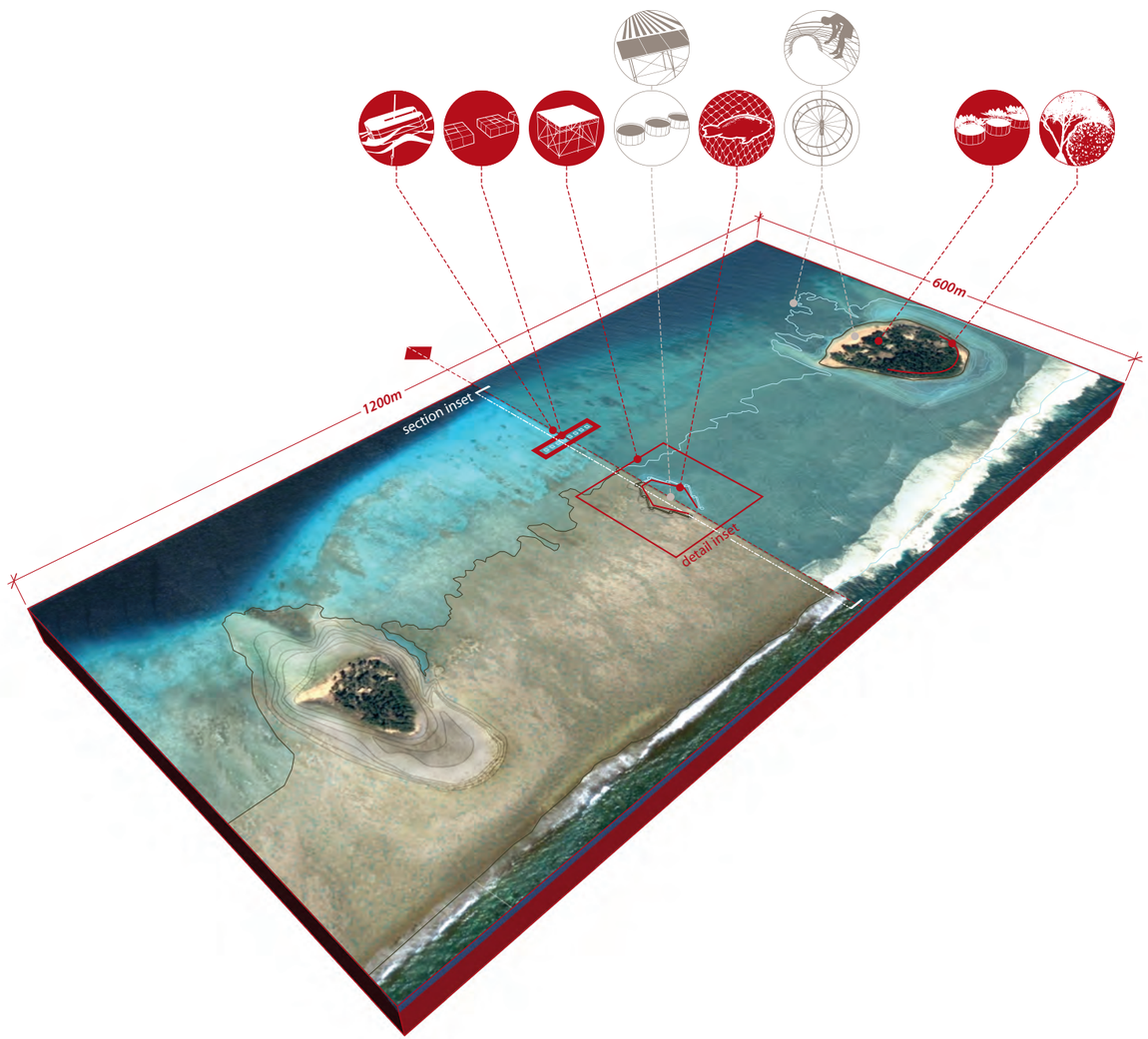
Projected Mean Sea Level 2062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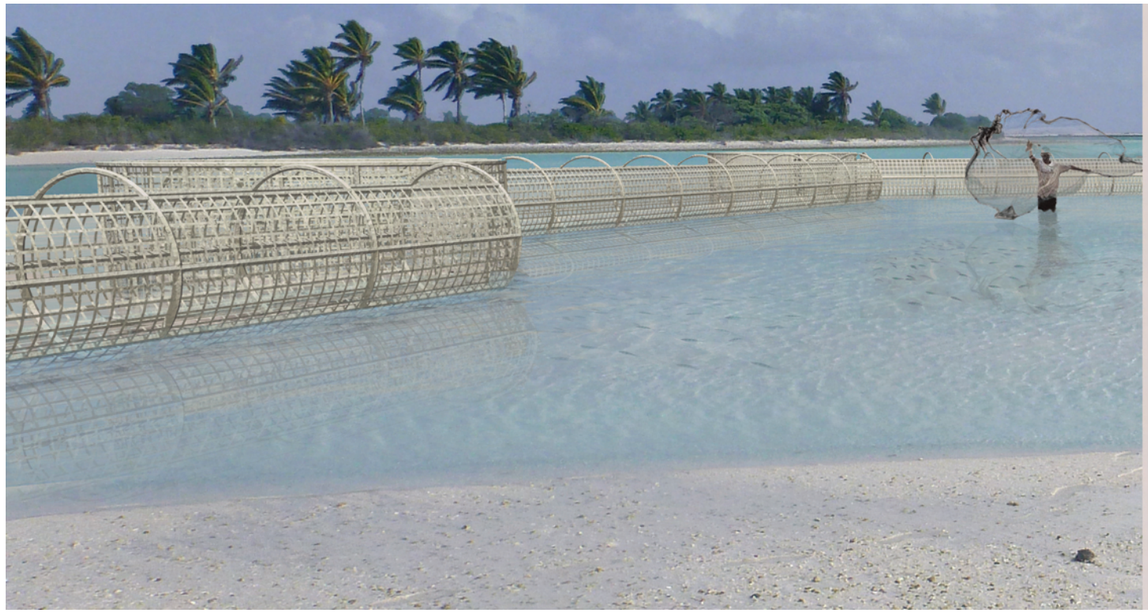

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Fish Trap
At this early stage in the proposal, the sedimentation array stands exposed during an ebbing tide. At high tide, reef fish which cruise the shallows are drawn into the trap by a funnel shaped net drawn across the opening to the reef. At later stages, the effectiveness of the trap is further increased by the additional bait provided by mariculture activities. Herbivorous fish are drawn into the trap by seaweed, and predatory species follow them in, or seek out crustaceans and crabs which have colonized the array. In the background at right, a bank of solar cells provide the low-voltage power required by the mineral accretion process.

FIG. 4.21

Proposal Stage 3

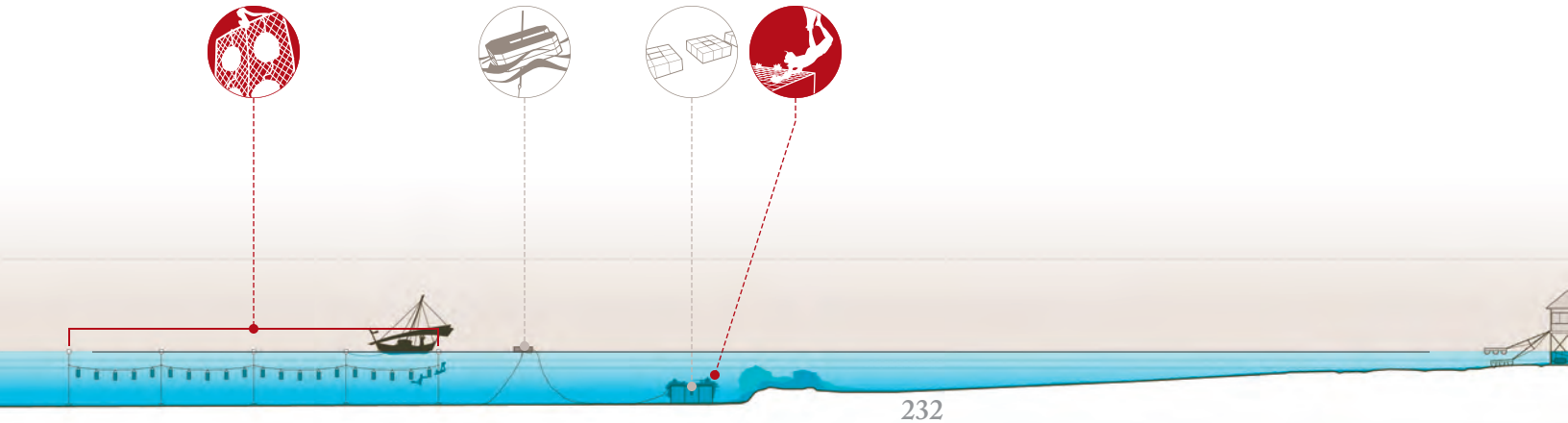
3-4 years (2020)

In this phase:

- Expansion of reef-flat mariculture, with the next round of exclosures deployed.
- The first phase of pearl farming operations begin: spat is locally collected if possible, but can also be sourced from on-shore breeding tanks if collection provides low-yields;
- Pearl oysters are installed in baskets suspended in lagoon, offshore from the sedimentation array - grow-out of the first 'crop' of oysters will take several years.
- Sunshades / roof is constructed on at least one of the platforms, to provide a protected working environment for work related to pearl farming (spat collection activities, or as a safe storage facility for baskets, lines, or other equiptment).
- The first significant sedimentation will begin to occur, as the fish trap acts as a sink for incoming currents and waves during stormy weather.
- Planting operations are expanded on the adjacent island: Pandanus hedges encircle raised planters which are used to cultivate fruit trees and taro, and a forest of Breadfruit seedlings is planted.

Input / Outcomes:

The pearl operation represents a significant opportunity to partner the local stakeholders with external investment. Getting the pearl operation producing on any significant scale will involve significant investment in training (of both oyster tending and seeding, as well as associated construction activities and diving).



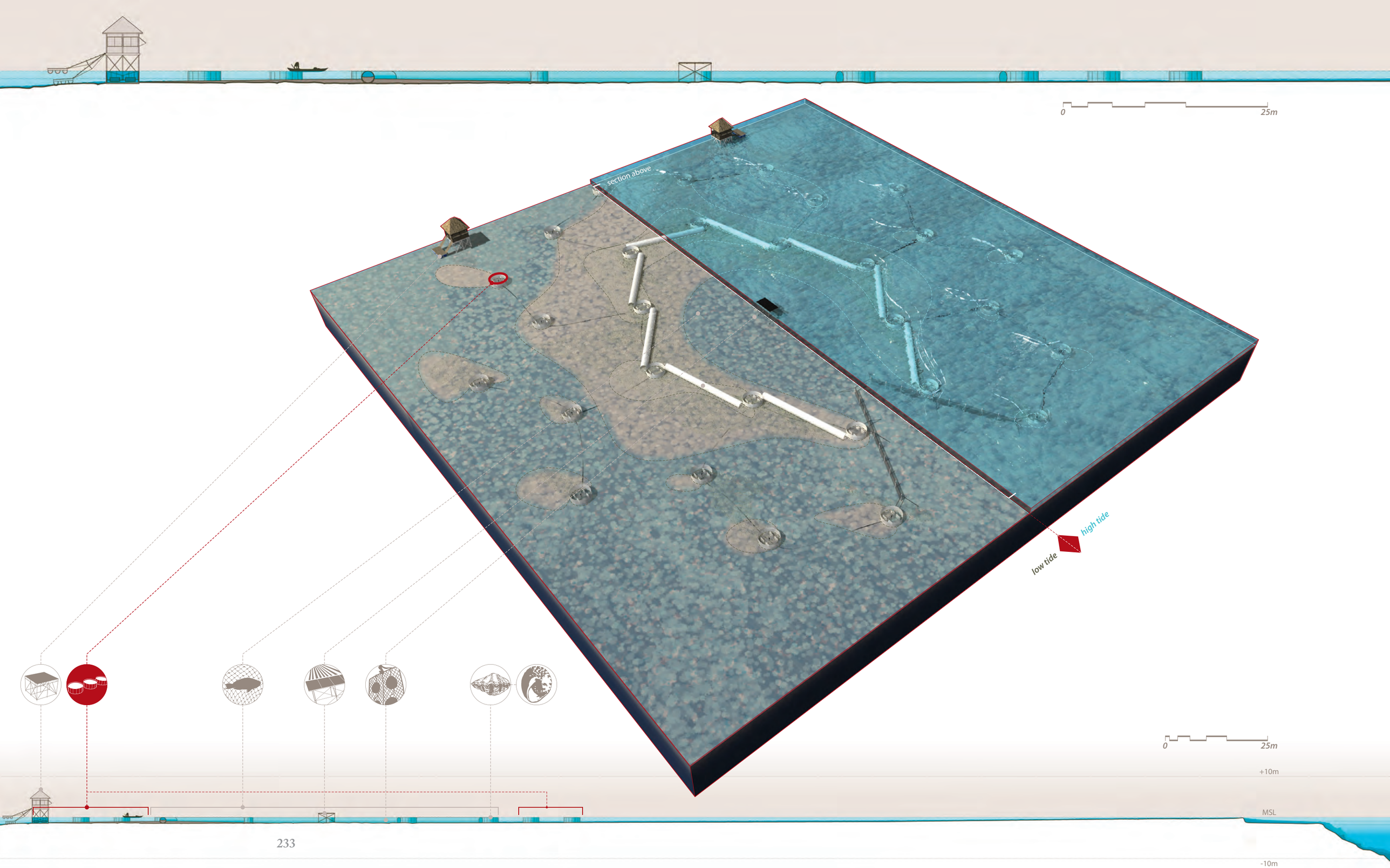

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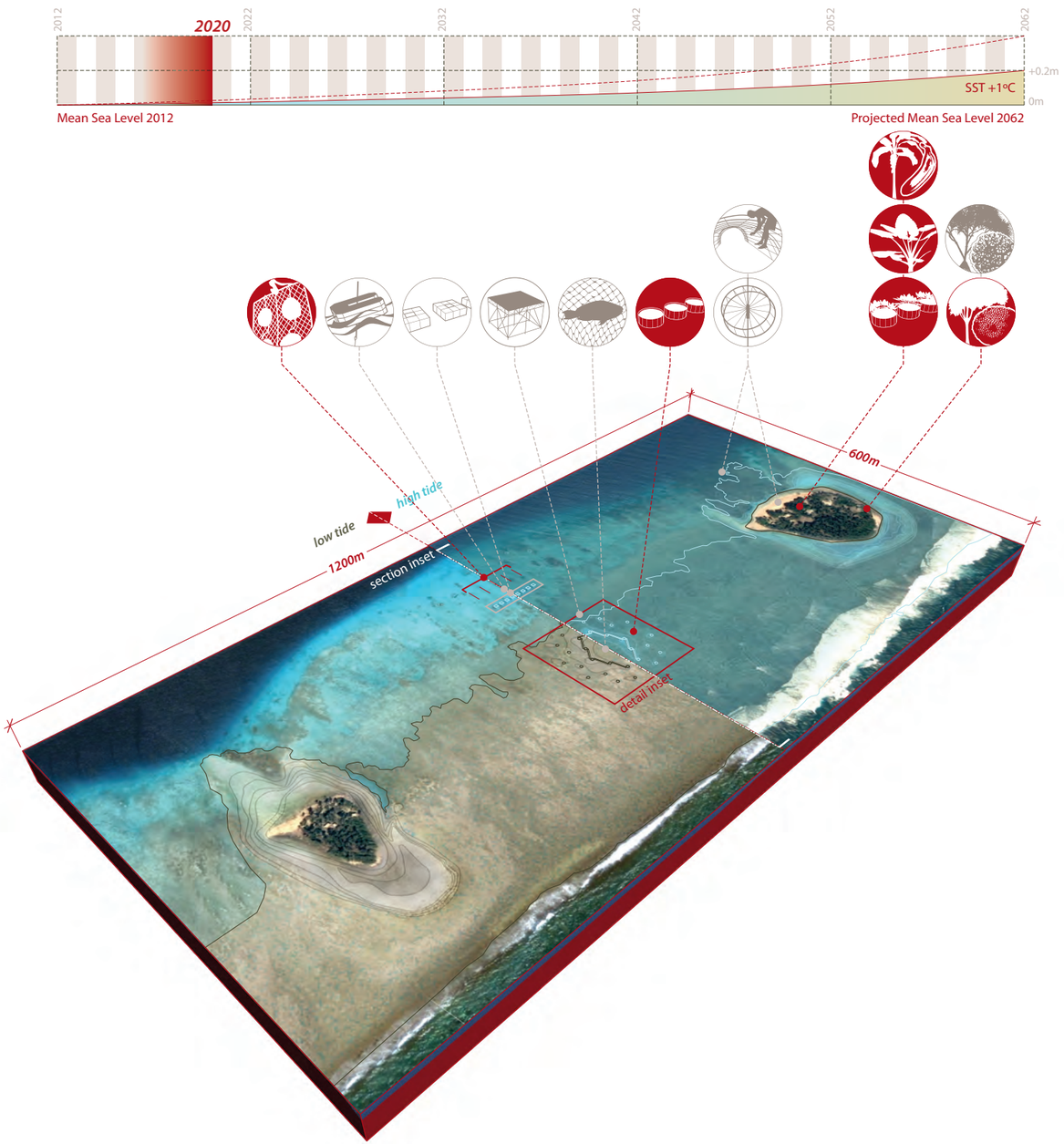
FIG. 4.22

Proposal Stage 4



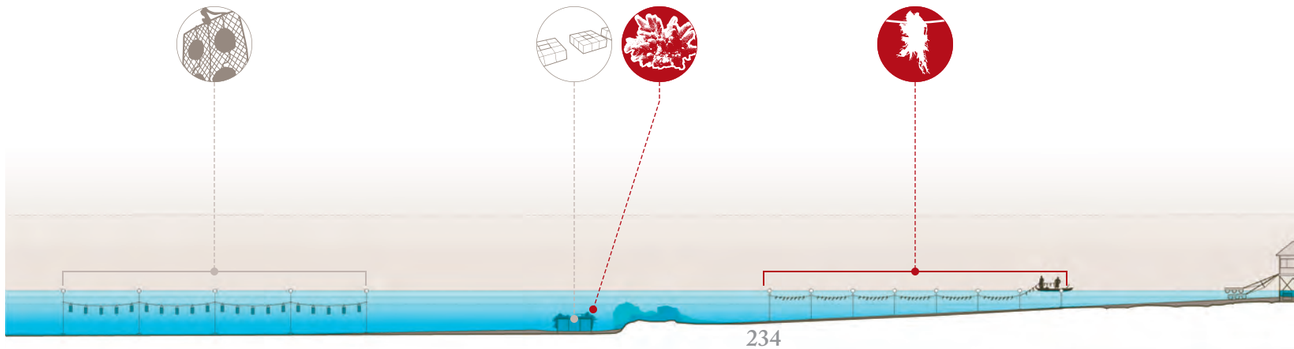
3-4 years (2024)

In this phase:

- Sedimentation array is completed: spars are deployed to create large exclosure areas for seaweed mariculture.
- Reef-platforms are expanded. Space is required for hanging and drying seaweed and working out of the sun.
- The sedimentation array forms individual plots: each cell provides enough space for a single farmer or family team;
- Seaweed operations attract fish, increasing the productivity of the fish-trap.
- Seaweed farming can also take place in the nearshore lagoon on floating lines. During fish shoaling periods, propagules are maintained in the protective exclosures.
- As indicated in the renderings which follow, seaweed cultivation may require additional platform construction. Perhaps each plot will be managed by independent groups who will determine when and what takes place. Alternatively, the whole array might be managed centrally, with individuals acting as workers for a larger co-operative or corporation. In any case, the details of deployment and activity are open.
- Initial pearl harvest has taken place, providing capital for expansion of pearl operations. A seeding facility will be required, either constructed on the reef platform or on the adjacent islands.
- The artificial reef also begins to produce coral for market, and attracts new species for hunting and fishing. The artificial reef can be expanded as economic returns dictate.

Input / Outcomes:

The seaweed operation provides the second major opportunity to pair local groups with external investment. The farming itself can be carried out by local people with a minimum of investment (it will require initial propagules sourced from abroad, as well as a supply of nylon lines and other equiptment involved in the farming operation). But a successful industry will require an economy of scale - ie. a significant number and concentration of farming operations to produce a regular crop for local markets in Majuro and Ebeye, and for export.



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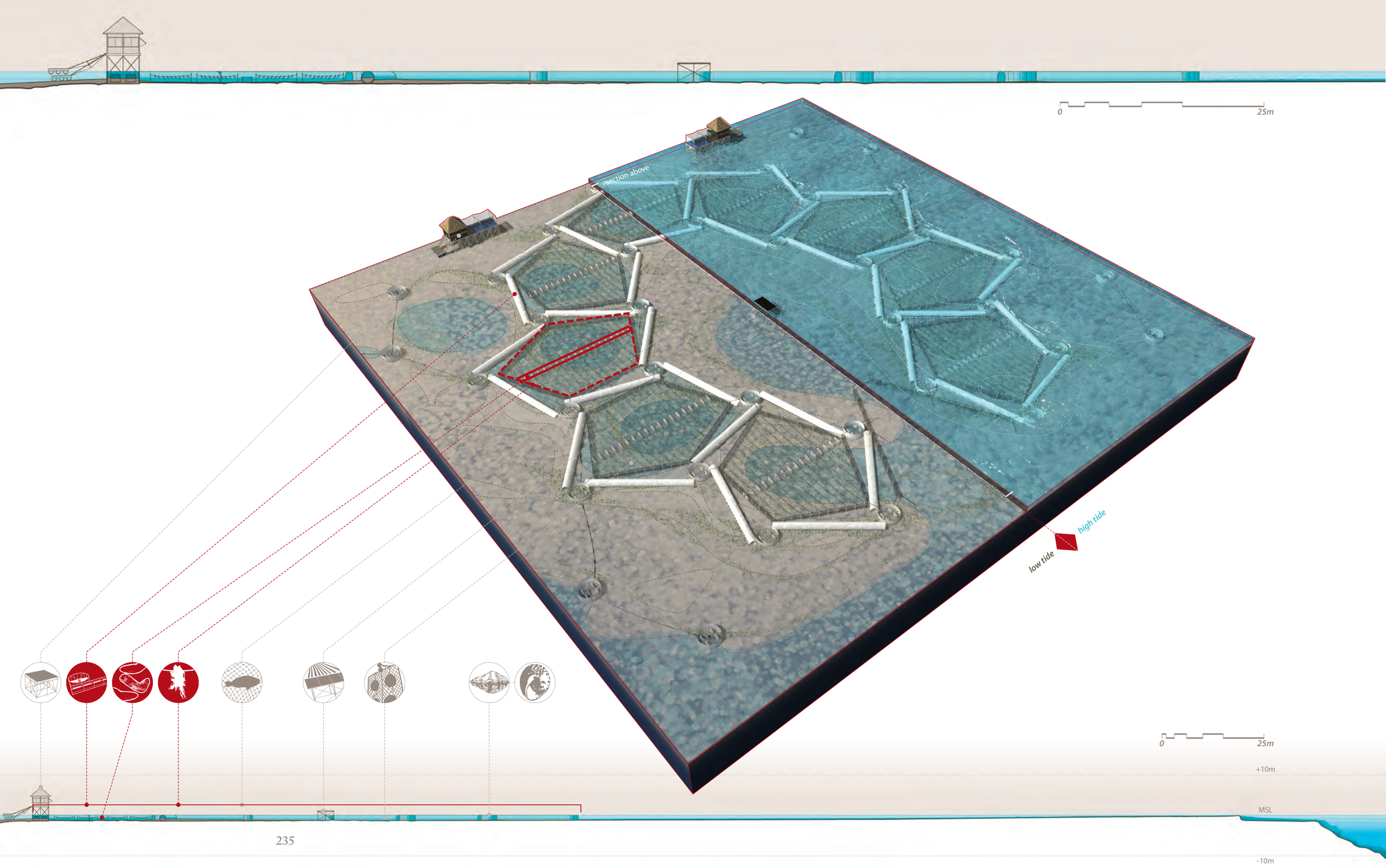
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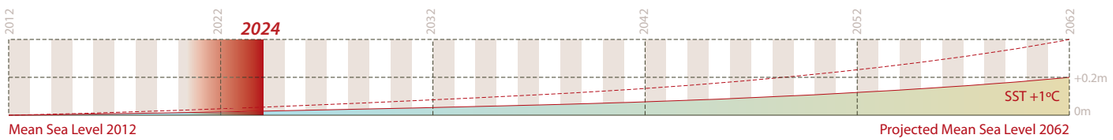
2012
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SST +1ºC
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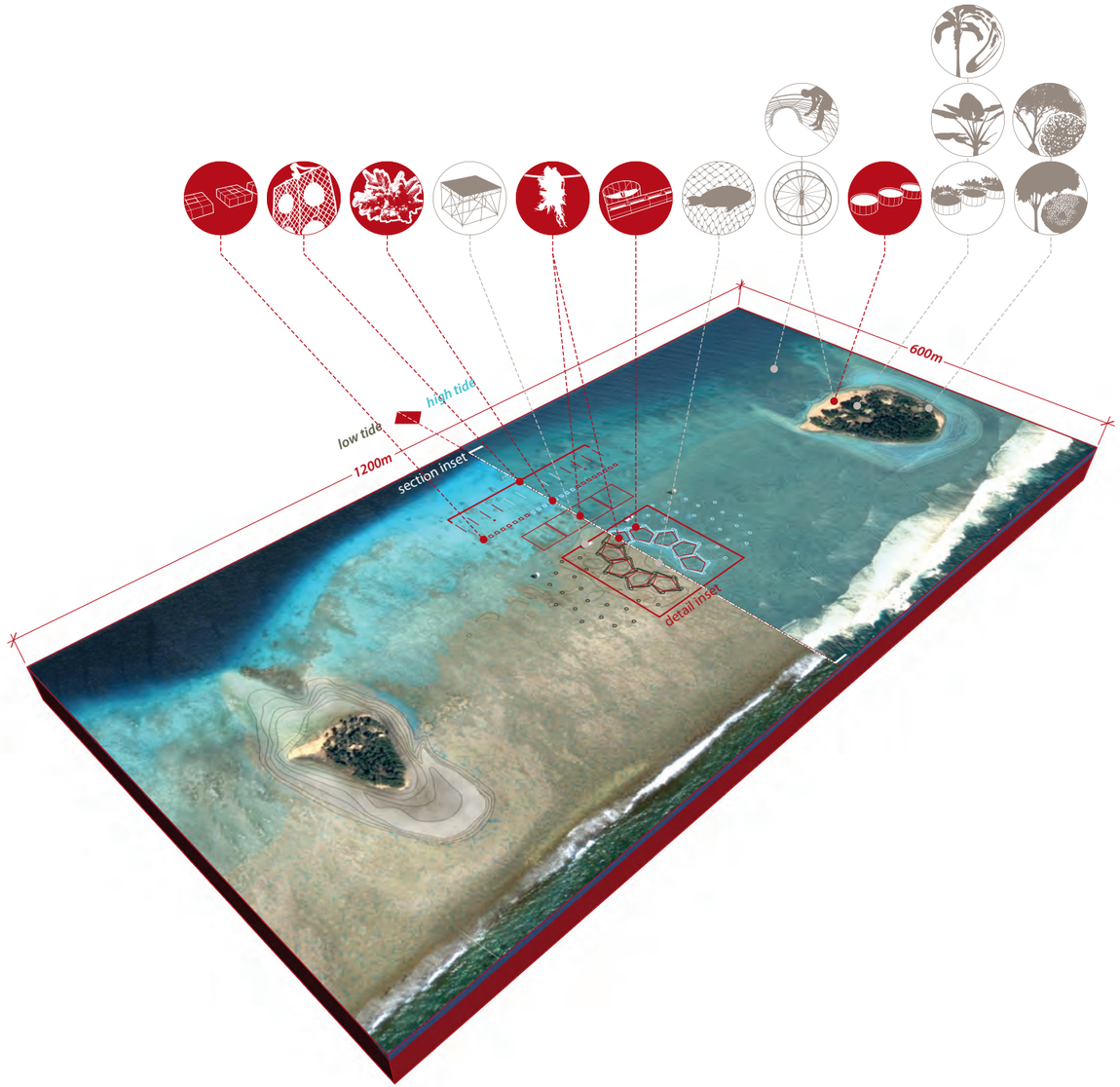
Mean Sea Level 2012
Projected Mean Sea Level 2062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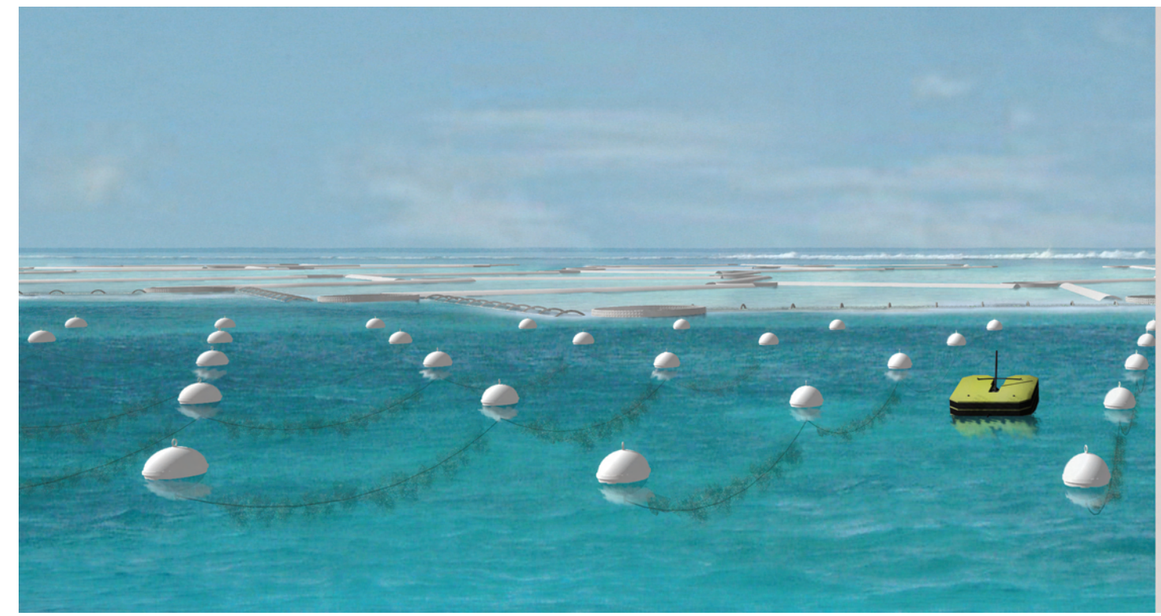


see inset

A Working Landscape
At centre, a small wave generator is providing power to the submerged artificial reefs, bobbing amidst floating seaweed lines. A large reef platform has been constructed which houses seaweed drying facilities, as well as a lab for oyster culturing and grow-out tanks for juvenile clams and shells. Once dry, the seaweed is bagged and packaged for export, carried to shipment facilities by canoe. The sedimentation array on the reef-flats beyond is partially exposed at mid-tide.

FIG. 4.23

Proposal Stage 5

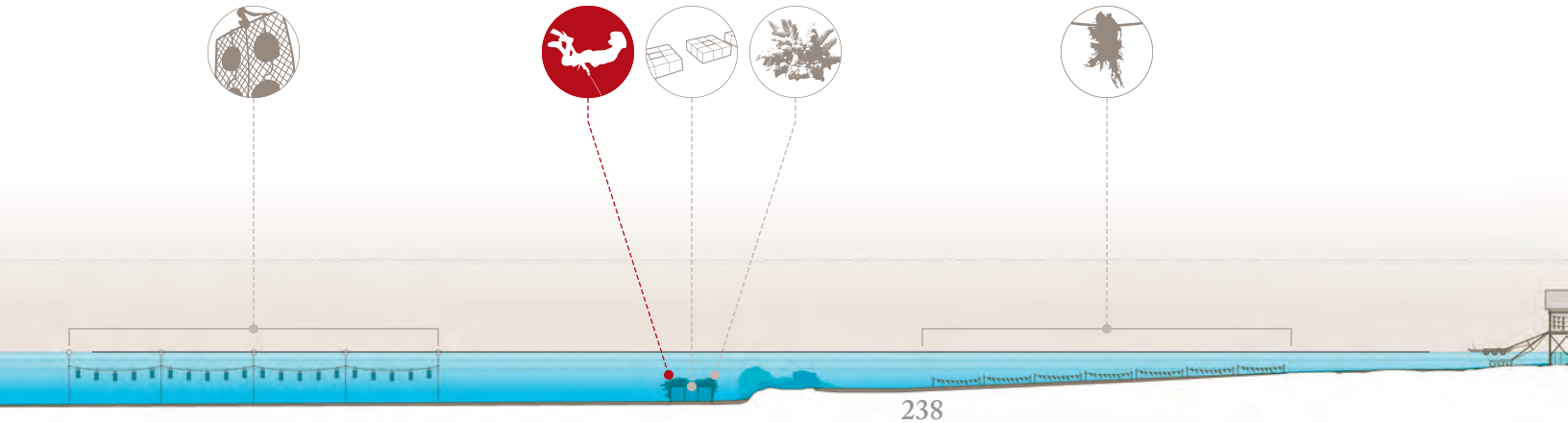
3-4 years (2028)

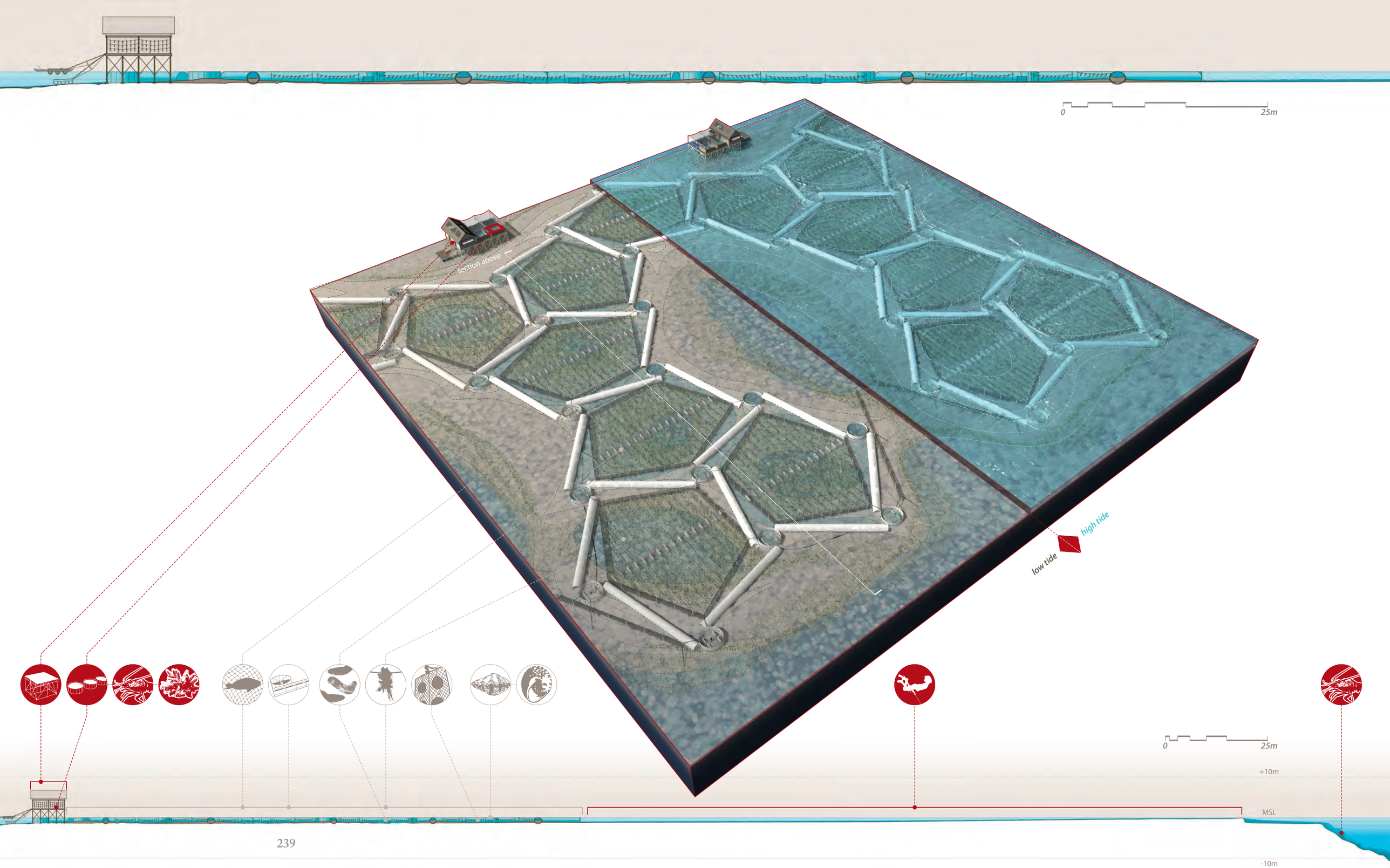
In this phase:

- At this point, all of the basic subsistence industries are in place: Pearl farming, mariculture, local foodcrops and seaweed production.
- Proceeds from this production now make more permanent settlement on the adjacent island possible for a larger group - the initial stakeholders who have taken part in the construction of the array, their families and children.
- The construction of a small settlement commences: housing, a more substantial power source (ie a medium-scale wind generator), and sanitation facilities (a living machine is ideal, to increase soil production).
- To increase self-sufficiency, shore-based mariculture should accompany settlement: milkfish and prawns can be cultured in association with the living machine.
- Also important for self-sufficiency will be the local manufacture of canoes and housing.
- With the increased power capacity of the wind-generator and larger workforce associated with settlement, biorock™ component production can now be increased. As the initial sedimentation arrays fill in with sediment, the facilities they provide are replaced with new adjacent arrays as the project expands horizontally across the reef flats.

Input / Outcomes:

Significant labour investment will be required to get a self-sufficient village established. Housing and sanitation facilities will require careful planning and experimentation to adapt technologies to the local conditions: for example, living machine plant and fauna selection. The goal is to have a fully self-reliant settlement established by the end of this stage - 20 years into the project - which provides housing and livelihoods for the colonizing group. This village need not be inhabited full-time. For settlements inside the Mid-Atoll Corridor, the population will be required to move to safer locations during annual missile-testing events. In any case, mobility will enable connections with populations spread around the atoll, setting up the possibility of seasonal enterprises with substantial down-time spent in urban areas or major settlement islands.

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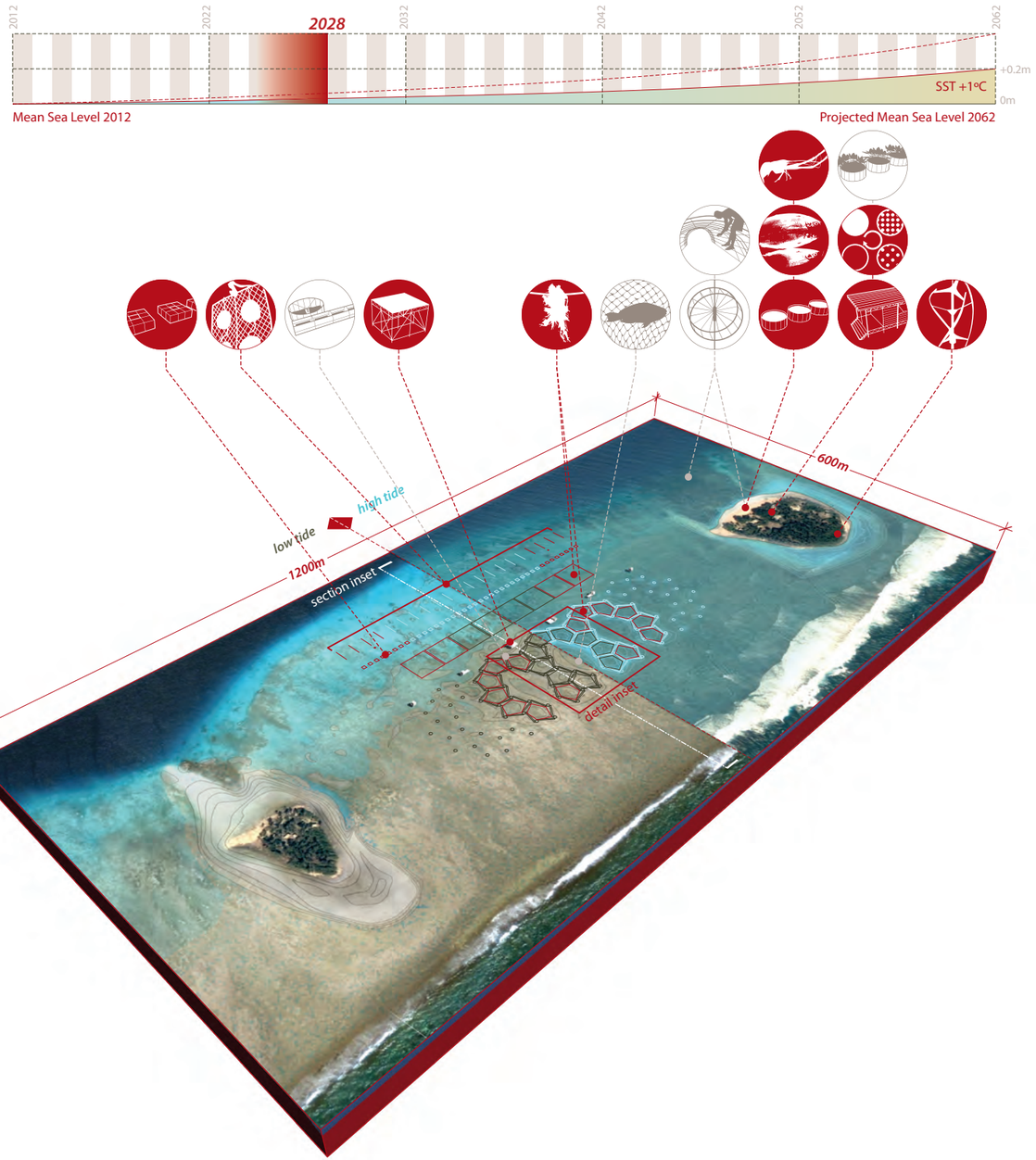
2012
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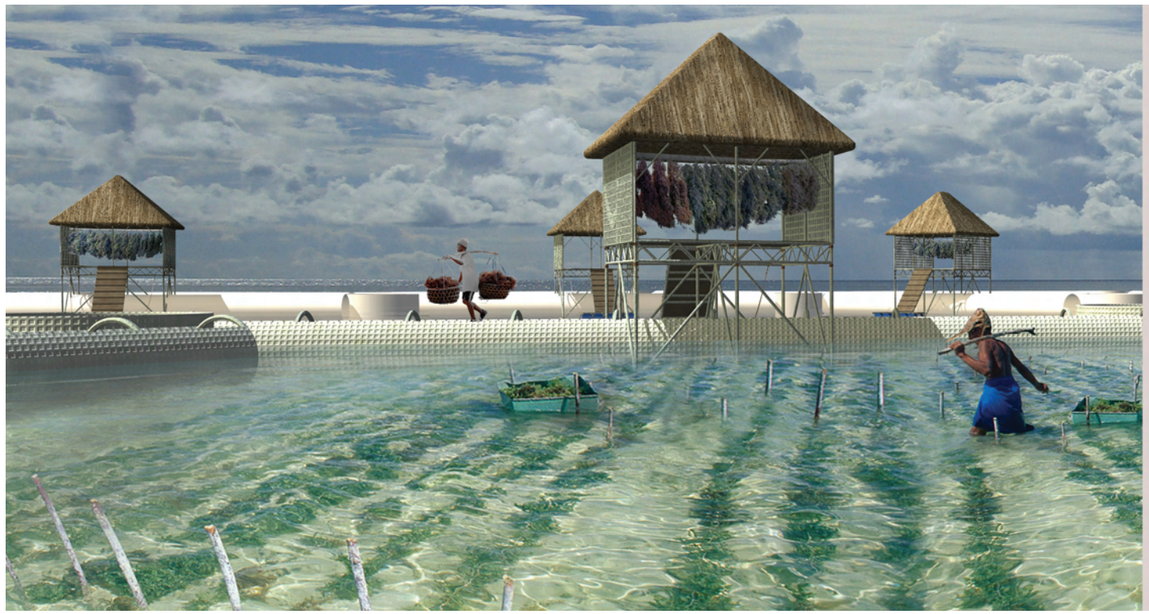


see inset

Collecting & Drying Seaweed
The exclosure pens allow the culturing of seaweed in favourable conditions for growth while protecting the crop from fish and urchins. The array allows the tide to flow through, flushing the system - essential for the health of the sea plants - but slows its retreat, minimizing the amount of time the plants are exposed out of water. The exclosure areas form 'nurseries' in support of larger seaweed operations in the adjacent lagoon: propagules are stored here prior to deployment, or to maintain crop reserves during annual periods when certain fish species are schooling - which can devastate crops left in open water.

FIG. 4.24

Proposal Stage 6

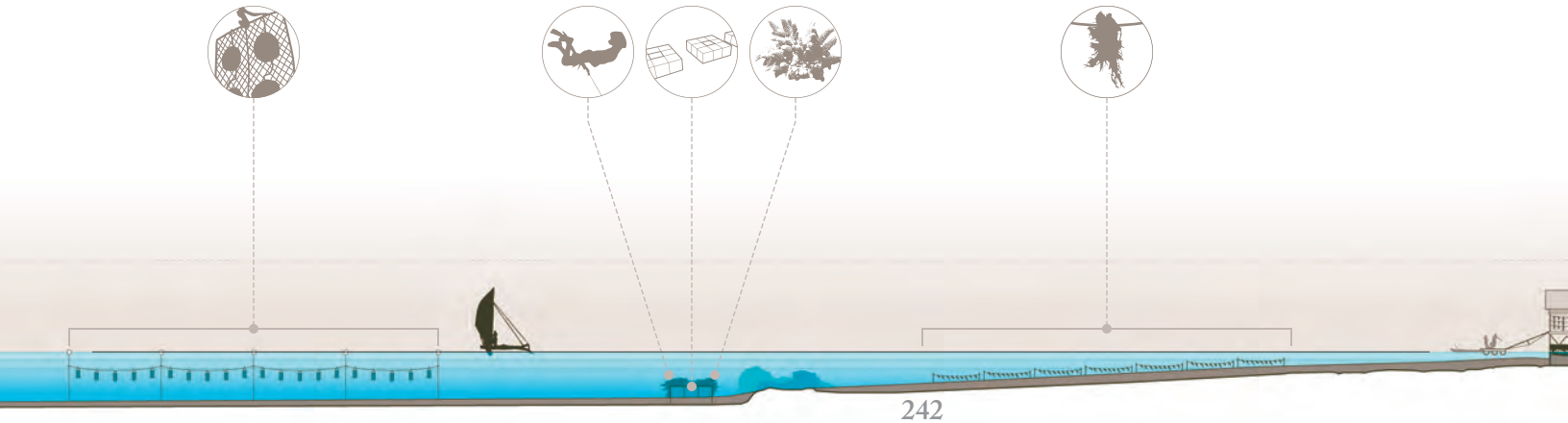
3-4 years (2032)

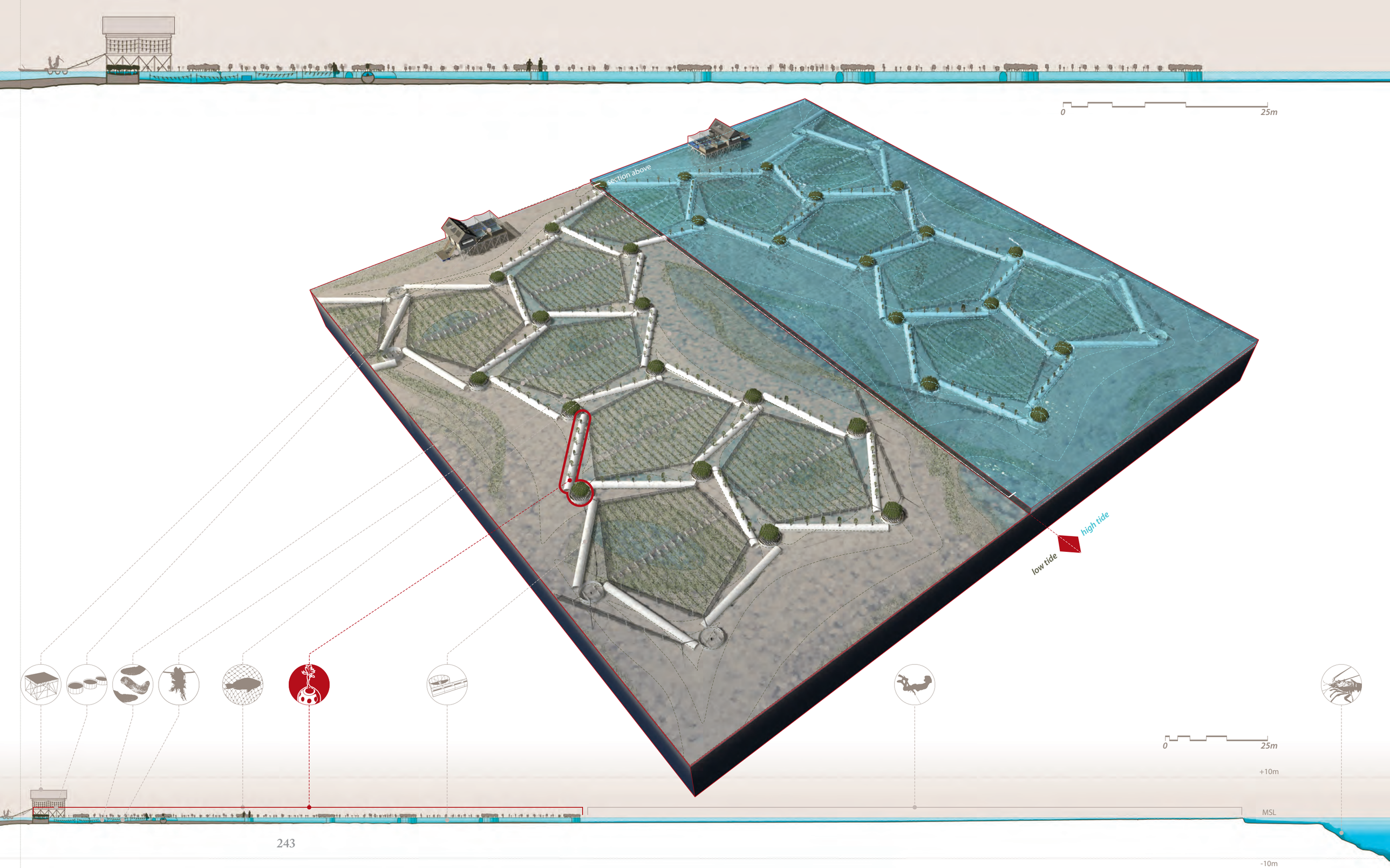
In this phase:

- This stage represents a kind of 'phase-shift' in the project: the major subsistence activities (pearl-farming, seaweed mariculture, etc.) shift to the newer peripheral areas, while the original sedimentation array is decommisioned.
- The central sedimentation array - now substantially choked with sand - is selectively planted with mangrove seedlings. Seedlings are deployed as areas become shallow enough (seedlings must remain above higher high water).
- Once established, mangrove plantings will alter the sedimentation dynamics of the landforms. Mangroves form an emergent biological geometry which overlays the sedimentation layer - the future development of the emerging islands will now be dictated by the vagaries of plant-growth, changing current regimes, and storm events which will inevitably cause the largest and most unpredictable changes to the islands.
- The mangrove forest will also begin to attract new species and create new micro-ecosystems. As the forest grows, it will afford some protection from the marine environment, eventually allowing colonization by more terrestrial plants: coconut palms and beach vegetation will likely be the first.

Input / Outcomes:

Mangroves will be sourced from within the Marshall's if possible. It is important to note that the development of a mangrove stand on the reef flat is extremely rare in the atolls. As with the introduction and cultivation of many other species, the mangrove forest represents a purposeful anthropogenic alteration of the natural ecosystem. Whether or not the sedimentation array will prove to be a suitable substrate for mangrove growth remains to be proven. The basic concept is that the array itself - spars and pens - will fill in with sediment more quickly than the surrounding 'cells' of the fish-traps and seaweed plots. Seedlings are deployed to the shallowest areas first. Once established, these first stands will provide propagules for further cultivation.

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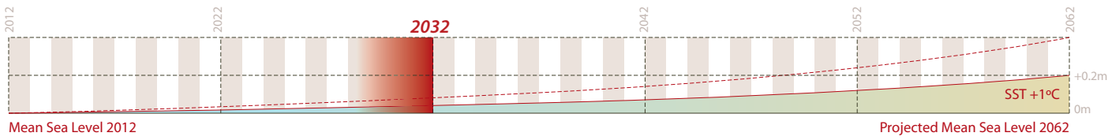
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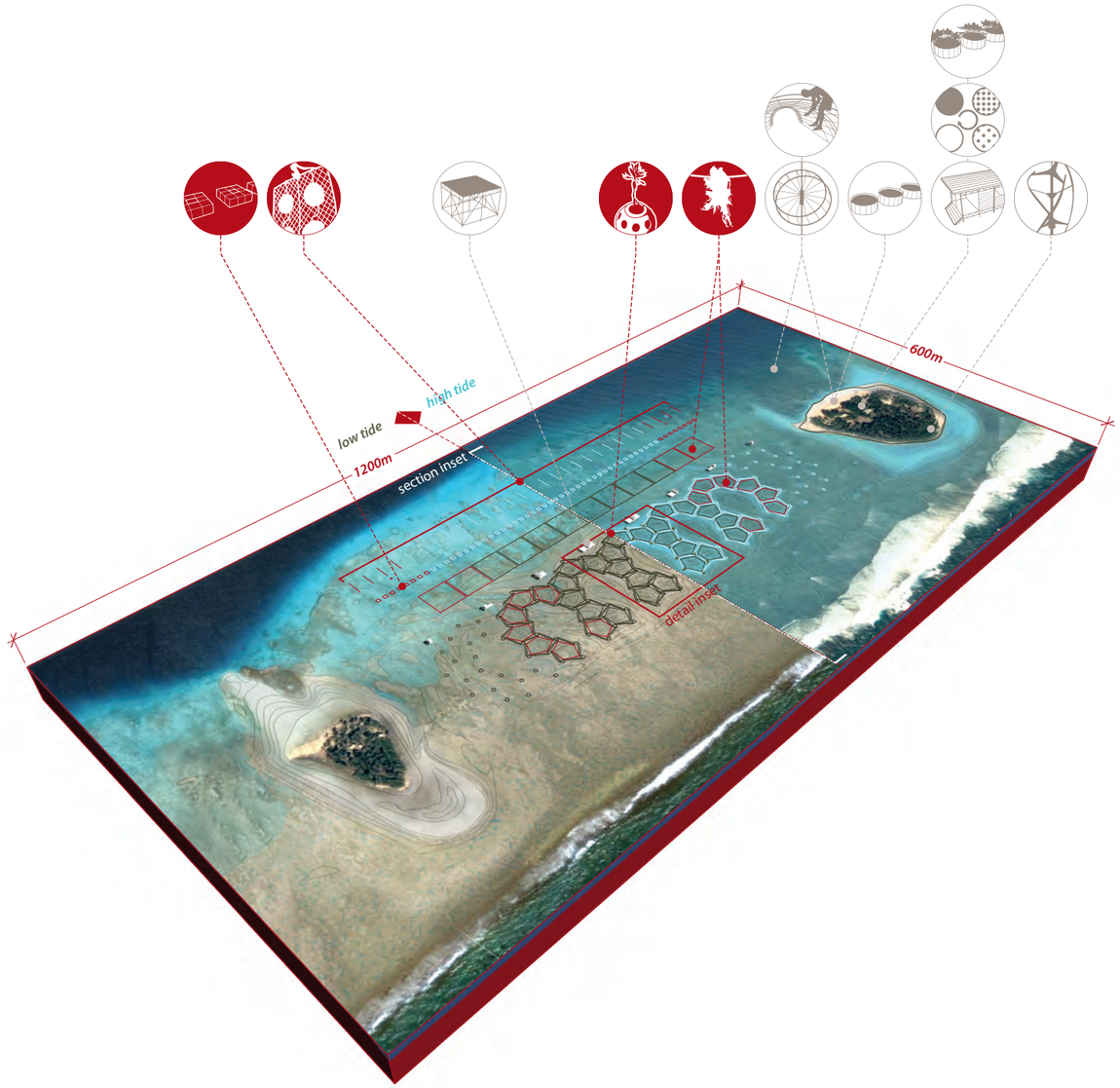
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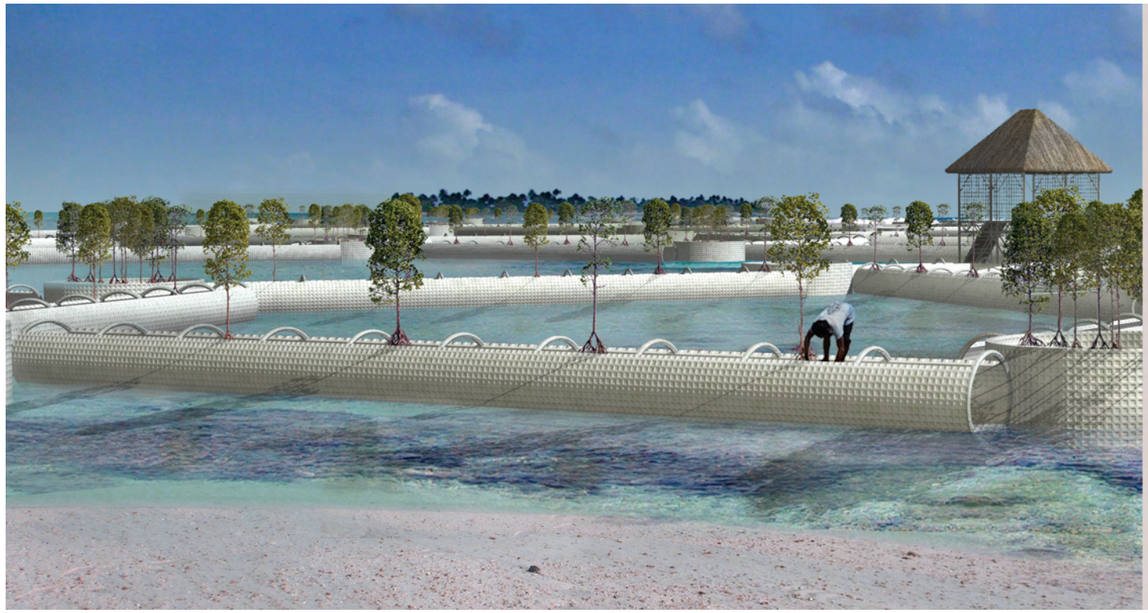


see inset

Catalyzing Change
Young mangroves - grown as seedlings in protected locations - are installed on the sedimentation array. The establishment of the mangrove forests will bring new flora and fauna and make this an increasingly bountiful fishing and hunting ground. The mangroves will outgrow their artificial substrate and colonize the surrounding shallows. Self-propagation will form a dense forest which will slowly fill in with sediment and organic matter from the living processes of the plants and animals which come to inhabit it.

FIG. 4.25

Proposal Stage 7

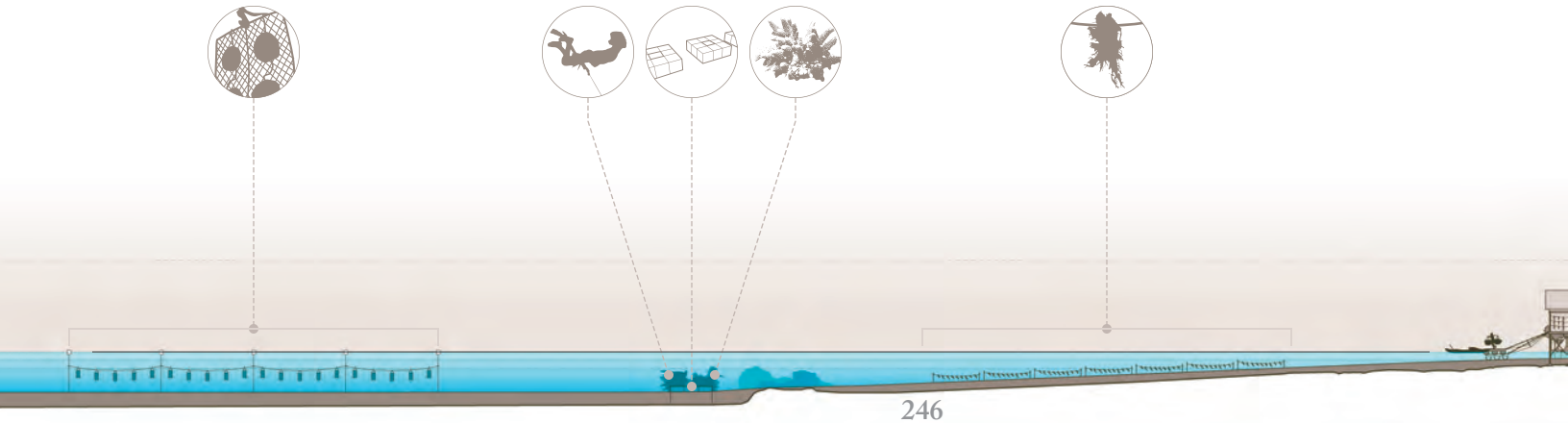
5-8 years (2040)

In this phase:

- Within 5-8 years, the young mangrove forest forms a dense growth around the original fish-trap. The mat of roots and entangled vegetation completely encircles the cells of the array, forming tidal pools which slowly choke with debris and fallen vegetation.
- These pools are likely to become hyper-saline, and with the addition of organic matter produced by the surrounding forest should ultimately develop into swamps filled with cyanobacteria - *kopara*. This is an essential stage in the development of the island, as the cyanobacteria comprises one of the only natural sources of phosphate available for the creation of soil.
- The emerging islands form a ring around a tidal lake - the former fish-trap - which is now at or above mean sea level. Sediment continues to accumulate around the periphery, and dunes and beaches form around the windward mangroves;
- Platforms (either built earlier as seaweed drying shelters, or built anew at this stage) can now become workspaces for various mariculture and arboriculture activities.
- In the diagrams, aquaculture tanks are shown deployed in the cells of the array: there are multiple options for development at this point. Large-scale fish or shellfish mariculture can be established in terrestrial tanks. The cells can be excavated for cultivation of different seaplants (while *Eucheama* requires clean, open water with currents, other species can be grown along with fish in protected ponds). Some cells might be devoted to certain beach plants which produce useful food or medicinal products. Others might be used as giant composts.

Input / Outcomes:

At this stage in the process, the outcomes are not easy to predict. How quickly will the mangrove forest grow? What kinds of subsistence industries might flourish in this semi-aquatic environment? Would it be more fruitful to allow the mangrove forest to develop naturally, while continuing mangrove cultivation horizontally across the reef shelf?



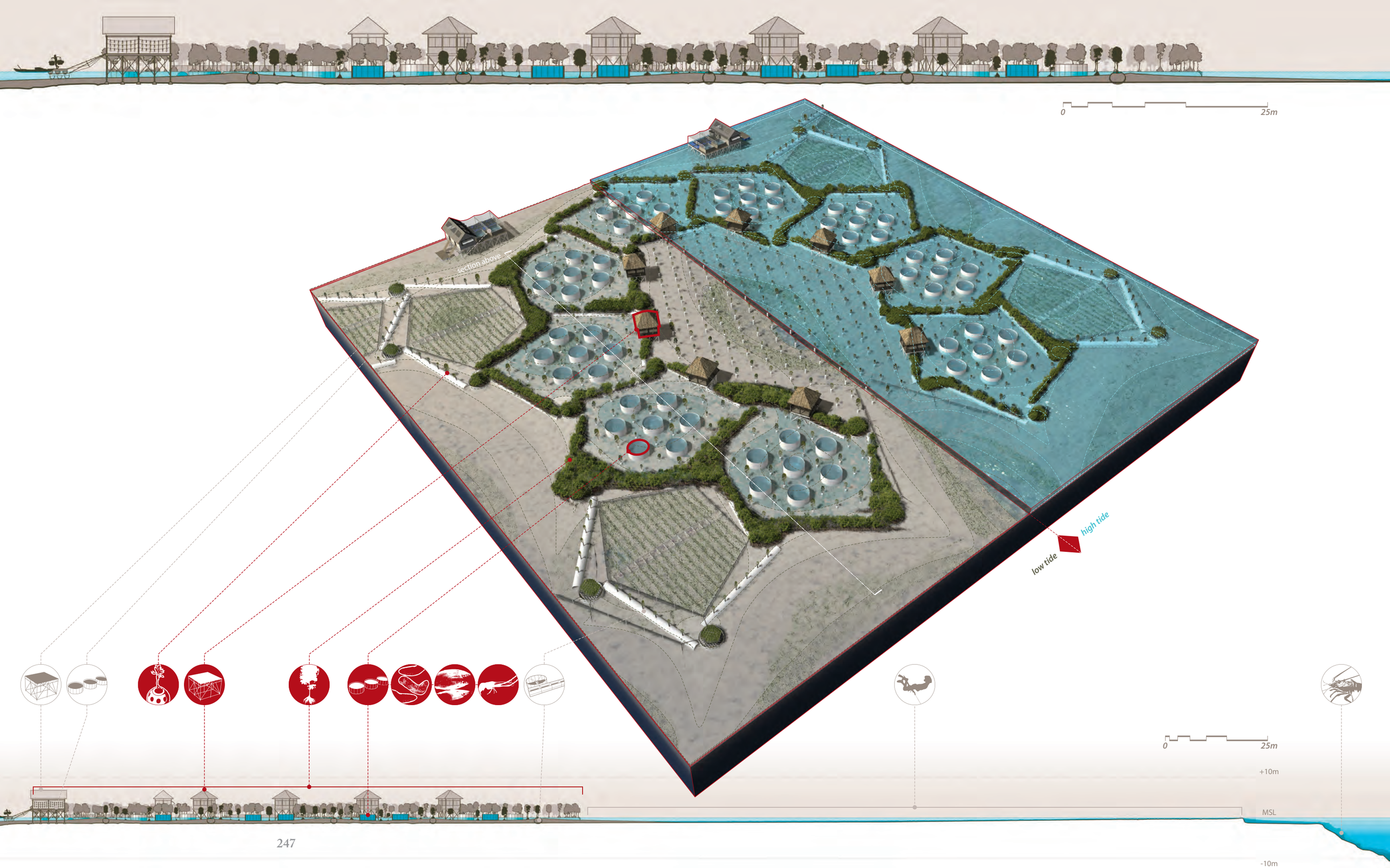

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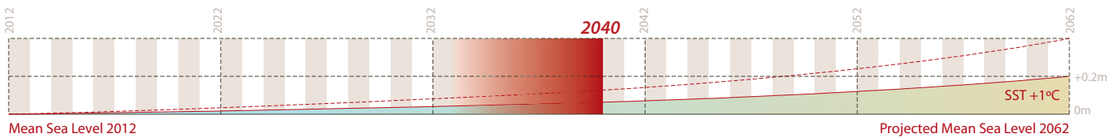
FIG. 4.26

Proposal Stage 8



see inset

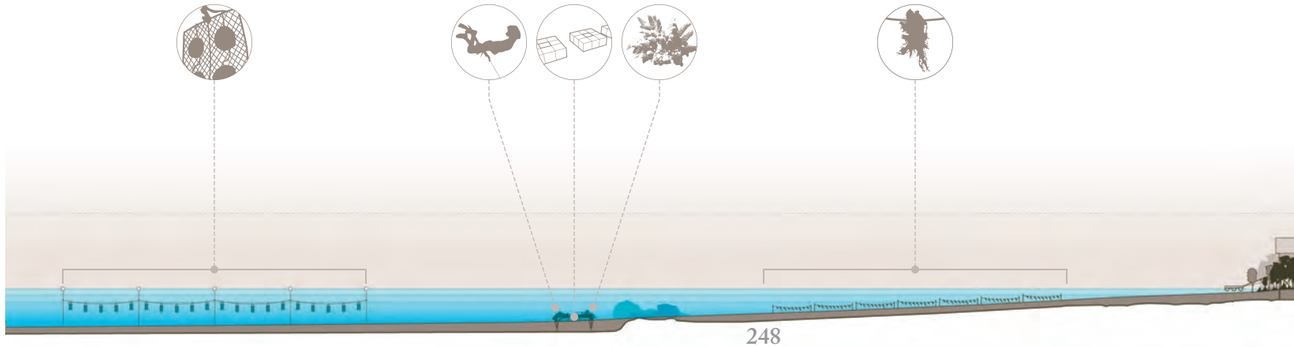
5-8 years (2048)

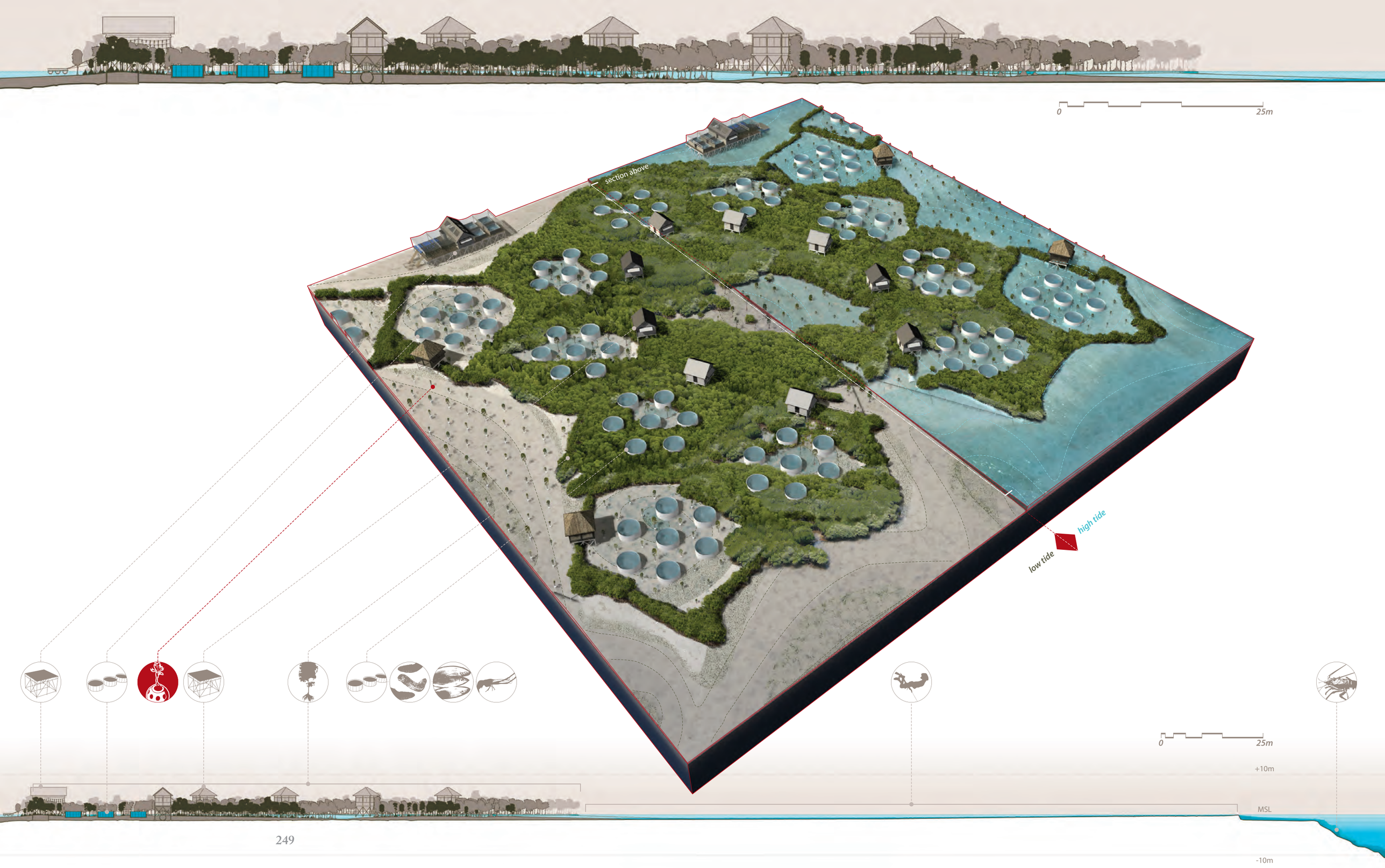
In this phase:

- The major processes set up thus far continue. The array will continue to support a growing population as long as there is still room for horizontal expansion - the pace of which will be determined by the growing population.
- As the central array fills in, areas can be cleared and selectively planted: once above the waterline, Pandanus and coconuts can be planted.
- The emerging islands will provide seasonal accomodation for workers engaged in various industries: most will continue to return to more permanent settlements either daily or weekly.
- But increasingly, as the landforms fill in, it will become possible to grow various foodcrops in raised planters (or even floating planters?) and settle for long periods on the islands.
- Different settlements might develop different outcomes. Some areas will no doubt be more suitable for certain crops. As islets and dunes form, current regimes will create unpredictable changes to erosion and tidal flow. Rather than fighting against these natural processes, the diversity of cultivars allows adaptability to changing conditions. Certain areas can be maintained for specific crops, while others might be decommissioned or moved when they become unsuitable to conditions.

Input / Outcomes:

By the end of this period, the emerging islands have developed a broad base of livelihood activities. The pseudo-natural environment which has been established will be more capable of responding to sea-level change than even the natural *motu* - and far more resilient than the typical urban settlements. The biorock™ reef is now a continuous feature along the entire stretch of lagoon shore - producing sand which is constantly washed up among the mangroves. The mangroves and other vegetation anchor the dunes together, protecting the landforms during storms and floods. The people who settle here will also have to be resilient: prepared to take shelter on leaward islands in typhoon season, and willing to live in a marine environment.

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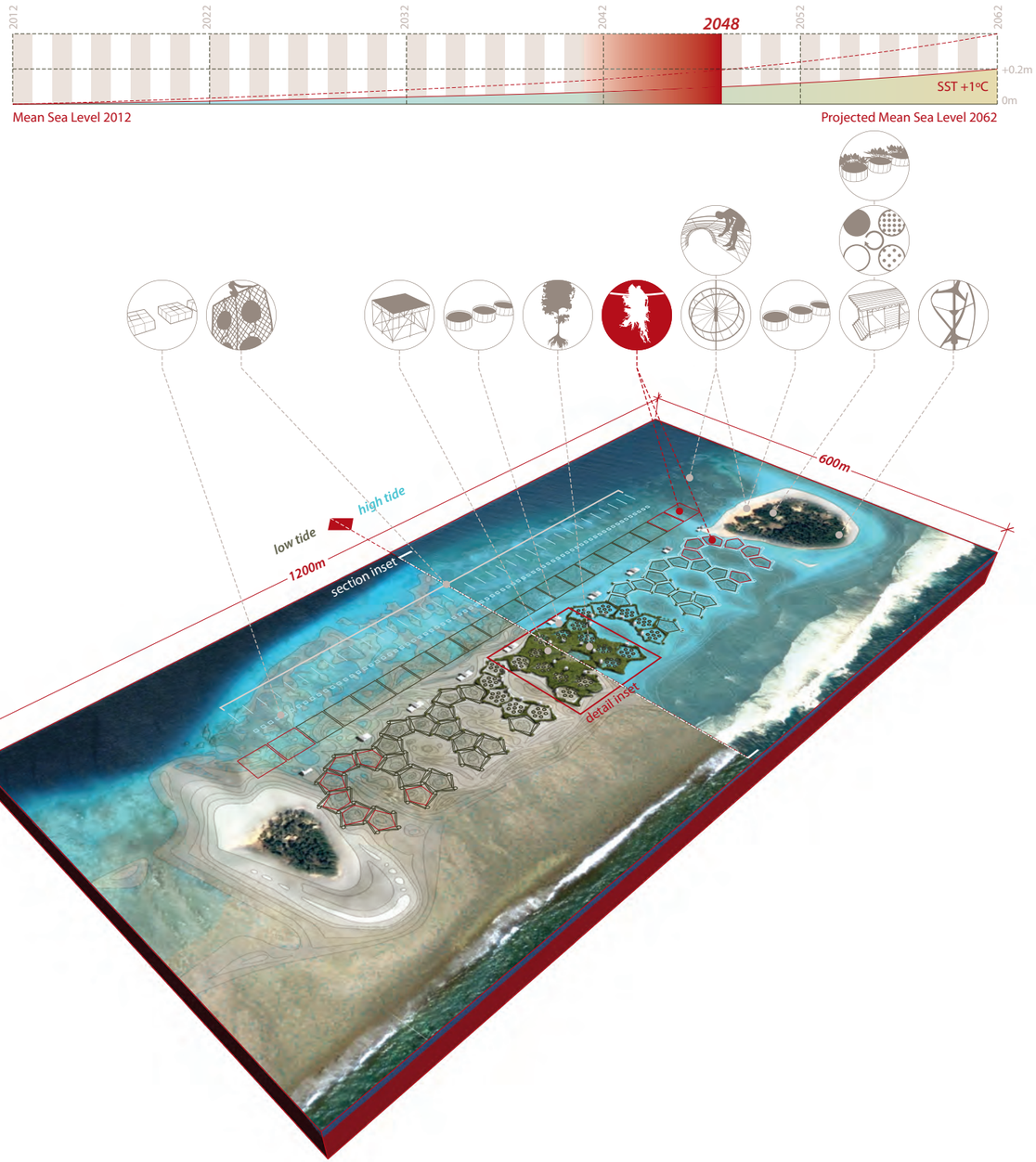
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Mangrove Forests
A mangrove stand has vigorously colonized the sedimentation array. A drying hut has been retro-fitted with thatch walls, and is now a home for a man and his family who earn a living tending to aquaculture ponds in the forest beyond. They supplement this income with the bounty provided by the emerging island landscape - hunting, fishing and culling the mangrove forest. Sedimentation will eventually choke out the mangroves, making it possible to clear the highest points of new islets for the planting of stabilizing vegetation such as Pandanus and other salt-tolerant species.

FIG. 4.27

Proposal Stage 9

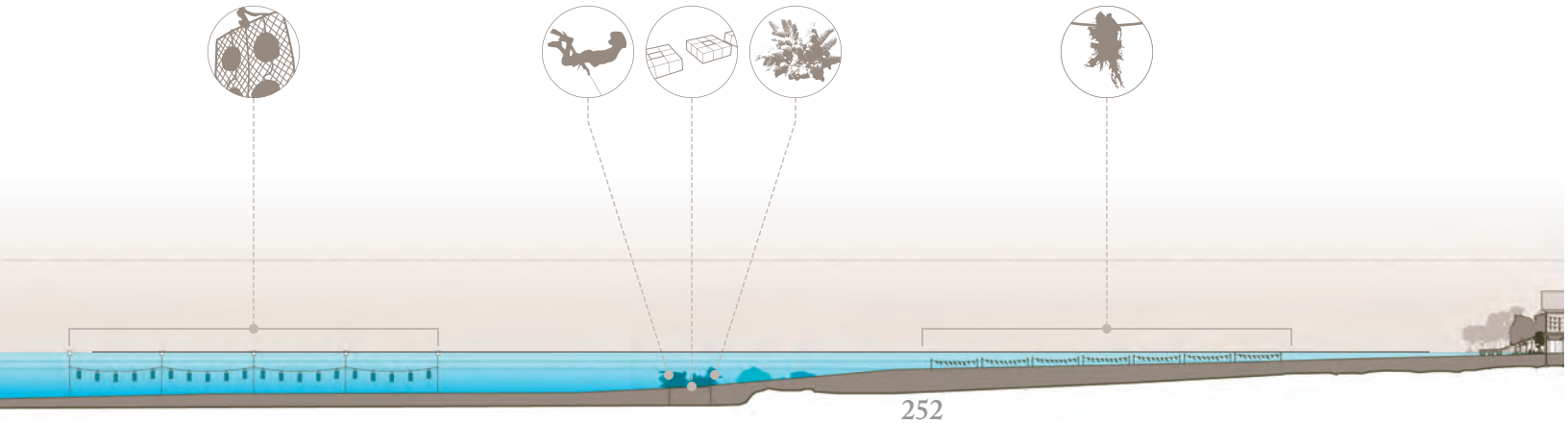
5-8 years (2056)

In this phase:

- Large dunes and a natural strandwall have formed on the ocean face of the emergent island. This chokes out the windward mangroves, and high areas can now be cleared and planted with dune-stabilizing vegetation in preparation for inhabitation.
- The *kopara* swamps still fluctuate with the tides, filling with water during the highest tides, but much of the rest of the terrain is now slightly above sea level. Destructive storms are also productive: they damage crops and buidings, but they leave a legacy of sediment and rubble which is thrown by the highest waves over the ocean strand and collects and is consolidated by vegetation.
- The primary goal in this stage is to colonize. In preparation for this, the more protected lagoon-ward aquaculture farms are re-purposed for growing crops. Composted seaweed and shellfish are combined to provide a nutrient-rich base for growing taro in aquatic gardens. Pandanus is planted on high-ground, and coconuts can be planted along the lagoon.
- With agricultural production in place, housing and sanitation facilities can be constructed. The proposed housing must incorporate rooftop water collection. Water security will be the most serious obstacle to overcome. With a small population it will be possible to obtain drinking water from rainwater collection, but to enable growth the settlement must incorporate greywater re-use and living machine systems to purify water, and ultimately a high volume source will be required. Desalination technology may one day be cheap enough to utilize on a small, local scale; other possibilities include large-scale collection facilities, perhaps floating in the lagoon, or cisterns.

Input / Outcomes:

The population carrying capacity of low-lying atoll islands is difficult to speculate on. The traditional population of Kwajalein was in the hundreds, not thousands. With the implementation of the technologies and systems of this proposal, it is hoped that livelihoods can be created for at least a significant percentage of the existing population.

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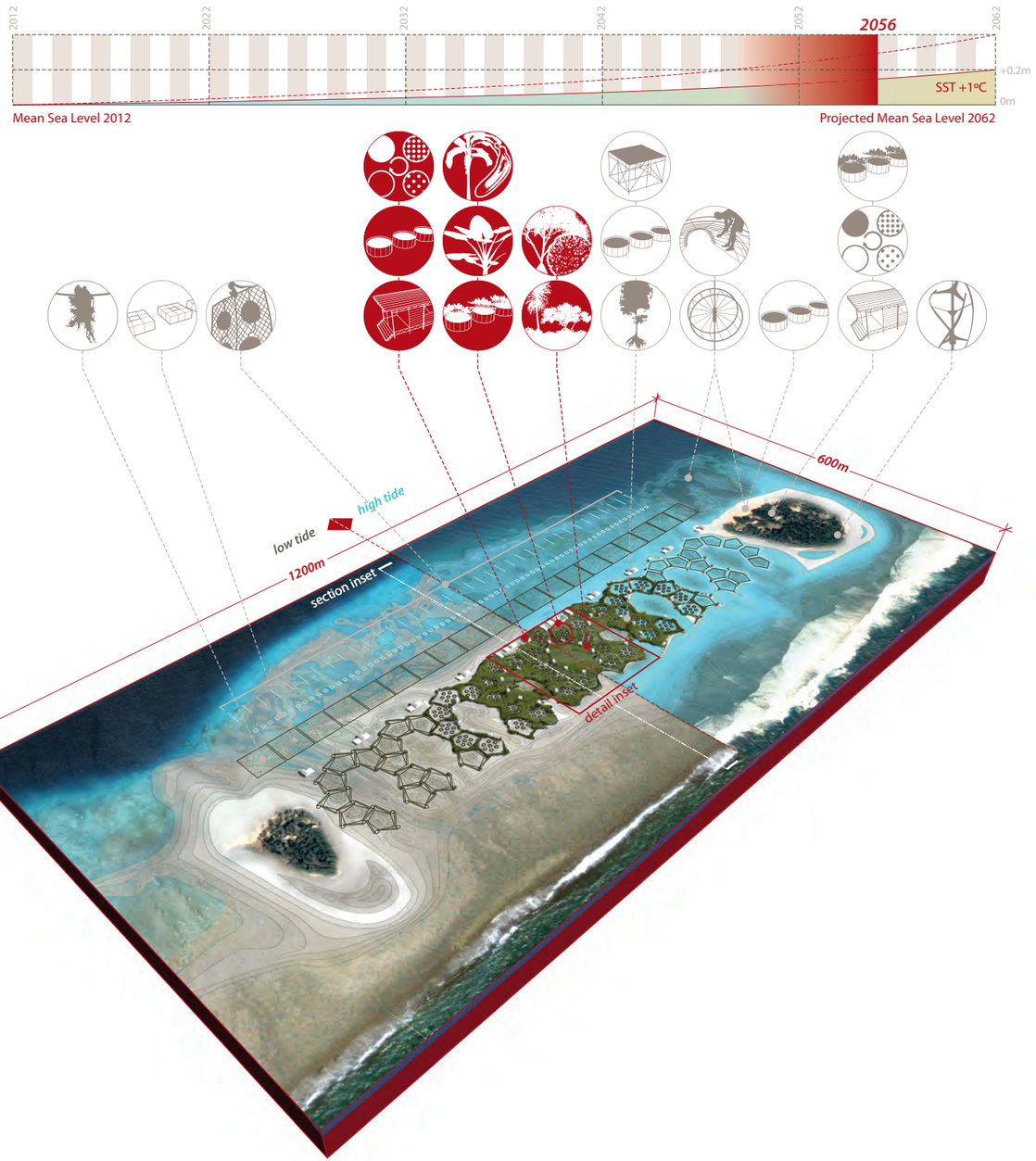
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Marine Urbanism
The inhabited sedimentation array stretches into the distance towards Ebjadrik, showing various stages of development. A fishtrap is visible in the left foreground; beyond this, the lights of inhabited reef platforms can be seen amidst a young mangrove forest. In the background to the right, a line of breakers pound incessantly on the living reef.

FIG. 4.28

Proposal Stage 10

P+

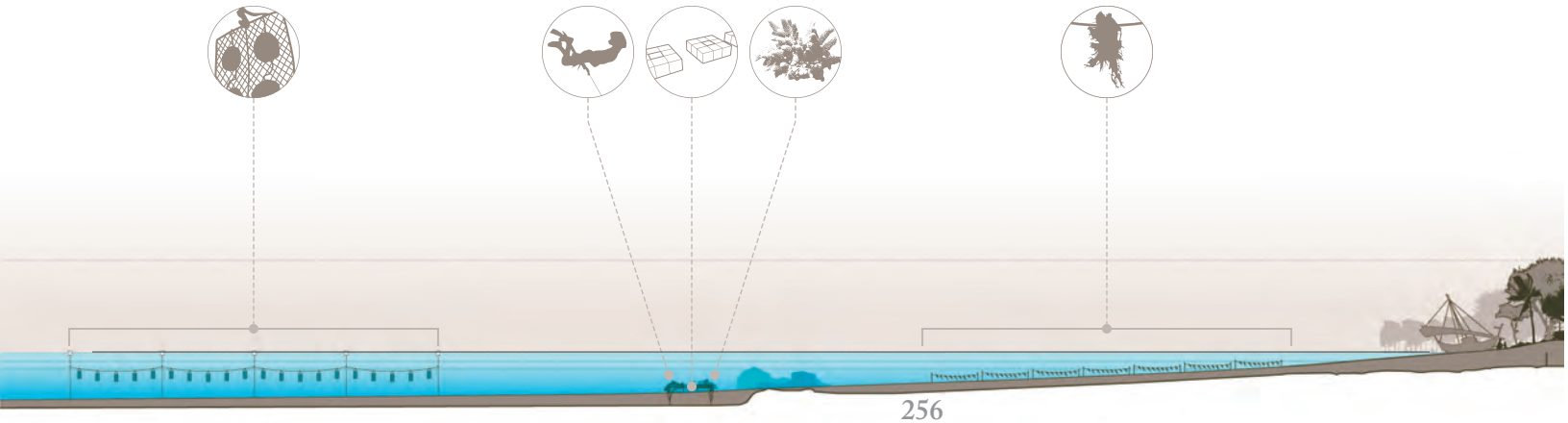
7-10 years (2066?)

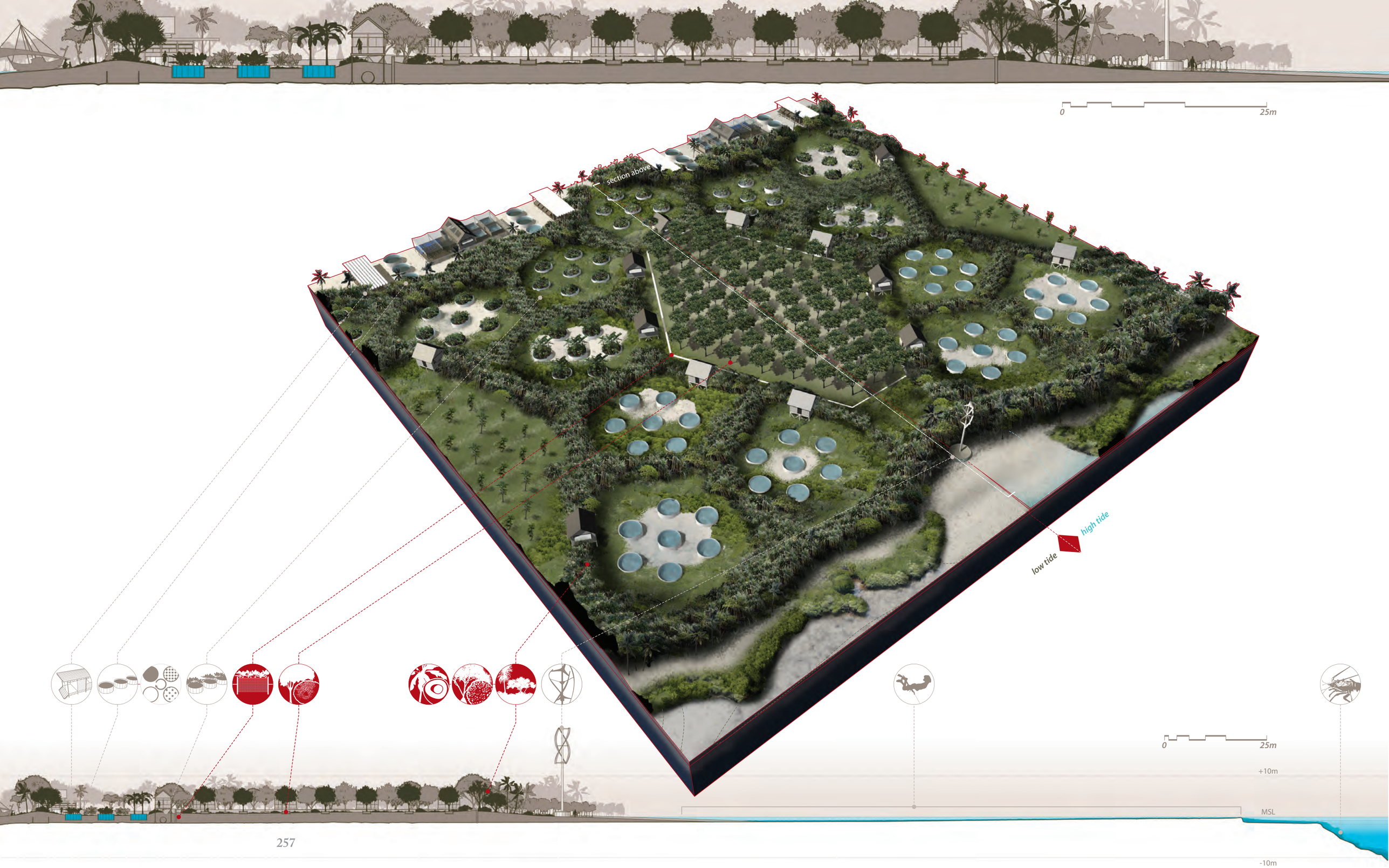
In this phase:

- Perhaps the most promising possibility is to construct large cisterns at the centre of each settlement. The cellular arrangement of the island substructure acts as a barrier to horizontal dissipation of fresh water: in order to transform this into a reliable fresh-water source, areas need to be walled-in and protected from saltwater overwash. There are several ways this might be achieved: a wall could be constructed from mineral-accreted panels, built into an excavated trench down to the reef shelf; rubble excavated from the fore-reef can be used to create gabion baskets for enclosure walls; or it may simply be possible to excavate a trench and line it with impermeable geo-textiles.
- Assuming a solution to the water security issue can be found, the 'raised island' is now complete. It will continue to grow and react to changes in sea level and climate as long as the inhabitants work to ensure the continuing health of the surrounding reef ecosystems and the terrestial planting regimes.

Input / Outcomes:

To put things in perspective, in order to accomodate the existing population of Ebeye in marine settlements on Kwajalein's reef shelves would require a population density of about 125/km^2. Thus, this prototypical site should accomodate 65-70 people on at least a semi-permanent basis. Population mobility might mean that people spend part of each year living in dense urban conditions such as those found on Ebeye or on small islands associated with the reef-shelf settlements. Of course, the population will not remain stable: current growth is offset by out-migration, but if local possibilities become tenable there is little doubt that many would prefer to remain in the atolls. The Marshallese atolls comprise only 181km^2 of "land." But there are hundreds of kilometres of intertidal reef shelf; if a semi-marine form of inhabitation such as that proposed here can be developed, it is possible that the RMI could support a local population in excess of 200,000 people in far more desirable conditions than those found in the contemporary urban centres - and with greater autonomy, self-reliance, and opportunities to pursue diverse livelihoods.

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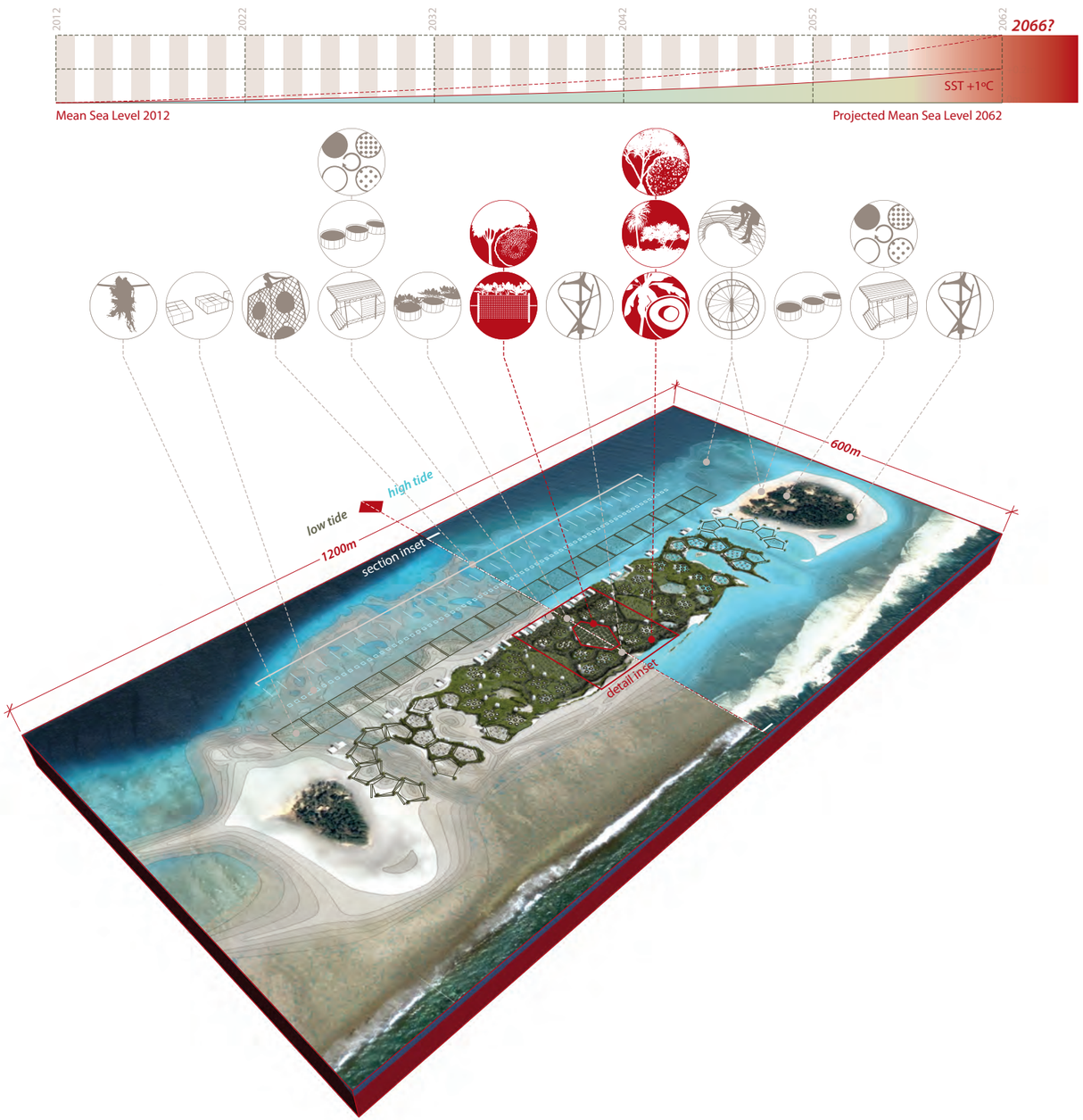

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There is no 'solution' to Ebeye. It is clear that the situation created by the actions of the US military has progressed beyond the point at which simple, sustainable solutions can be proposed without both the concerted efforts of the Marshallese people themselves and radical changes at the policy level in the RMI government and the military apparatus which maintains USAKA. As the century progresses, and the effects of climatic changes to come become clear, there is little doubt that the urban centres in the Marshall Islands will become increasingly untenable. Sea levels will slowly rise, as will sea temperatures which threaten the health of the coral reefs which are the source of the sand which has sustained these tiny islets for millenia. On urban atolls, the reefs will be threatened by nutrient pollution from runoff, sedimentation and erosion as long as inappropriate land reclamation practices and over-exploitation of the fisheries continues. The warming ocean will cause changes to climate patterns, bringing more frequent and more severe droughts and storm events to the region. Briny waves will wash over the land in places where they never have before in living memory; they will flood houses and choke the roots of the crops the Marshallese rely on for their life and livelihood.

There can be no return to subsistence lifestyles. The indigenous way of life has long since been rendered obsolete by the dislocations which have preceeded the present condition: today, the population in the Marshall Islands has grown too large to be supported by traditional subsistence lifestyles - even with the rebirth of the navigating tradition. In any case, contemporary people do not aspire to such a return. Some may wax poetic about the simplicity of island life before the Americans came. But in their actions and life choices they aspire to the modern,

usually for the sake of the next generation: modern education, modern health care, and all the luxuries and problems which accompany modern life. For as the long as the contemporary political situation of 'free association' remains in place, it is unlikely that the tide of out-migration will abate, and the Marshallese will continue to move by the thousands to the new 'islands' they have established on the US mainland. But, as demonstrated by other groups of islanders who have gone down this path before them, this need not be the end to the Marshallese culture and way of life. Rather, the Marshallese migrants who have built a new life in Arkansas and elsewhere vigorously work to keep this culture alive for their children, and if these children, growing up state-side, one day return to the islands, they may bring new skills, new vision, and fresh potentials.

There is a tendency to essentialize the actors in scenarios such as this: the Marshallese as helpless victims, pitted against the hardset jaw of the pitiless American military. But as usual, things are not so simple. The military is not a monolith, bent on the mindless expansion of Empire, intent to crush any and all resistance it encounters amongst the indigenous resisters to the war machine. Certainly, few of the American servicemen and civilian contractors who have lived and worked at USAKA would see themselves as part of any such monstrous regime. Men and women who have grown up at USAKA - 'Kwaj kids'[1] - see this place as their home, and are often not only sympathetic to the cause of the Marshallese at Ebeye, but often actively involved in programs of integration, education, and aid.[2] The military adminstration itself has wavered from obdurate refusals to accept that the people of Ebeye are in any way a US responsibility, to occasional and sincere attempts to improve the situation, sending engineers and workers to repair and assess Ebeye's infrastructure and working to maintain the large number of jobs available to Marshallese on Kwaj, even as the base has downsized. It should be clear to the US that any attempt to improve the Ebeye situation in a sustainable way will by neccessity require access to and through the MAC: Ebeye is just too small, geographically hemmed in by the artificial boundary which cuts its people off from the rest of the atoll.

Similarly, no indictment of the policies and actors which have created and perpetuated these conditions would be complete without the implication that various successive regimes of Marshallese governance have failed to address this problem: swooping in certainly, in times of crisis[3] but otherwise ignoring Ebeye, perhaps wishing it would disappear. To the central government in Majuro, Ebeye represents

1 Dvorak. (2007): p49.
2 See for example Kwajalein Hourglass Vol. 52 No. 5 for a story about Bilal Abdullah, an American contractor who runs a basketball camp on Ebeye. There are many examples of participation and integration. Bigelow, Layton. (2011): p4.
3 As, for example, when the water system failed, or with recent epidemics such as the 2001 cholera outbreak. See Crismon. (2005): p304.

both a persistent thorn in its side and an important bargaining chip with the United States. It is a sad fact that it has often been in the interests of both administrations to stay-the-hand, preventing any real improvements and maintaining a marginal, disenfranchised position for the ri-Kuwajleen. Ebeye represents the human fallout that always attends the racket that is modern warfare.

One can only hope that the environmental progressiveness which has signalled a change in the RMI government in recent years also signals a real commitment to social issues which have been ignored for too long. Much has been squandered on ineffectual schemes to develop inappropriate industries. The failures of development initiatives are often blamed on the incapacity of the islands themselves - fishing fleets fail to make a profit for lack of fish; copra is not profitable because the islands are to small to make large enough plantations; businesses fail because they are too remote. But they fail for another, more critical reason: they do not take into account the human component. What do people dream about? What do they want for their future, the future of their children?

* * *

Design concerns itself with re-invention, renewal, re-thinking the way people live or inhabit the land or the urban environment. But as designers, we must always be aware of the violence and aggression which attends such programs of re-invention. In the urban environment, every act of construction is simultaneously an act of replacement or deletion. In the context of imagining new forms of landscape or inhabitation, design proposals cast existing formats or ways of life as obsolete or irrational in order to justify revolutionary change, which is frequently accompanied by upheavals, relocations, or other forms of social reorganization.

Confronted with a problem, the designer brings together the tools of analysis - maps, graphs, data, theory and science - and proposes rational solutions rooted in the confident belief that the ills we see in the world have clear cause and effect relations. As outsiders, we reflect upon the wisdom with which indigenous peoples once managed their

resources and societies in some far away distant past, and often lament the loss of this traditional knowledge in favour of western values or technologies. But the contemporary condition is one of hybridity. For example, the impetus and confidence to assert islander sovereignty was borne of cultural nationalism, a concious attempt to resurrect and sustain pre-colonial values and ways of life. This transfer of persistent pre-modern power structures into the contemporary democratic format was not motivated by nostalgia: the reinvention of the iroij as modern political leaders was just one of many ways the islanders sought to construct a modern identity which was uniquely their own. And yet, current conditions often seem to be exacerbated by such hybrid dreams. Western critics are quick to point out that the traditional social structure is to blame for the inequalities of Ebeye, or blame the stagnation of the RMI economy on the ineffectiveness of incompetent or corrupt traditional leaders. We simultaneously canonize lost cultural practices while condemning the enduring social structures to which they were integrally tied.

Throughout this project, I have struggled with the realization that it is not only technical solutions which are required, but solutions which identify and address the dreams and urgent needs of local people. People are not only energized by the promises of the very rational goals of economic security, self-sufficiency and the wealth that they associate with life in the developed world. At the beginning of this exercise I set out with the best of intentions, but intentions which were nevertheless clouded by the pervasive belief in what design can do: which is to say, invent new realities which have the power to challenge and transform. Sometimes the opposite is the case. Designers - like other agents of 'development' or transformation, utilize tools and language which is very often unable to apprehend the very things which have the power to effect change and transformation. Design is an increasingly globalized exercise, and the work of designers frequently speculates on the future of landscapes and peoples which are foreign to them. The most important lesson I will take away from this project is the realization that to continue to have relevance, designers must energetically engage with the traditions, customs and beliefs of the people who would inhabit our speculations.

Contemporary technology - computation, imaging, mapping, etc. -

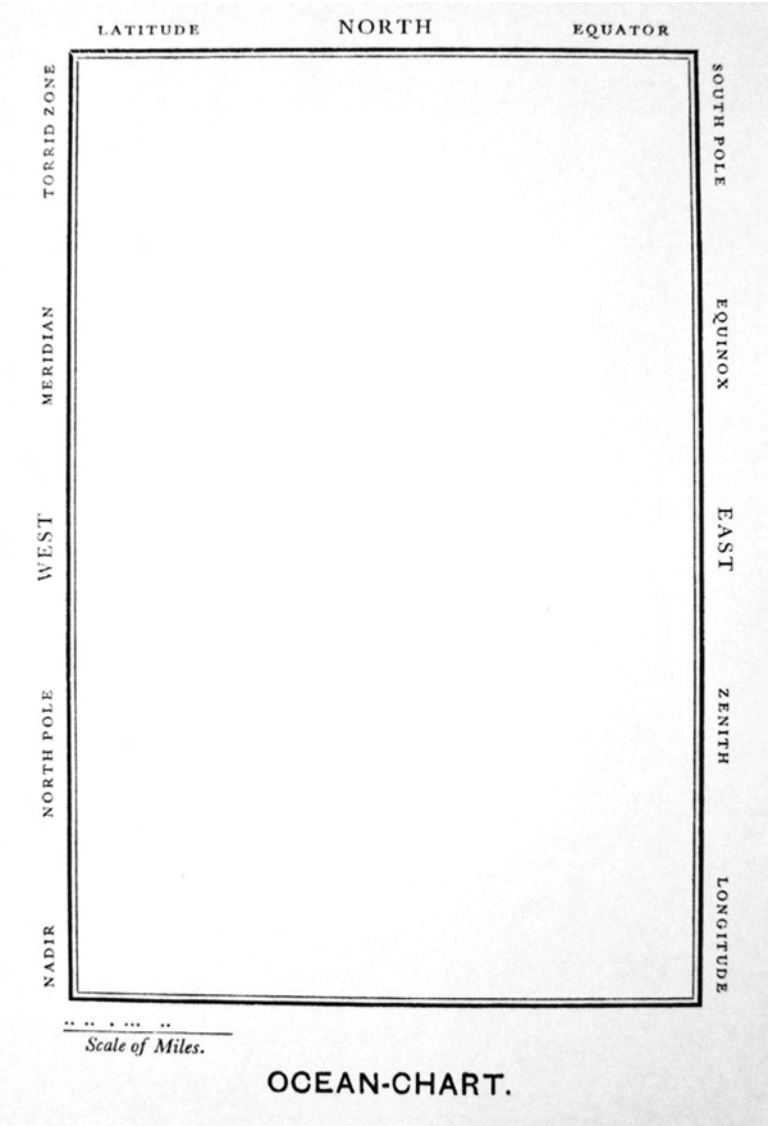
allows us to confidently imbue our speculations with the appearance of hard, verifiable science, giving them the appearance of fact. But we should be aware that this propensity to cloak our propositions in facticity[4] - which we use to promote our ideas, to conceal the limits of possibility, or advocate for the plight of particular groups of people or landscape - can also have the effect of limiting our vision of the very real possibilities offered up by elements which cannot be mapped, figured, or quantified readily. It is not romantic or sentimental to proclaim that the future will not be made possible by new technologies alone, but rather by what local, ordinary people can achieve. As we construct propositional futures, we should not ignore the political and social implications, and we must develop the confidence to concede that we do not have all the answers - that real change will require engagement and experimentation on the ground. In that sense the energy and creativity of local people is surely the most valuable resource we have to consider.

* * *

> "I was in college, offering a talk with a great friend, Argentine film director Fernando Birri. And then the young, the students, asked questions; sometimes at me, sometimes at him. To him they posed the most difficult question of all: a student stood up and asked: "what is the use of utopia?" I looked at him with pity, I thought ouch, ow, what a mess now... But he answered brilliantly, the best way. He said that the utopia is on the horizon, and said more: I know very well that I will never reach it. If I walk ten steps, the utopia will walk away ten steps; when more I look for it, less will I find it, because it is moving away when more I approach. Good question, no? What is the use! The Utopia is used for this: to get us to walk."[5]

4 I borrow this term from Woods, et al. (2010): p34. They are describing in this passage the propositional nature of mapping, and the maps inherent conceit which cloaks the opinions or beliefs of the author with the image that what is drawn on the map IS reality. I think this concept is an apt comparison to the work of speculative designers in the digital age: not least because we are increasingly fluent and adept at manipulating mapping and GIS for our own ends, but also because the images we produce are increasingly realistic and matter-of-factly proclaim that what we have made WILL BECOME reality.

5 Galeano, in an interview with Enzo de Leon. (2011).



Ocean Chart
From Lewis Carroll's *The Hunting of the Snark: An Agony in 8 Fits*. Perhaps a perfect expression of the continental view of oceania?

Maps of Oceania

European maps have had an enormous impact on the history of the Pacific islands and peoples. Even before Europeans began to explore this ocean, it was conceptualized by the west in proto-cartographic form: "out beyond the known areas of the empire, you came to some very dangerous people... and beyond there came the dragons... and beyond there you better not go!"[1] It was to subdue the void, the great terrifying emptiness of the oceanic, that would be the inaugural task of the modern map. Exploration of the Pacific was contingent on the development of cartographic technologies - the mathematics of bearings, the sextant, and the chronometer - which enabled the measurement and ultimately the 'striation' of this void.[2] The great European 'Age of Discovery' which this technology enabled is, however, a posthumous re-branding which suggests an interest in the discovery of the diverse peoples and landscapes of the Pacific, and misrepresents the intent and ultimate impact of European explorations. The voyages of James Cook, to which the appelation is most consciously applied, in fact embodied a profound disappointment in the final, terminal realization that the southern continent - which had motivated so much oceanic speculation - did not exist.[3] From the outset, European enterprises in oceania were motivated by distinctly continental prejudices: they saw no value in the low atoll islands which had little to offer in terms of resources or safe harbours; rather, it would be the logics of strategic denial which eventually motivated the imperial nations of the west to 'adopt' a whole ocean of "new-caught and sullen people."[4] In the mapping and subsequent bureaucratic division of the Pacific,

1 Fuller, R.B. Quoted from Snyder, Glascock, dirs. (1974).
2 Deleuze, Guattari. (1987): p479. I here allude to the well-known passage which describes how the sea is not only the archetype of all smooth space, "but the first to undergo a gradual striation gridding it in one place, then another, on this side and that." Polynesian / Micronesian navigation represents a directionality which has been supplanted by the dimensionality of European navigation technologies - the ascendancy of the map. This is not just a matter of aesthetics, as discussed in Part One.
3 For a discussion of the motivations of Cook's voyages, and a nuanced view of his interactions with specific islander peoples, see Thomas. (2003).
4 While Europeans immediately recognized the value of the high islands of the south seas (Tahiti, Fiji, and other large volcanic islands) and New Zealand, it would take until the late 19th century for western powers to recognize the geo-strategic importance of the atolls of Micronesia. The quote is taken from Kipling's 1899 lament to the costs of imperialism, "The White Man's Burden." Kipling. (1909): p359.

the colonial powers also categorized the peoples of the islands, defining population groups by similarities in race, language, or cultural tradition. That "foreign knowledges of the Pacific have both used and aspired to eclipse indigenous knowledges... is obvious from the earliest ethnologies of the region."[5] Beginning with Cook, and more specifically with Johann Reinhold Forster,[6] Europeans set up hierarchies based on observations of development and degeneration, ranking Pacific peoples on a scale from civilization to barbarism. The French explorer Jules Dumont D'Urville, following his voyage through the western Pacific in 1829, produced a cartographic description that divided the islands into three distinct groups: Melanesia (the "dark" islands populated by Papuan and other dark-skinned peoples), Polynesia (the "many" diverse islands south of the equator) and Micronesia (the "tiny" coral atolls in a "far sea").[7]

Distant archipelagoes were amalgamated, uniting the destinies of discrete cultures with the stroke of a pen. The natives who inhabited these far-flung atolls were seen to be undeniably primitive, assumed by early European explorers to be degenerate remnants of some long extinguished classical civilization.[8] D'Urvilles' categorizations remain remarkably persistent in the present day, reinforced as they were by colonial and imperial divisions and in other ways broadcast and expanded by the ethnological partitions of anthropology and linguistics. Pictorial images of Oceania and islanders were concurrently informed by and reflected in these ethnological mappings, and gave rise to various tropes which persist today - the 'Island Princess' or 'Hula Girl', and the 'Headhunter'[9] for example. Propagated in innumerable books, films, paintings, tourist brochures and photographs, and constantly reiterated to the point of exhaustion, it is difficult to overstate the effect that these stereotypes have had on differential western influence in the islands.

5 Jolly. (2007): p509.
6 Ibid., p516. Along with his son Georg, the Forsters were the naturalists on Cook's 2nd voyage.
7 Dvorak. (2007): p65.
8 Davis. (1997): p40.
9 European explorers commonly regarded the peoples of Melanesia and Micronesia as primitive and degenerate, in contrast to the noble and advanced Polynesians in whom they recognized familiar patterns of nobleman and commoner, and the organizational structures of vast empires with which to establish trade. See Jolly. (2007).

> "For peoples who suffer the yoke of imperialism, it is a total system of foreign power in which another culture, people, and way of life penetrate, transform, and come to define the colonized society. The results are always destructive, no matter the praises sung by the colonizer. But the extent of damage depends on the size of the colony, the power of the colonizing country, and the resistance of the colonized. In the Pacific, tiny islands, large predatory powers - such as the United States, France, Indonesia - and small Native populations all but ensure a colonial stranglehold... Of course, the function of imperialism is the exploitation of the colony: its lands and oceans, labor, women, and, in the Pacific, its mythic meaning as a "South Sea paradise."[10]

Contemporary economic cartographies have manufactured their own partitions, in denotations such as 'Pacific Rim' and 'Asia-Pacific,' which variously imply and enforce edge conditions and relationships of subjection / superiority - "the high ground of strategic economic and geopolitical interest and of moral presumption."[11] These tautologies tell a tale in which islanders are simply rooted, tethered to their tiny islands, moored physically and temporally, bound by traditions of times past, while Europeans and Asians are the mobile invaders, bringing development and innovation.

The conspicuous issue throughout contemporary Oceania is that the planning and decision-making mechanisms of the regimes of power - island governments, the agents of international diplomacy, lending and aid agencies, politicians, and a multitude of speculative interests (military, tourism, resource extraction, etc.) - are informed by an assessment of the Pacific region which is economically, geographically and culturally deterministic.[12] This view, upon which the "present and future of the Pacific islands states and territories are planned and decided upon," contrasts markedly with the experiences and views of ordinary islanders, "who, because of the poor flow of benefits from the top, scepticism about stated policies and the like, tend to plan and make decisions about their lives independantly, sometimes with surprising

10 Trask. (1999): p42.
11 Jolly. (2007): pp. 516-520.
12 Hau'ofa. (1993): pp2-4.

and dramatic results that go unnoticed or ignored at the top."[13] Efforts to mobilize change and instigate development have been predicated upon systems of measurement which assess opportunities in units or criteria which consistently find the Pacific islands to be lacking, and which might seem to consign islanders to a perpetual state of dependance within the international community. Hau'ofa[14] suggests that this dominant paradigm is in fact already challenged by the independant actions of islanders themselves, in a process which he calls "world enlargement;" new economic realities have enabled islanders "to shake off their confinement and they have since moved, by the tens of thousands, doing what their ancestors had done before them: enlarging their world as they go, but on a scale not possible before."[15]

* * *

Maps are a serious communicative medium for the development of complex arguments, carrying within them the same degree of instrumentality as prose: the ways in which we depict our world condition very powerfully the ways we are able to conceptualize and operate upon it. Maps are more than just images of the world from above - not merely figures of reality, they bring their own worlds into being.[16] While it is tempting - now more than ever, in an age where we are used to peering down at the fully spherical, fractally detailed vision provided by Google Earth - to imagine that maps simply present 'reality' in a format that makes it intelligible, it is important to understand that maps are *always* propositional, no matter what they

13 Ibid., p2.
14 A Fijian scholar, professor and writer who taught at the University of the South Pacific, of Tongan descent, born in Papua New Guinea - a truly pan-Pacific character. See Madraiwiwi. (2009). In his seminal essay "Our Sea of Islands," Hau'ofa speaks of his own deep distress having witnessed island peoples' continuing subjugation and dependance, brought about by conditions he initially "agreed wholeheartedly with" as they "seemed to be based on irrefutable evidence." He recounts how he was haunted by the faces of his students as he came to the realization that he was actively participating in the reinforcement and propagation of their own belittlement and marginalisation; he began a desperate search for a way to reframe the way islanders looked at their world. See Hau'ofa. (1993): pp2-4.
15 Ibid., p6.
16 See, for example Wood. (2010): pp15-66, and Corner. (1999): pp153-170.

represent. The agency of the author is instrumentalized in the choice of what and how realities are distorted, and by what is included and what is excluded from the map image. Maps condition what they depict by how they show relationships between things; all maps are tools, suited to a particular job. Thus their effectiveness cannot be judged simply by how closely they approximate reality, but rather by how powerfully they explain and convince us of the validity of their makers propositions.

> "When [...] I said that most speakers of English use 'map' in a straightforward way to describe an artifact that selectively links places in the world (theres) to other kinds of things (thises), I deliberately failed to draw attention to the propositional character of the thises and the theres, since it's the map's refusal to acknowledge its propositional character - its propensity to cloak its propositions in facticity - that made maps useful to the early modern state in the first place and that, for precisely this reason, heavily promoted their use. Propositions supported by evidence and argument, even propositions simply sufficiently often repeated, soon enough solidify into facts, and facts are what states were most eager to solidify into."[17]

The telling of a history is, of course, never a matter of a simple narrative. The many actors visible on the stage hint at the agency of hidden direction, and the spectacle of the performance cloaks a multitude of silent influences backstage. Histories present both 'big' stories - the mythologies of nations and cultures - and 'small' stories - the paths carved by individuals or groups through the larger context. It is the 'big' stories we are most used to reading in maps, the framing of states or regions, the demarcation of limits and boundaries, inside and outside, us and them. There is a tendency for maps to present representations of data as reality, to idealize reality or essentialize it. But in so doing, maps have the power to disenfranchise the 'small' actors, to ignore the specificity of the peoples or landscapes they presume to classify. Too often the exercise of mapping reflects a western or modern model for quanitification or classification at the expense of the realities on the ground as experienced by local people.

The maps on the pages which follow are provided to give the reader an

17 Wood. (2010): p34.

overview of the context and historical background in which the thesis operates. Reading Oceania through maps is not a simple proposition: the ratio between land area, distance, and the size of populations and economies place these island nations on a different order of magnitude from the countries of the west and continental developing nations. These maps challenge the usual forms of 'picturing' the Pacific by providing some insight into the diversity of landscapes and people found here.

Pacific Winds & Currents challenges a picturing of the ocean as an undifferentiated void; it is a vast and diverse seascape with as much variability as any continental landscape.

The Tyranny of Distance examines the power of contemporary air travel itineraries to divide and isolate. An ocean once criss-crossed by the inter-island trade of indigenous canoes is now circumscribed and partitioned by the logic of intercontinental flights.

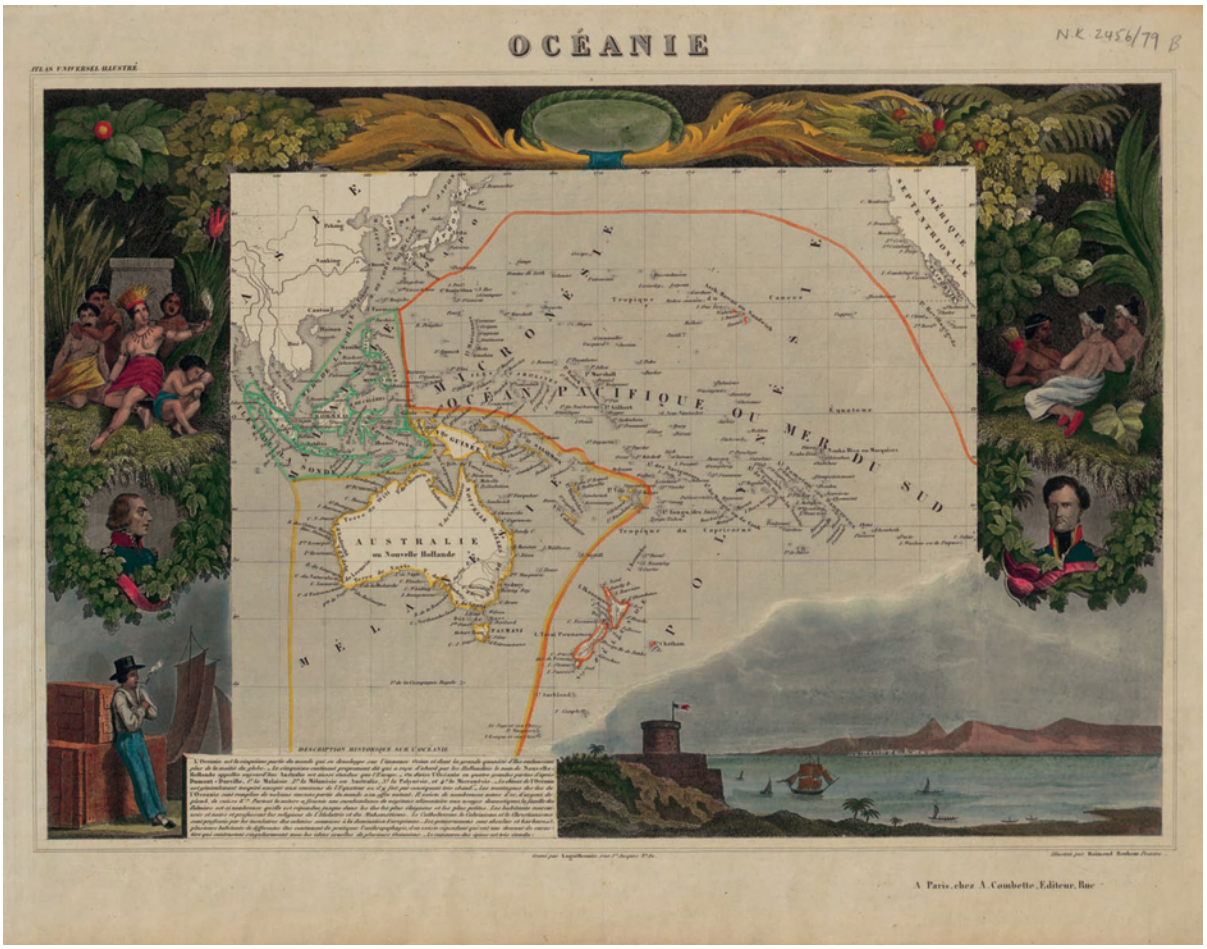
Imperialism & Sovereignty portrays an ocean made up of nations which describe multiple shades of grey, rather than the simple black and white differentiation between independence vrs. dependence or annexation.

History of Pacific Peoples describes the history of many of the cultural groups of Oceania. It is not a comprehensive picture, but gives some hint as to the magnitude of the achievements of the ancestors of the Polynesians and Micronesians.

Language Groups of Oceania problematizes d'Urville's enduring categorizations by examining the linguistic and cultural diversity of Oceania.

Oceania Geomorphology and Island Typologies hints at the diversity of landscape types contained within this enormous area.

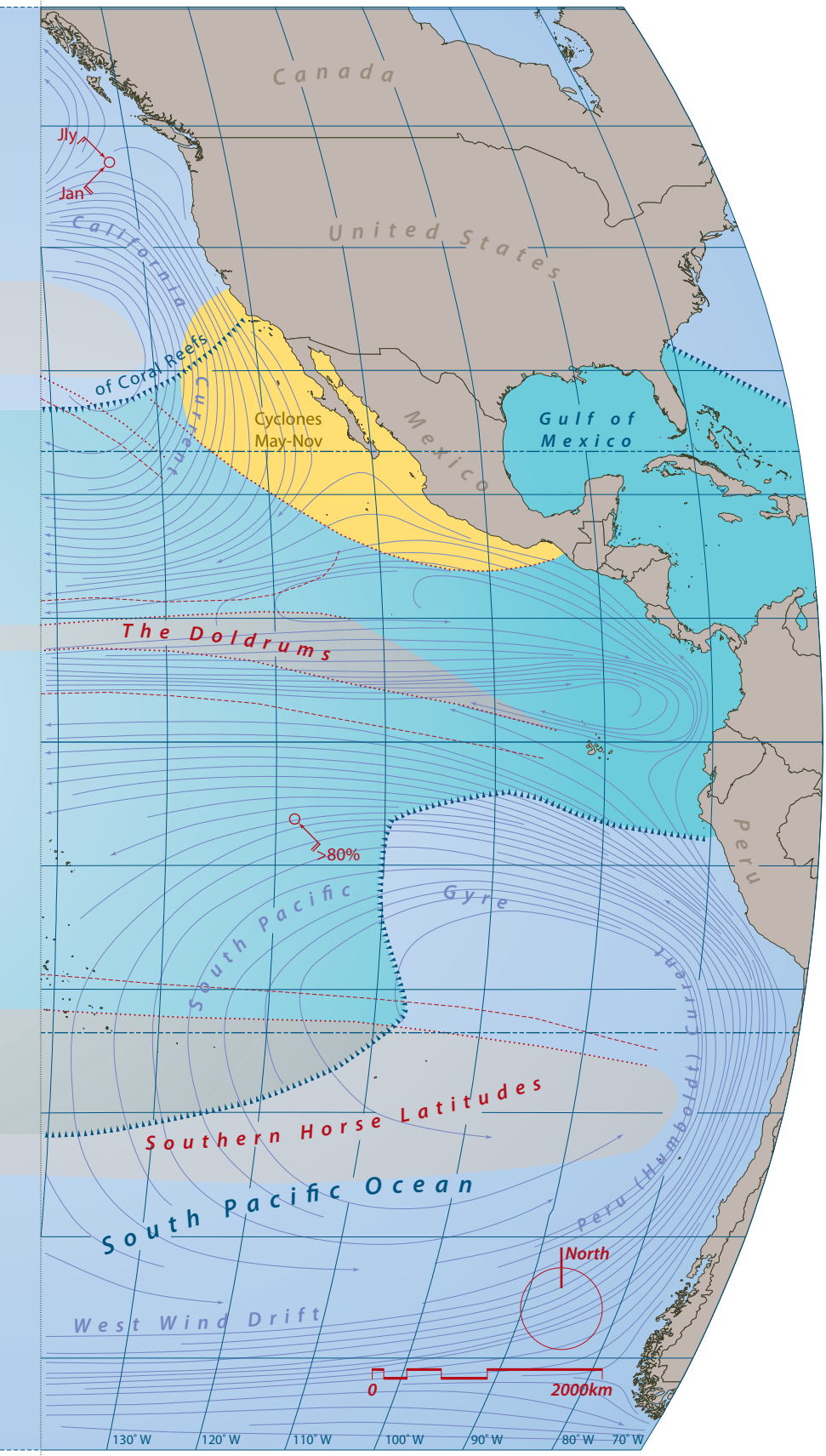
The rest of the maps are devoted to various aspects of the contemporary nations of the Pacific: economies, population sizes, etc.



D'Urville's Pacific
Océanie, a map attributed to Levasseur, E., after d'Urville, published in 1854 in *Atlas universel de géographie physique*. Micronesia, Polynesia and Melanesia are all clearly noted, although the 'borders' of these ethnographic categorizations have since shifted. The islanders of the Pacific are also clearly separated from the Malaysian peninsula and the islands of southeast Asia.


Russia
Sea of Okhotsk
Bering Sea
Alaska Current
North Pacific Ocean
Kamchatka Current
North Pacific Drift
Westerly
Stormy
Jan
Jly
North Pacific Gyre
(Japan) Current
Sea of Japan
China
East China Sea
Kuroshio
Northern Horse Latitudes
Approximate Northern Limit
Typhoons May-Nov
Oct-Apr
South China Sea
Cyclones Year Round
Light Variables
Sept-Apr
Phillipine Sea
Marshall Islands
Northeast Trades
>80%
North Equatorial Current
May-Sept
Celebes Sea
Equatorial Counter Current
South Equatorial Current
Java Sea
Banda Sea
Arafura Sea
Southeast Trades
>80%
60-80%
40-80% Jan
>80% Jly
Timor Sea
Coral Sea
Cyclones Nov-April
Cyclones Nov-April
Australia
East Australian Current
Approximate Southern Limit of Coral Reefs
Light Variables
Jan
Jly
Tasman Sea
Indian Ocean
Roaring Forties
Stormy
West Wind Drift
50°N
40°N
30°N
20°N
10°N
EQR
10°S
20°S
30°S
40°S
50°S
110° E
120° E
130° E
140° E
150° E
160° E
170° E
180° IDL
170° W
160° W
150° W
140° W

Pacific Winds & Currents



LEGEND

Currents

Current

Surface Ocean Currents

Reef Zone
(area where coral can grow)

Winds

Common Wind Name
Prevailing Condition %
Cyclone Season

Unstable Wind Regimes

Frequent Tropical Cyclones

Typhoons

Prevailing Wind Direction

Avg. Wind Intensity
(1 bar = 10 knots)

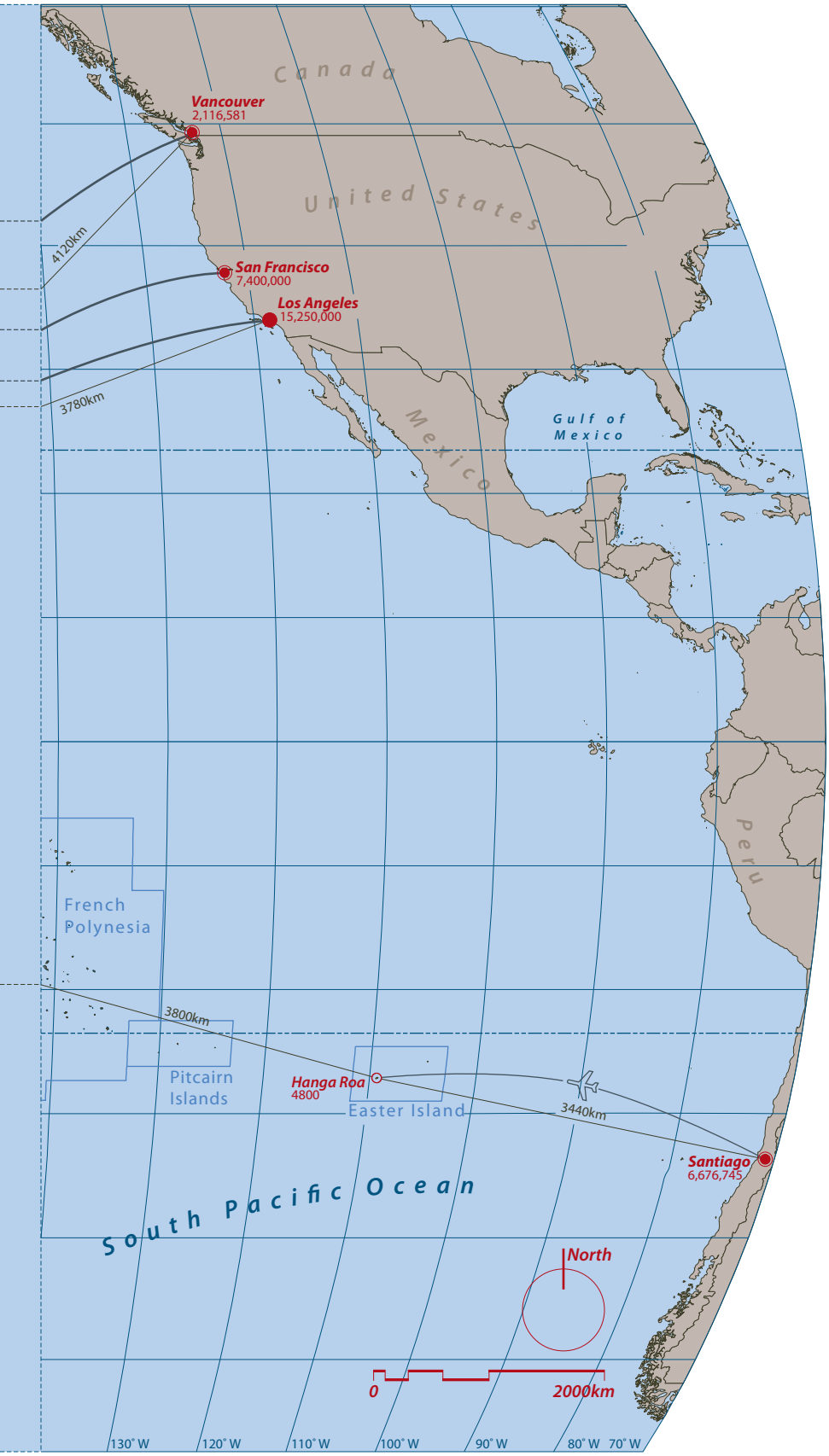
Features

Seas

Land

Ocean & Reefs


Russia
Sea of Okhotsk
Bering Sea
North Pacific Ocean
China
Sea of Japan
Japan
Seoul 24,500,000
Osaka 2,700,000
Tokyo 35,676,000
East China Sea
Naha 905,000
Taipei 2,600,000
Hong Kong 7,100,000
Taiwan
Phillipines
South China Sea
Manilla 11,100,000
Phillipine Sea
Guam
Capitol Hill 63,000
Guam 178,000
Northern Mariana Islands
Marshall Islands
Kwajalein 15,000
Majuro 23,000
Kosrae 8000
Weno 8000
Kolonia 12,000
Yap 6300
Palau 21,000
Palau
Micronesia
Malaysia
Celebes Sea
Papua New Guinea
Ternate 190,000
Manokwari 75,000
Biak 103,000
Sorong 26,000
Jayapura 170,000
Lorengau 6000
Kavieng 20,000
Madang 62,000
Lae 131,000
Kimbe 20,000
Arawa 46,000
Poponetta 28,000
Honiara 77,000
Nauru
Nauru 10,000
Tarawa 29,000
Kiribati
Tuvalu
Fanafuti 5000
Tokelau
Samoa
Wallis & Futuna
Pago Pago 13,000
Apia 62,000
Cook Islands
Papeete 118,000
Avarua 12,000
French Polynesia
Niue
Tonga
Nukualofa 43,000
Neiafu 7400
Fiji
Nadi 42,000
Suva 143,000
Lautoka 55,000
Vanuatu
Port Vila 36,000
Luganville 14,000
Noumea 93,000
New Caledonia
Solomon Islands
Honolulu 900,000
Hawai'i
Java Sea
Indonesia
Banda Sea
Arafura Sea
East Timor
Timor Sea
Coral Sea
Cairns 147,100
Townsville 181,743
Australia
Brisbane 2,004,262
Sydney 4,327,000
Tasman Sea
Auckland 1,350,000
Christchurch 365,000
New Zealand
Indian Ocean
4040km
4760km
3270km
380km
2790km
4525km
4770km
4730km
50°N
40°N
30°N
20°N
10°N
EQR
10°S
20°S
30°S
40°S
50°S
110° E
120° E
130° E
140° E
150° E
160° E
170° E
180° IDL
170° W
160° W
150° W
140° W



LEGEND

Distance

Distances from Majuro (does not indicate connectivity) — 100km

Flights

Major Regional Routes

Major International Routes

Pacific Urban Areas

City/Town
POPULATION

Megacity (10,000,000+ people)

Major City (1,000,000-10,000,000 people)

Regional City (100,000-1,000,000 people)

Town / Centre (10,000-100,000 people)

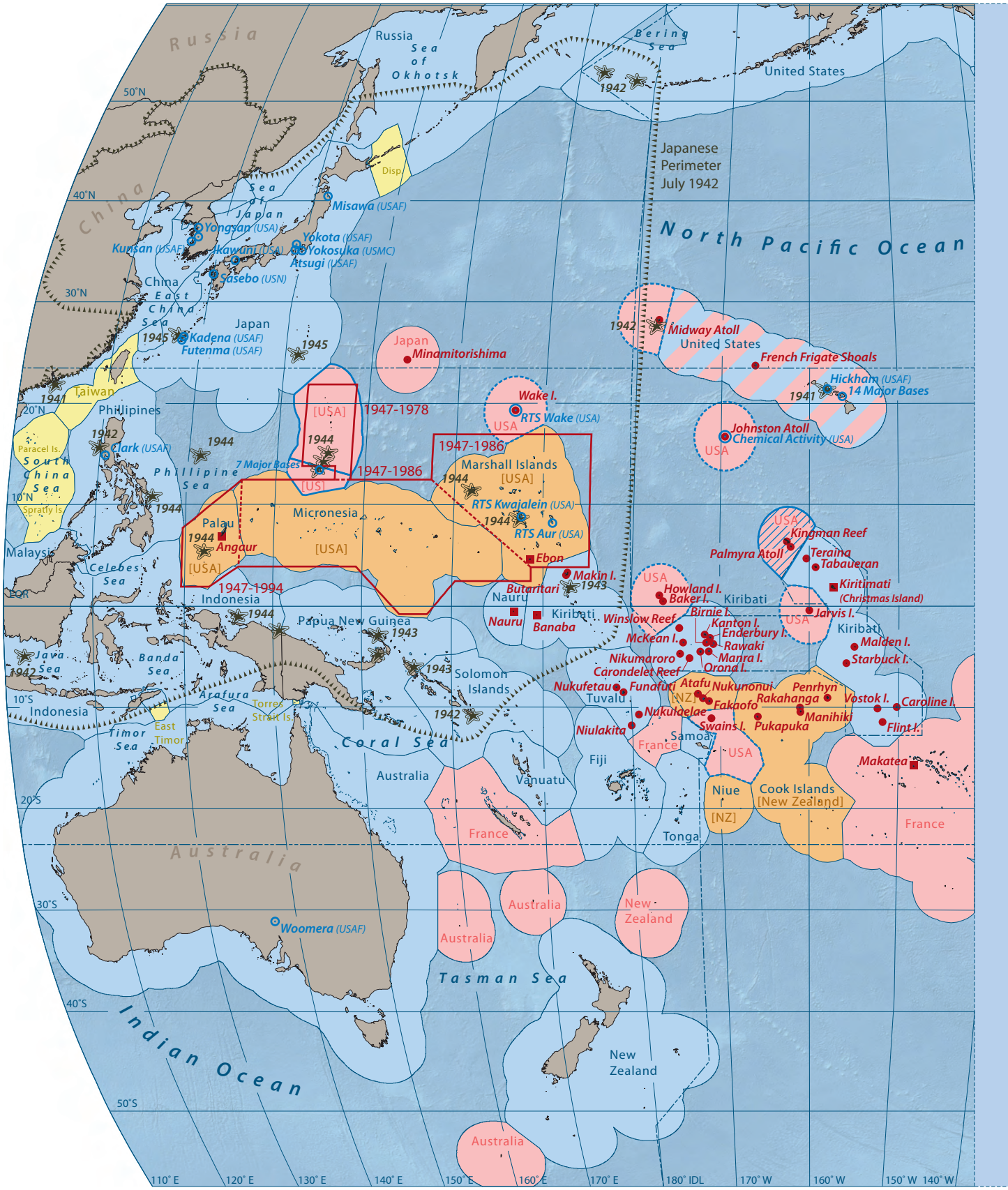
Settlement (1000-10,000 people)

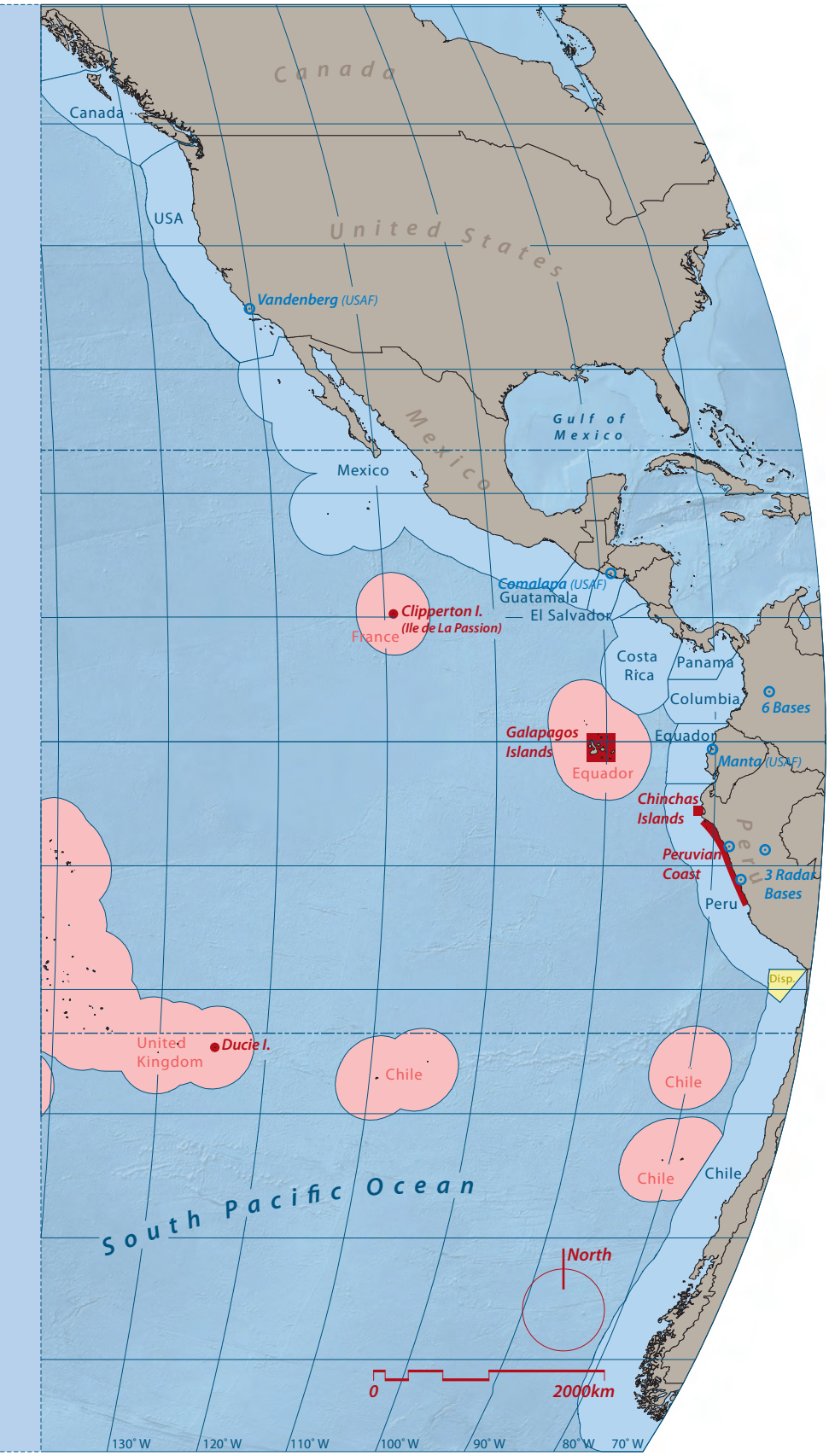
Features

Pacific Divisions
Seas

Land

Ocean & Reefs


Russia
Russia
Sea of Okhotsk
Bering Sea
United States
Japanese Perimeter July 1942
North Pacific Ocean
China
Sea of Japan
Misawa (USAF)
Yongsan (USA)
Kunsan (USAF)
Akawun (USA)
Yokota (USAF)
Yokosuka (USMC)
Atsugi (USAF)
Sasebo (USN)
China
East China Sea
Japan
Kadena (USAF)
Futenma (USAF)
Taiwan
Philippines
Clark (USAF)
Paracel Is.
South China Sea
Spratly Is.
Phillipine Sea
7 Major Bases
1947-1978
1947-1986
1947-1986
1947-1994
Japan
Minamitorishima
Wake I.
RTS Wake (USA)
USA
Marshall Islands
[USA]
RTS Kwajalein (USA)
RTS Aur (USA)
Ebon
Makin I.
Butaritari
Nauru
Nauru
Kiribati
Banaba
Palau
Angaur
Micronesia
[USA]
Malaysia
Celebes Sea
Indonesia
Papua New Guinea
Java Sea
Banda Sea
Arafura Sea
Torres Strait Is.
Indonesia
East Timor
Timor Sea
Solomon Islands
Tuvalu
Coral Sea
Australia
Vanuatu
Fiji
Samoa
France
Niue
[NZ]
Cook Islands
[New Zealand]
Tonga
France
Australia
Australia
Australia
New Zealand
Tasman Sea
Indian Ocean
New Zealand
Australia
Woomera (USAF)
Disp.
Midway Atoll
United States
French Frigate Shoals
Hickham (USAF)
14 Major Bases
Johnston Atoll
Chemical Activity (USA)
USA
Kingman Reef
Palmyra Atoll
Teraina
Tabaueran
Kiritimati
(Christmas Island)
Jarvis I.
Howland I.
Baker I.
Kiribati
Birnie I.
Winslow Reef
Kanton I.
Enderbury I.
McKean I.
Rawaki
Manra I.
Nikumaroro
Orona I.
Carondelet Reef
Nukufetau
Funafuti
Atafu
[NZ]
Nukunonui
Fakaofo
Nukulaelae
Swains I.
Niulakita
Penrhyn
Rakahanga
Manihiki
Pukapuka
Vostok I.
Caroline I.
Flint I.
Malden I.
Starbuck I.
Makatea
50°N
40°N
30°N
20°N
10°N
EQR
10°S
20°S
30°S
40°S
50°S
110° E
120° E
130° E
140° E
150° E
160° E
170° E
180° IDL
170° W
160° W
150° W
140° W



LEGEND

Legacy of WW2

- Major Battles
- Japanese *Nanyō Guntō*
- Trust Territory of the Pacific Islands (1947-1986)

US Military (PACOM)

- Military Inst. / Airfield (US)

Guano Islands

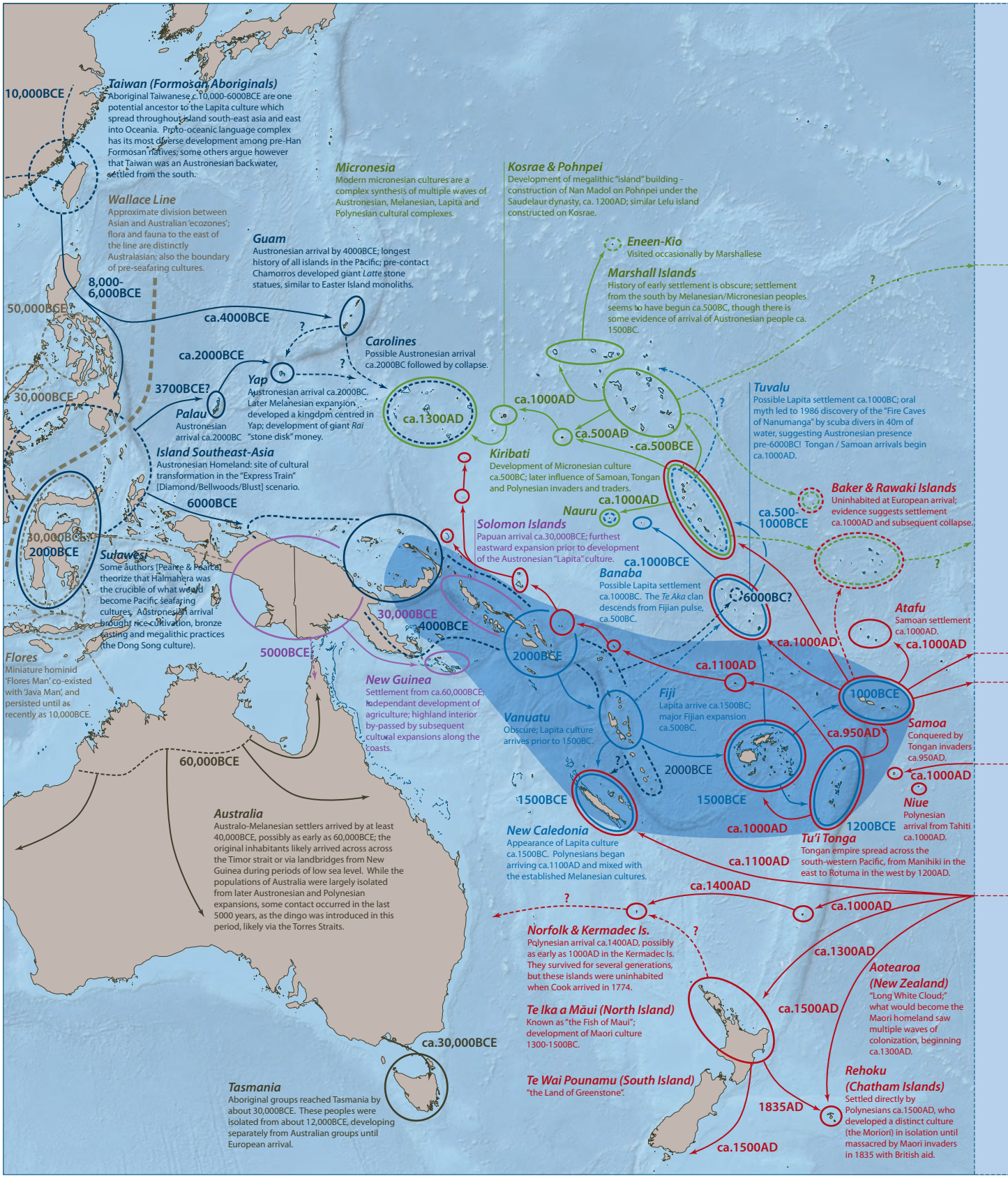
- Guano Island Claim (US)
- Phosphate Extraction (other)

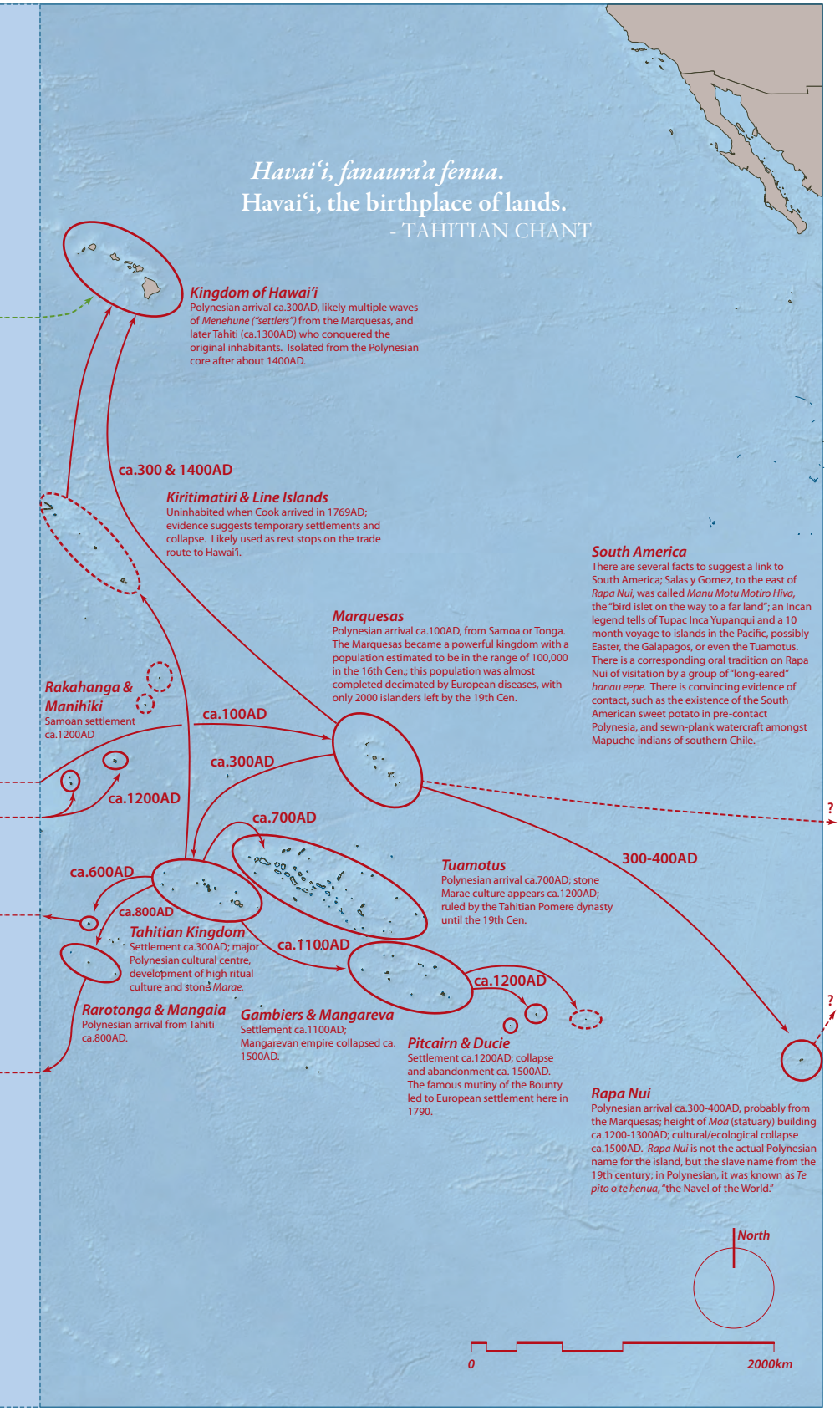
Exclusive Economic Zone (200 nm)

- Territorial Waters
- Disputed
- Free Association
- Maritime Possessions (Extra-territorial)
- US territory (Incorporated, unorganized)
- US territory (Unincorporated, organized)
- US territory (Unincorporated, unorganized)

Features

- Sea
- US Military Bases in Pacific Command (Force)
- Guano Island
- Land
- Ocean & Reefs


10,000BCE
Taiwan (Formosan Aboriginals)
Aboriginal Taiwanese c.10,000-6000BCE are one potential ancestor to the Lapita culture which spread throughout island south-east asia and east into Oceania. Proto-oceanic language complex has its most diverse development among pre-Han Formosan natives; some others argue however that Taiwan was an Austronesian backwater, settled from the south.
Wallace Line
Approximate division between Asian and Australian 'ecozones'; flora and fauna to the east of the line are distinctly Australasian; also the boundary of pre-seafaring cultures.
8,000-6,000BCE
50,000BCE
30,000BCE
Micronesia
Modern micronesian cultures are a complex synthesis of multiple waves of Austronesian, Melanesian, Lapita and Polynesian cultural complexes.
Kosrae & Pohnpei
Development of megalithic "island" building - construction of Nan Madol on Pohnpei under the Saudelaur dynasty, ca. 1200AD; similar Lelu island constructed on Kosrae.
Guam
Austronesian arrival by 4000BCE; longest history of all islands in the Pacific; pre-contact Chamorros developed giant *Latte* stone statues, similar to Easter Island monoliths.
Eneen-Kio
Visited occasionally by Marshallese
Marshall Islands
History of early settlement is obscure; settlement from the south by Melanesian/Micronesian peoples seems to have begun ca.500BC, though there is some evidence of arrival of Austronesian people ca. 1500BC.
ca.4000BCE
ca.2000BCE
Carolines
Possible Austronesian arrival ca.2000BC followed by collapse.
3700BCE?
Yap
Austronesian arrival ca.2000BC. Later Melanesian expansion developed a kingdom centred in Yap; development of giant *Rai* "stone disk" money.
Palau
Austronesian arrival ca.2000BC
ca.1300AD
ca.1000AD
ca.500AD
ca.500BCE
Tuvalu
Possible Lapita settlement ca.1000BC; oral myth led to 1986 discovery of the "Fire Caves of Nanumanga" by scuba divers in 40m of water, suggesting Austronesian presence pre-6000BC! Tongan / Samoan arrivals begin ca.1000AD.
Island Southeast-Asia
Austronesian Homeland: site of cultural transformation in the "Express Train" [Diamond/Bellwoods/Blust] scenario.
Kiribati
Development of Micronesian culture ca.500BC; later influence of Samoan, Tongan and Polynesian invaders and traders.
6000BCE
ca.1000AD
Nauru
Baker & Rawaki Islands
Uninhabited at European arrival; evidence suggests settlement ca.1000AD and subsequent collapse.
ca.500-1000BCE
Solomon Islands
Papuan arrival ca.30,000BCE; furthest eastward expansion prior to development of the Austronesian "Lapita" culture.
30,000BCE-2000BCE
Sulawesi
Some authors [Pearce & Pearce] theorize that Halmahera was the crucible of what would become Pacific seafaring cultures. Austronesian arrival brought rice cultivation, bronze casting and megalithic practices (the Dong Song culture).
ca.1000BCE
Banaba
Possible Lapita settlement ca.1000BC. The *Te Aka* clan descends from Fijian pulse, ca.500BC.
6000BC?
Atafu
Samoan settlement ca.1000AD.
ca.1000AD
30,000BCE
4000BCE
5000BCE
2000BCE
ca.1000AD
ca.1100AD
Flores
Miniature hominid 'Flores Man' co-existed with 'Java Man', and persisted until as recently as 10,000BCE.
New Guinea
Settlement from ca.60,000BCE; independant development of agriculture; highland interior by-passed by subsequent cultural expansions along the coasts.
Fiji
Lapita arrive ca.1500BC; major Fijian expansion ca.500BC.
1000BCE
Vanuatu
Obscure; Lapita culture arrives prior to 1500BC.
ca.950AD
Samoa
Conquered by Tongan invaders ca.950AD.
60,000BCE
2000BCE
ca.1000AD
1500BCE
1500BCE
Niue
Polynesian arrival from Tahiti ca.1000AD.
Australia
Australo-Melanesian settlers arrived by at least 40,000BCE, possibly as early as 60,000BCE; the original inhabitants likely arrived across across the Timor strait or via landbridges from New Guinea during periods of low sea level. While the populations of Australia were largely isolated from later Austronesian and Polynesian expansions, some contact occurred in the last 5000 years, as the dingo was introduced in this period, likely via the Torres Straits.
New Caledonia
Appearance of Lapita culture ca.1500BC. Polynesians began arriving ca.1100AD and mixed with the established Melanesian cultures.
ca.1000AD
1200BCE
Tu'i Tonga
Tongan empire spread across the south-western Pacific, from Manihiki in the east to Rotuma in the west by 1200AD.
ca.1100AD
ca.1400AD
ca.1000AD
Norfolk & Kermadec Is.
Polynesian arrival ca.1400AD, possibly as early as 1000AD in the Kermadec Is. They survived for several generations, but these islands were uninhabited when Cook arrived in 1774.
ca.1300AD
Aotearoa (New Zealand)
"Long White Cloud;" what would become the Maori homeland saw multiple waves of colonization, beginning ca.1300AD.
ca.1500AD
Te Ika a Māui (North Island)
Known as "the Fish of Maui"; development of Maori culture 1300-1500BC.
ca.30,000BCE
Rehoku (Chatham Islands)
Settled directly by Polynesians ca.1500AD, who developed a distinct culture (the Moriori) in isolation until massacred by Maori invaders in 1835 with British aid.
Te Wai Pounamu (South Island)
"the Land of Greenstone".
1835AD
Tasmania
Aboriginal groups reached Tasmania by about 30,000BCE. These peoples were isolated from about 12,000BCE, developing separately from Australian groups until European arrival.
ca.1500AD



LEGEND

Lapita Complex

Extent of Lapita Pottery discoveries

Pacific Islands History

- Polynesian cultures (ca.100AD-)
- Micronesian cultures (ca.1500BC-)
- Lapita culture (ca.1600-500BC)
- Austronesians (ca.10,000-2000BC)
- New Guinean cultures (ca.60,000BCE-)
- Aboriginal Australians (ca.60,000BCE-)
- Australo-Melanesians (Prehistoric)

Features

- Land
- Ocean & Reefs

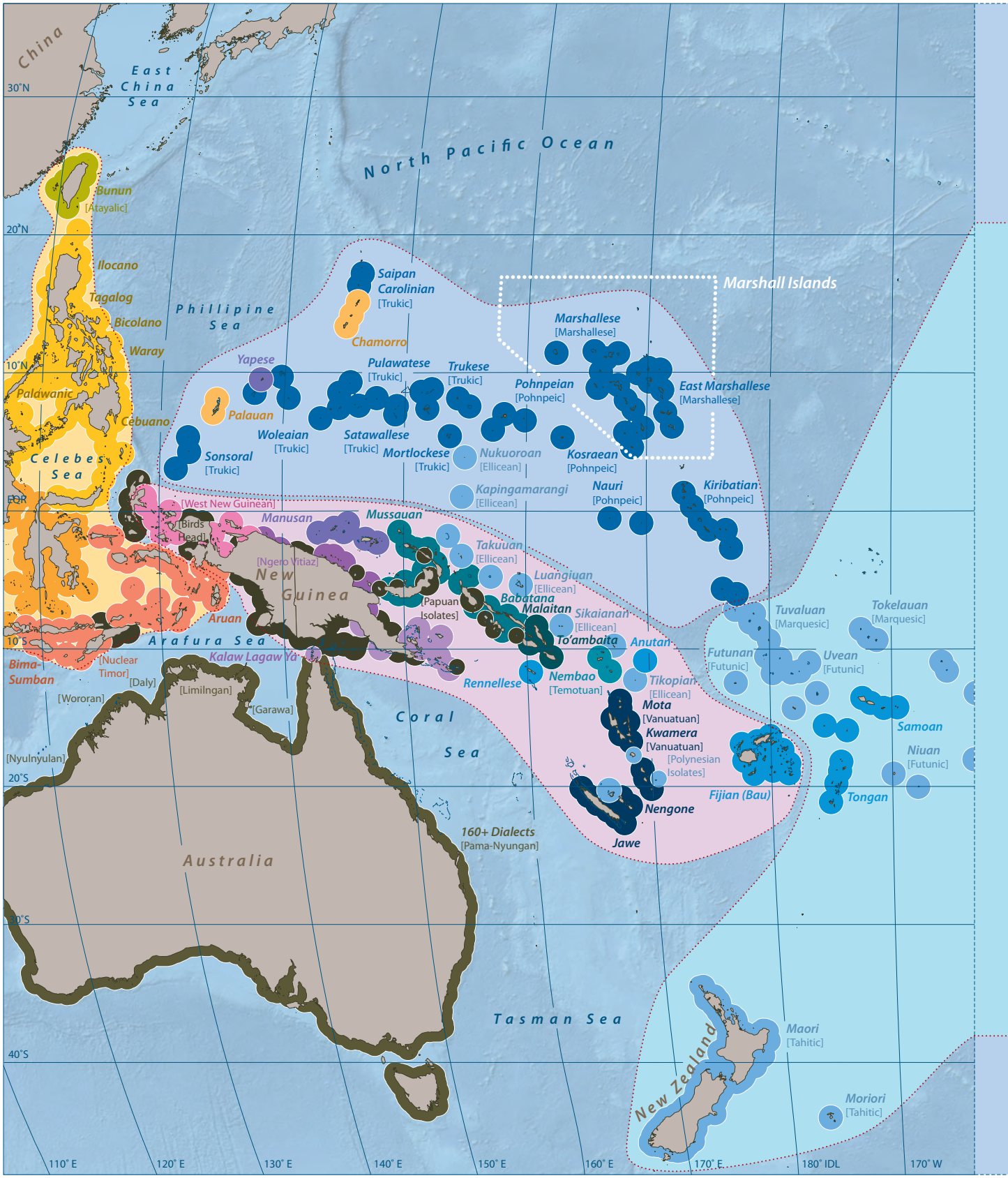

China
East China Sea
North Pacific Ocean
Bunun
[Atayalic]
Ilocano
Tagalog
Bicolano
Waray
Palawanic
Cebuano
Celebes Sea
Phillipine Sea
Saipan
Carolinian
[Trukic]
Chamorro
Marshall Islands
Marshallese
[Marshallese]
East Marshallese
[Marshallese]
Yapese
Palauan
Pulawatese
[Trukic]
Trukese
[Trukic]
Pohnpeian
[Pohnpeic]
Woleaian
[Trukic]
Satawallese
[Trukic]
Mortlockese
[Trukic]
Nukuoroan
[Ellicean]
Kosraean
[Pohnpeic]
Sonsoral
[Trukic]
Kapingamarangi
[Ellicean]
Nauri
[Pohnpeic]
Kiribatian
[Pohnpeic]
EDR
[West New Guinean]
[Birds Head]
Manusan
Mussauan
[Ngero Vitiaz]
New Guinea
Takuuan
[Ellicean]
Luangiuan
[Ellicean]
[Papuan Isolates]
Babatana
Malaitan
Sikaianan
[Ellicean]
Aruan
Arafura Sea
To'ambaita
Anutan
Kalaw Lagaw Ya
Bima-Sumban
[Nuclear Timor]
[Daly]
[Wororan]
[Limilngan]
[Garawa]
Rennellese
Nembao
[Temotuan]
Tikopian
[Ellicean]
Mota
[Vanuatuan]
Kwamera
[Vanuatuan]
[Polynesian Isolates]
Coral Sea
[Nyulnyulan]
Nengone
Jawe
Fijian (Bau)
160+ Dialects
[Pama-Nyungan]
Australia
Tasman Sea
New Zealand
Maori
[Tahitic]
Moriori
[Tahitic]
Tuvaluan
[Marquesic]
Tokelauan
[Marquesic]
Futunan
[Futunic]
Uvean
[Futunic]
Samoan
Niuan
[Futunic]
Tongan
30°N
20°N
10°N
EQR
10°S
20°S
30°S
40°S
110° E
120° E
130° E
140° E
150° E
160° E
170° E
180° IDL
170° W

FIG. A1.5

Language Groups of Oceania

LEGEND

Categorization

- Polynesia
- Micronesia
- Melanesia
- Island Southeast Asia

Austronesian (Major Families)

Language / Dialect [Linguistic Subgroups]

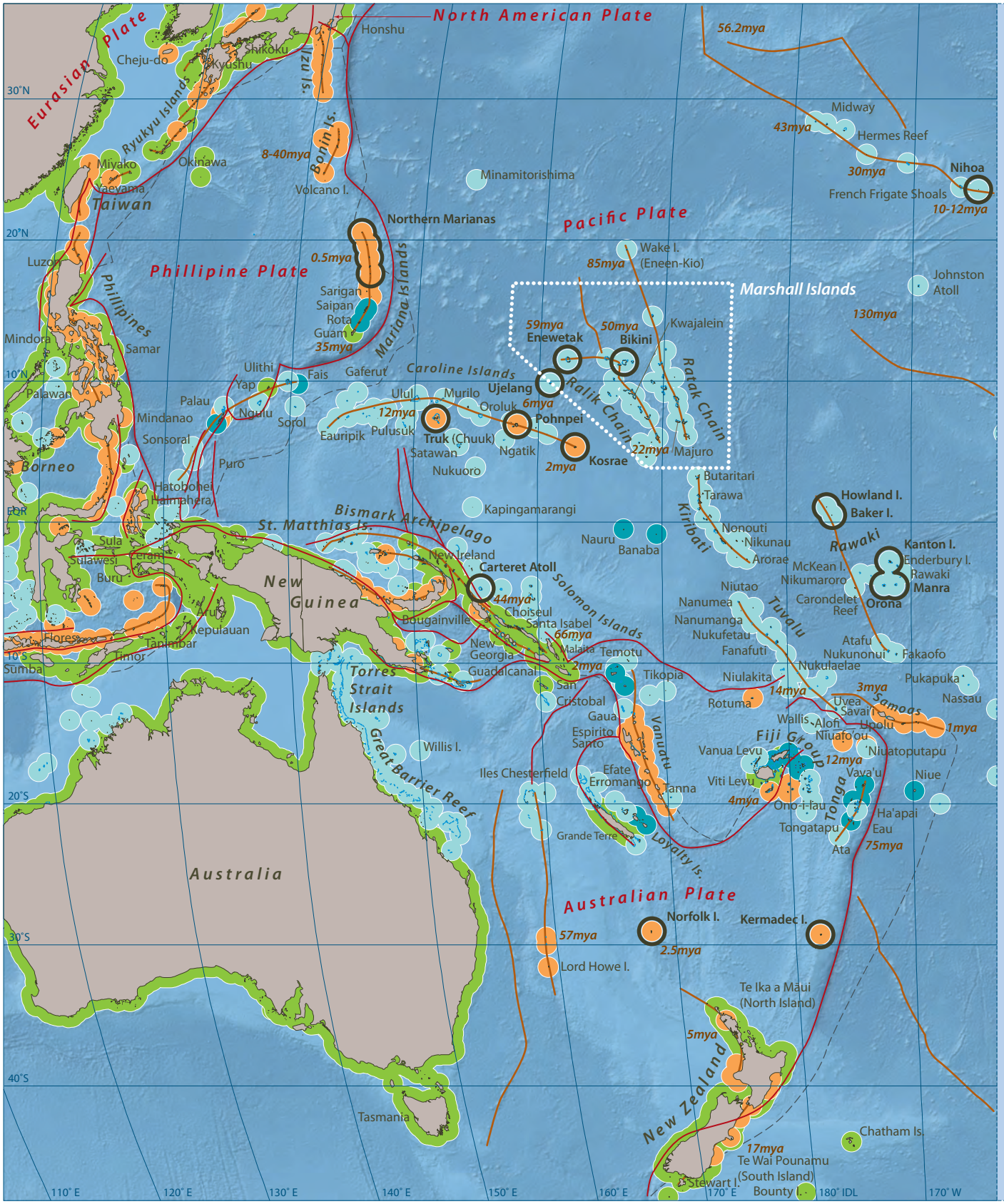
- Polynesian
- Central Pacific
- Micronesian
- Southern Oceanic
- Temotuan
- Meso-Melanesian
- South-east Solomonic
- Admiralty Islander
- Northern New Guinean
- Papuan Tip Languages
- Western New Guinean
- Central Malayo-Poynesian
- Western Malayo-Polynesian
- Phillipine
- Formosan

Other

- Papuan Languages
- Australian Languages

Features

- Land
- Ocean & Reefs


North American Plate
Eurasian Plate
Honshu
Shikoku
Kyushu
Cheju-do
Izu Is.
Ryukyu Islands
Bonin Is.
Miyako
Yaeyama
Okinawa
Taiwan
8-40mya
Volcano I.
Minamitorishima
Northern Marianas
0.5mya
Pacific Plate
Phillipine Plate
Luzon
Phillipines
Mariana Islands
Sarigan
Saipan
Rota
Guam
35mya
Mindoro
Samar
Palawan
Ulithi
Fais
Gaferut
Yap
Palau
Ngulu
Mindanao
Sonsoral
Sorol
Caroline Islands
Ujelang
Murilo
Ulul
Oroluk
6mya
Pohnpei
12mya
Pulusuk
Eauripik
Truk (Chuuk)
Satawan
Ngatik
Kosrae
2mya
Nukuoro
Ralik Chain
Ratak Chain
Kwajalein
Bikini
Enewetak
59mya
50mya
22mya
Majuro
Marshall Islands
Wake I.
(Eneen-Kio)
85mya
Johnston
Atoll
130mya
56.2mya
Midway
43mya
Hermes Reef
30mya
Nihoa
French Frigate Shoals
10-12mya
Borneo
Puro
Hatobohei
Halmahera
Bismark Archipelago
St. Matthias Is.
Kapingamarangi
Butaritari
Tarawa
Kiribati
Nauru
Banaba
Nonouti
Nikunau
Arorae
Howland I.
Baker I.
Rawaki
Kanton I.
Enderbury I.
Rawaki
Manra
Orona
McKean I.
Nikumaroro
Carondelet
Reef
Sula
Sulawesi
Ceram
Buru
New Ireland
Carteret Atoll
44mya
New
Guinea
Bougainville
Choiseul
Santa Isabel
Solomon Islands
66mya
Malaita
Temotu
New
Georgia
Guadalcanal
2mya
Tikopia
San
Cristobal
Gaua
Espirito
Santo
Vanuatu
Tanna
Efate
Erromango
Iles Chesterfield
Grande Terre
Loyalty Is.
Niutao
Nanumea
Nanumanga
Nukufetau
Fanafuti
Tuvalu
Niulakita
Rotuma
14mya
Atafu
Nukunonui
Nukulaelae
Fakaofo
Pukapuka
Nassau
3mya
Samoas
Uvea
Savai'i
Upolu
Wallis
Alofi
Niuafo'ou
1mya
Fiji Group
Vanua Levu
Viti Levu
12mya
Niuatoputapu
Vava'u
Niue
Tonga
Ono-i-lau
4mya
Ha'apai
Eau
Tongatapu
Ata
75mya
Flores
Timor
Sumba
Kepulauan
Tanimbar
Aru
Torres
Strait
Islands
Great Barrier Reef
Willis I.
Australia
Australian Plate
Norfolk I.
Kermadec I.
57mya
2.5mya
Lord Howe I.
Te Ika a Māui
(North Island)
5mya
New Zealand
Tasmania
Chatham Is.
17mya
Te Wai Pounamu
(South Island)
Stewart I.
Bounty I.
30°N
20°N
10°N
EQR
10°S
20°S
30°S
40°S
110° E
120° E
130° E
140° E
150° E
160° E
170° E
180° IDL
170° W

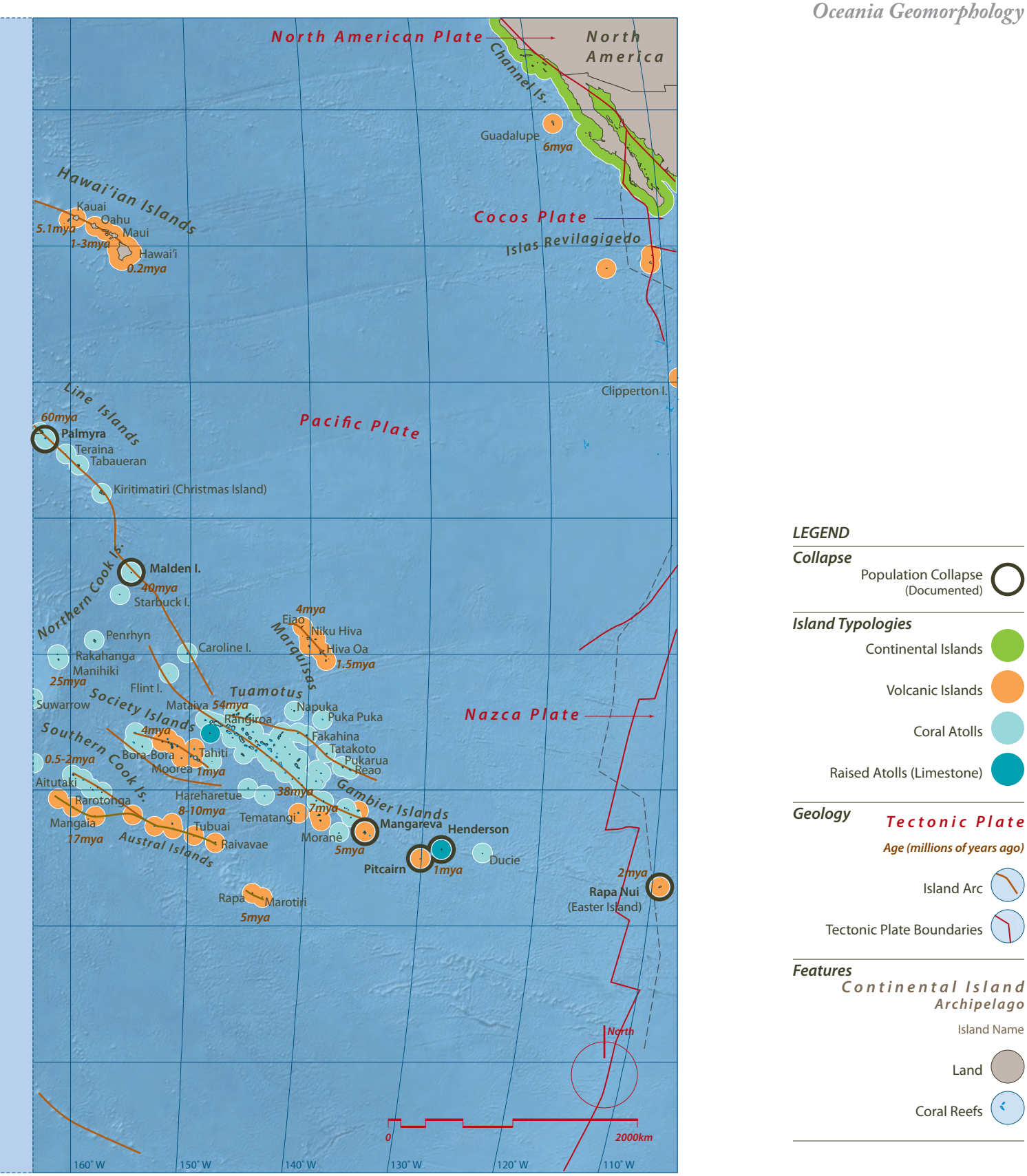
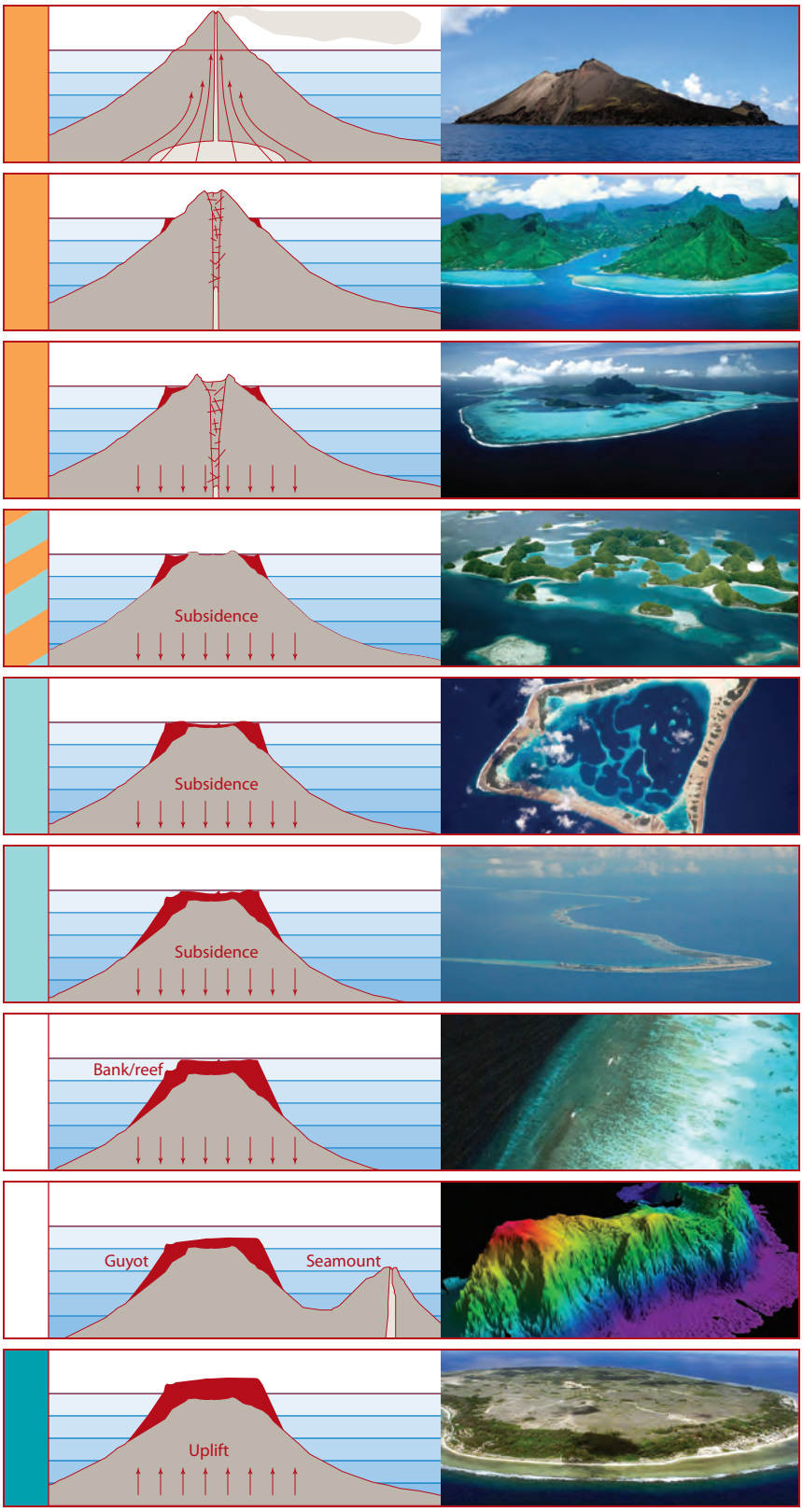

North American Plate
North America
Channel Is.
Guadalupe
6mya
Hawai'ian Islands
Kauai
Oahu
Maui
Hawai'i
5.1mya
1-3mya
0.2mya
Cocos Plate
Islas Revilagigedo
Clipperton I.
Line Islands
60mya
Palmyra
Teraina
Tabaueran
Pacific Plate
Kiritimatiri (Christmas Island)
Malden I.
40mya
Starbuck I.
Northern Cook Is.
Penrhyn
Rakahanga
Manihiki
25mya
Caroline I.
Flint I.
Suwarrow
Society Islands
Southern Cook Is.
Mataiva
54mya
Tuamotus
Rangiroa
Napuka
Puka Puka
Fakahina
Tatakoto
Pukarua
Reao
Marquisas
4mya
Eiao
Niku Hiva
Hiva Oa
1.5mya
Nazca Plate
4mya
Tahiti
Bora-Bora
Moorea
1mya
0.5-2mya
Aitutaki
Rarotonga
Mangaia
17mya
Hareharetue
8-10mya
Tubuai
Raivavae
Austral Islands
Tematangi
38mya
7mya
Gambier Islands
Mangareva
Henderson
Moranė
5mya
Pitcairn
1mya
Ducie
2mya
Rapa Nui
(Easter Island)
Rapa
Marotiri
5mya
North
0
2000km
160° W
150° W
140° W
130° W
120° W
110° W
LEGEND
Collapse
Population Collapse
(Documented)
Island Typologies
Continental Islands
Volcanic Islands
Coral Atolls
Raised Atolls (Limestone)
Geology
Tectonic Plate
Age (millions of years ago)
Island Arc
Tectonic Plate Boundaries
Features
Continental Island
Archipelago
Island Name
Land
Coral Reefs

FIG. A1.7

Island Typologies



Young Volcanic Island (0-0.1mya)
Fanouafo'ou (Tonga);
Fukutoku-Okanoba (Ryukyu Islands);
Kuwae (Vanuatu);
Krakatoa (Indonesia).

Volcanic Island with Fringing Reef (0.1-1mya)
Tahiti, Moorea (French Polynesia);
Oahu, Molokai (Hawai'i, USA);

Volcanic Island with Lagoon and Barrier Reef (1-5mya)
Bora Bora (French Polynesia);
Upolu (Samoa);
Rarotonga (Cook Islands).

Atoll with Volcanic Remnants: "Almost Atoll" (5-10mya)
Chuuk (FSM);
Aitutaki (Cook Islands);
Palau (Palau).

Enclosed Atoll (10mya+)
Nukuoruo (FSM);
Bikini (RMI);
Atafu (Tokelau);
Aitutaki (Cook Islands).

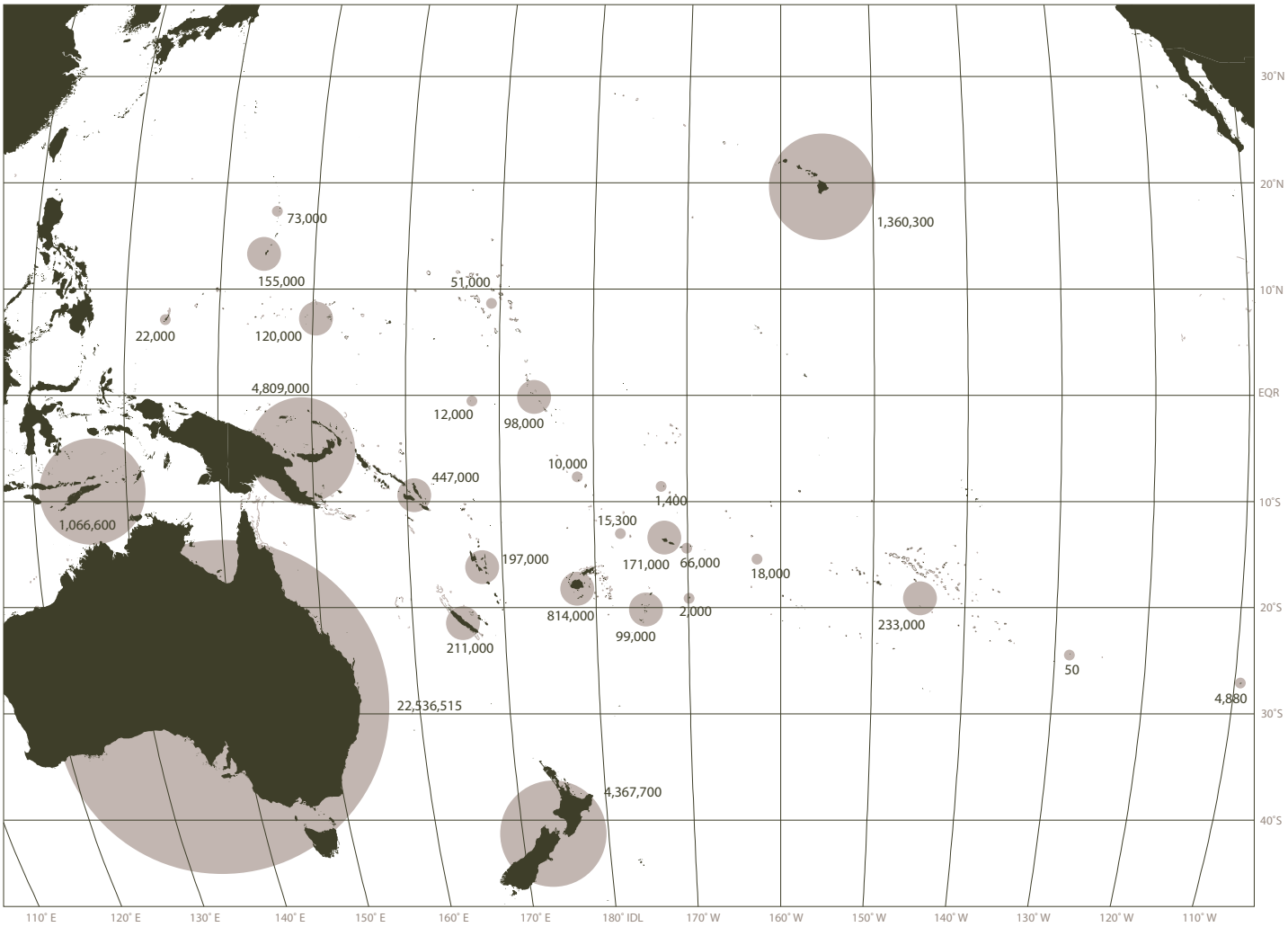
Partially Submerged Atoll (10mya+)
Kwajalein (RMI);
Huvadhu (Maldives);
Rangiroa (French Polynesia);
Iles Chesterfield (Nouvelle Caledonie).

Submerged Atoll (10mya+)
Sayha de Malha Bank (Indian Ocean);
Great Chagos Bank (Indian Ocean);
Lansdowne Bank (New Caledonia).

Guyot & Seamount (10mya+)
Ratak Guyot (RMI);
Kammu Guyot, Hancock Seamount (Emperor Seamounts);
Lō'ihi Seamount (Hawai'i, USA).

Raised Coral Island (Raised Atoll or 'Makatea') (10mya+)
Makatea (French Polynesia);
Nauru (Nauru);
Niue (Niue);
Banaba (Kiribati).

Oceania – Population



Population
(2010)

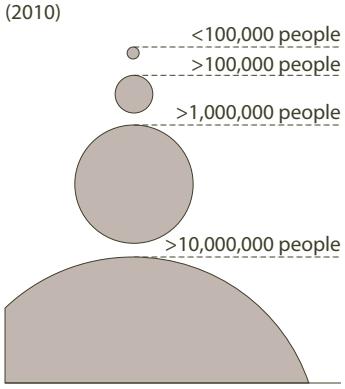
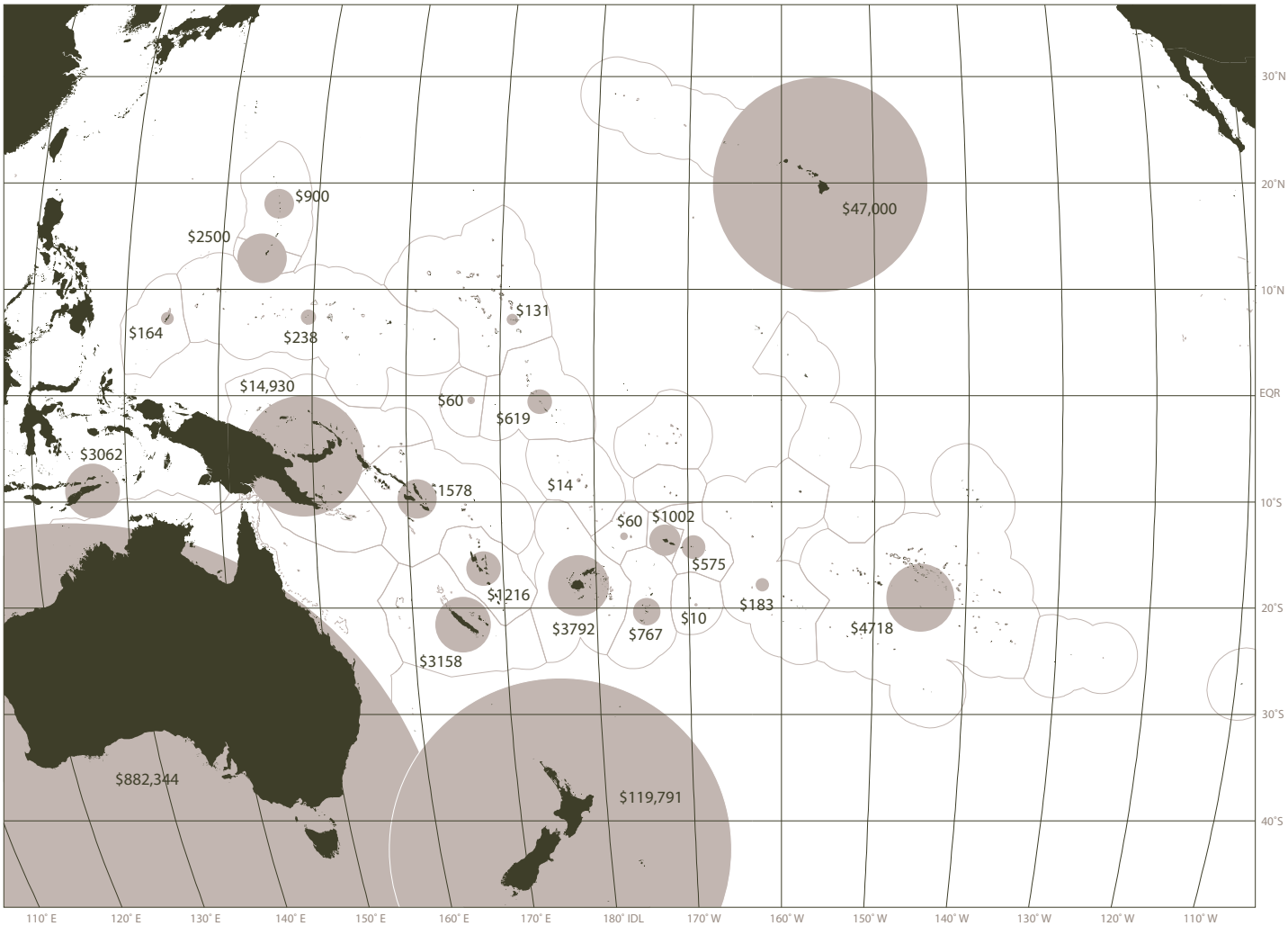


FIG. A1.9

Oceania – GDP

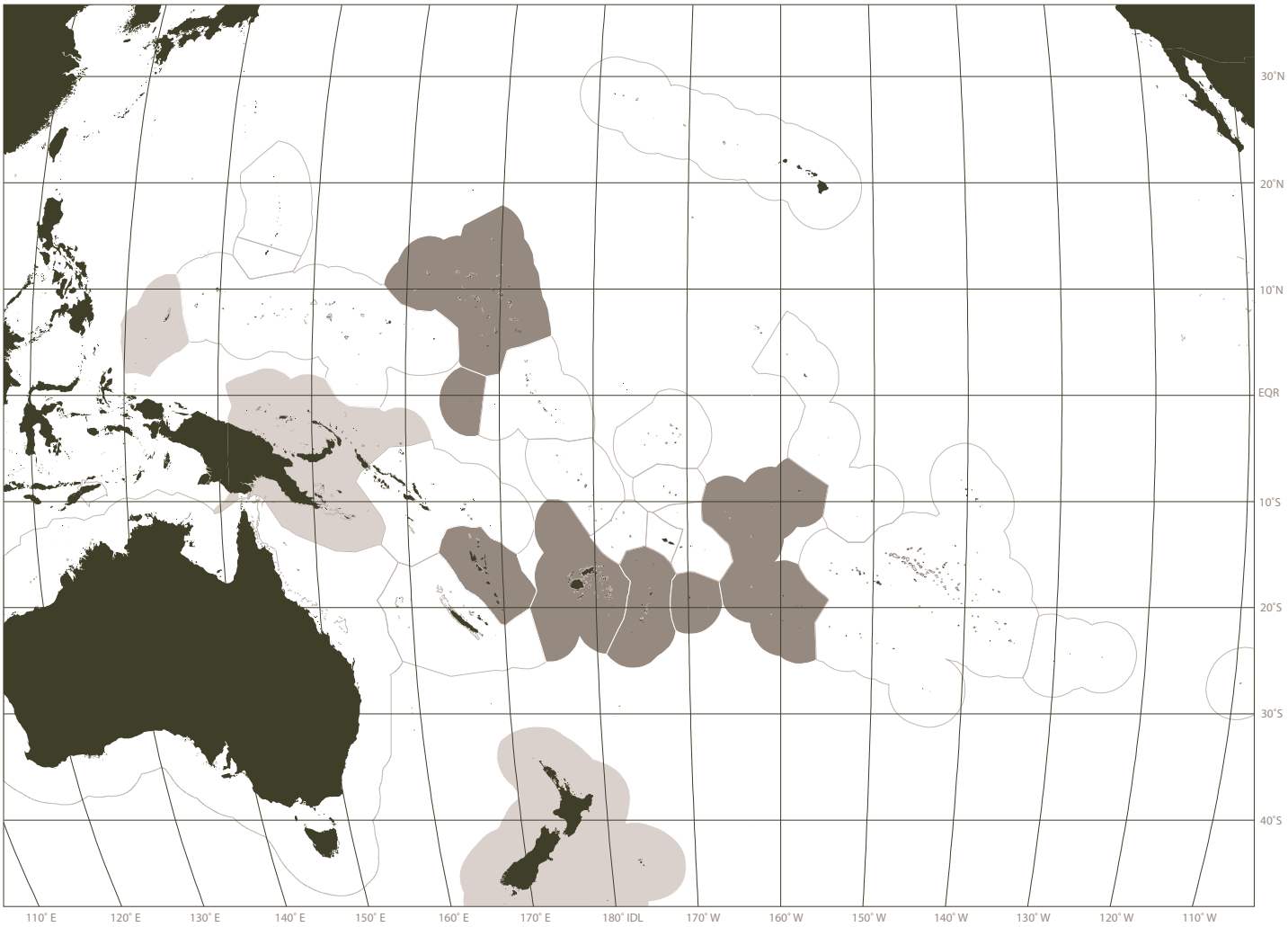


GDP
(in millions $US, 2010)

$10 Million
$100 Million
$1 Billion
$10 Billion
GDP

FIG. A1.10

Oceania – Offshore Banking



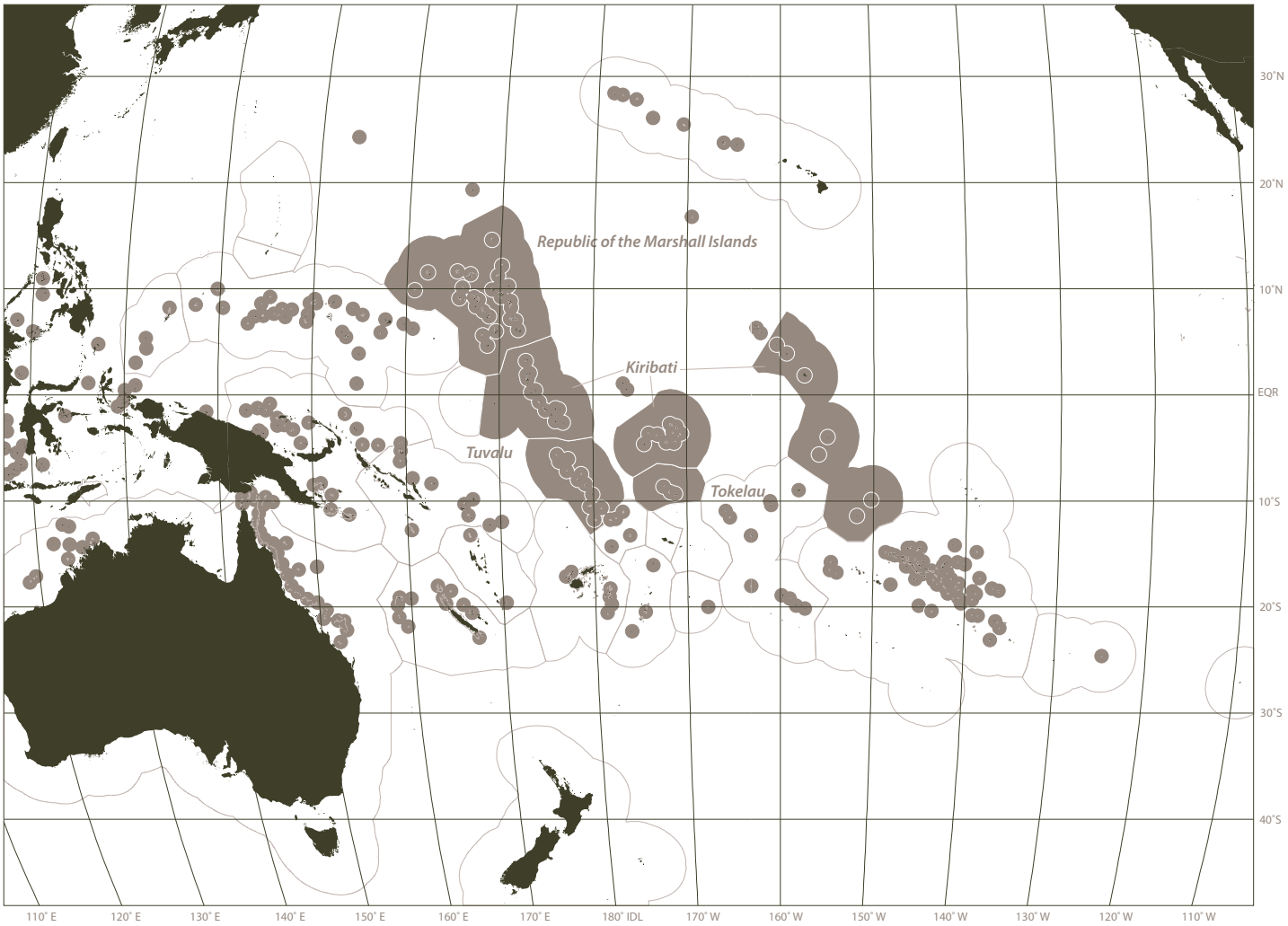
Offshore Banking

OECD Blacklist 26 June 2000: Accusations of Money Laundering

Offshore Banking Centre

FIG. A1.11

Oceania – Atoll Nations

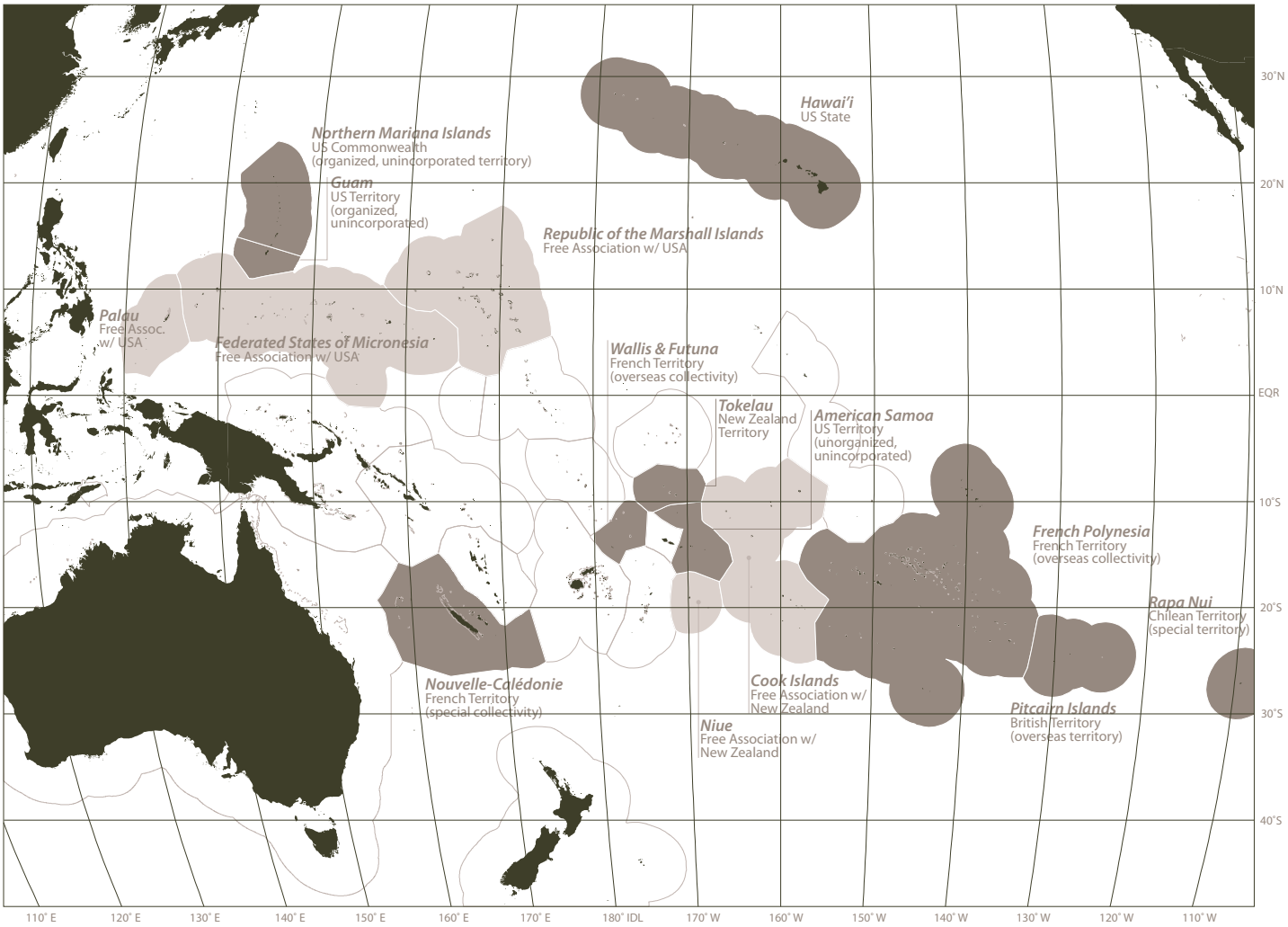


Atoll States

States composed entirely of atoll islands

Atolls

Oceania – Land Areas



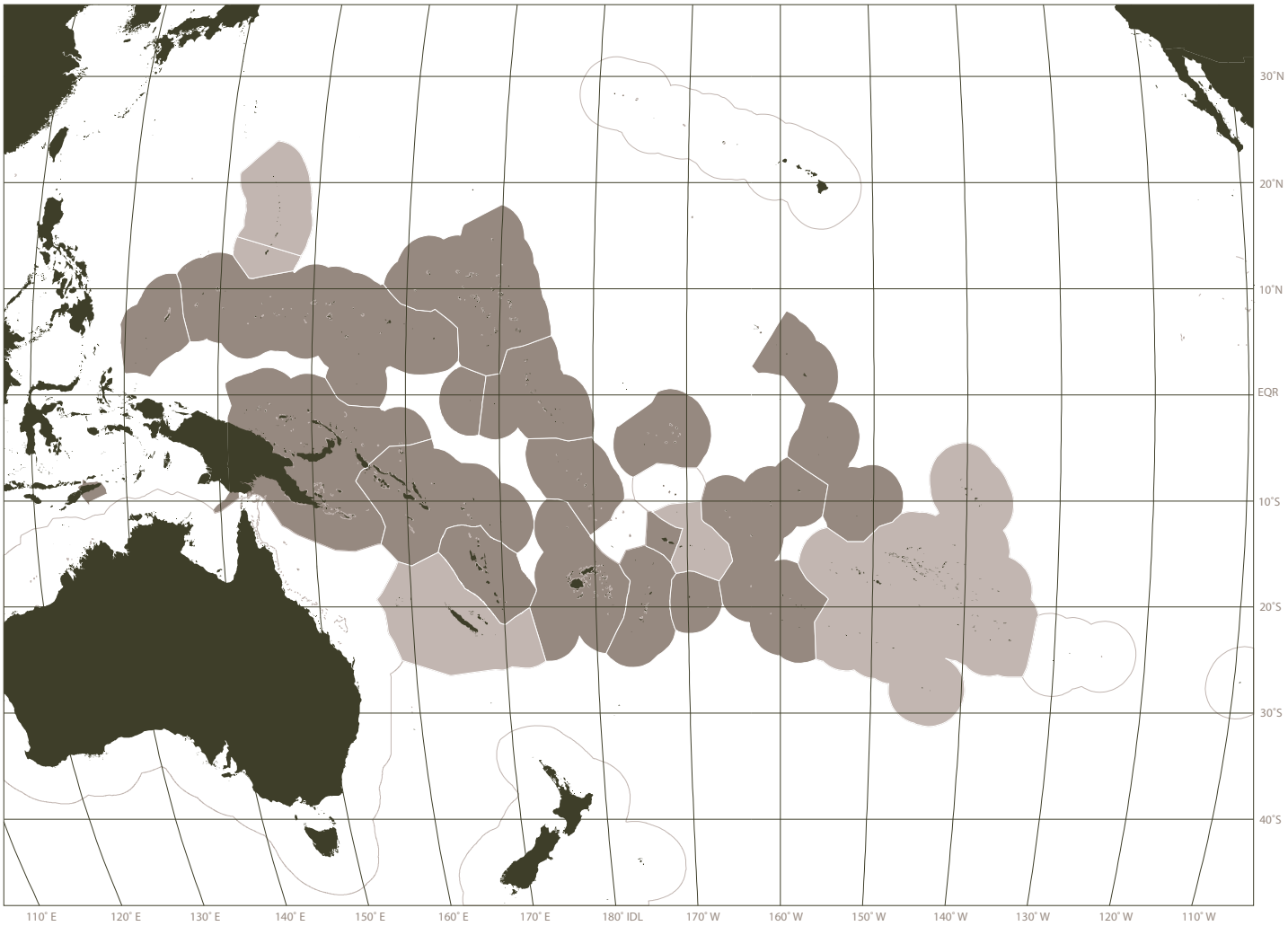
Dependence & Control

Outre-mer / overseas territories

Associated State
(Free Association)

FIG. A1.13

Oceania – Small Island States

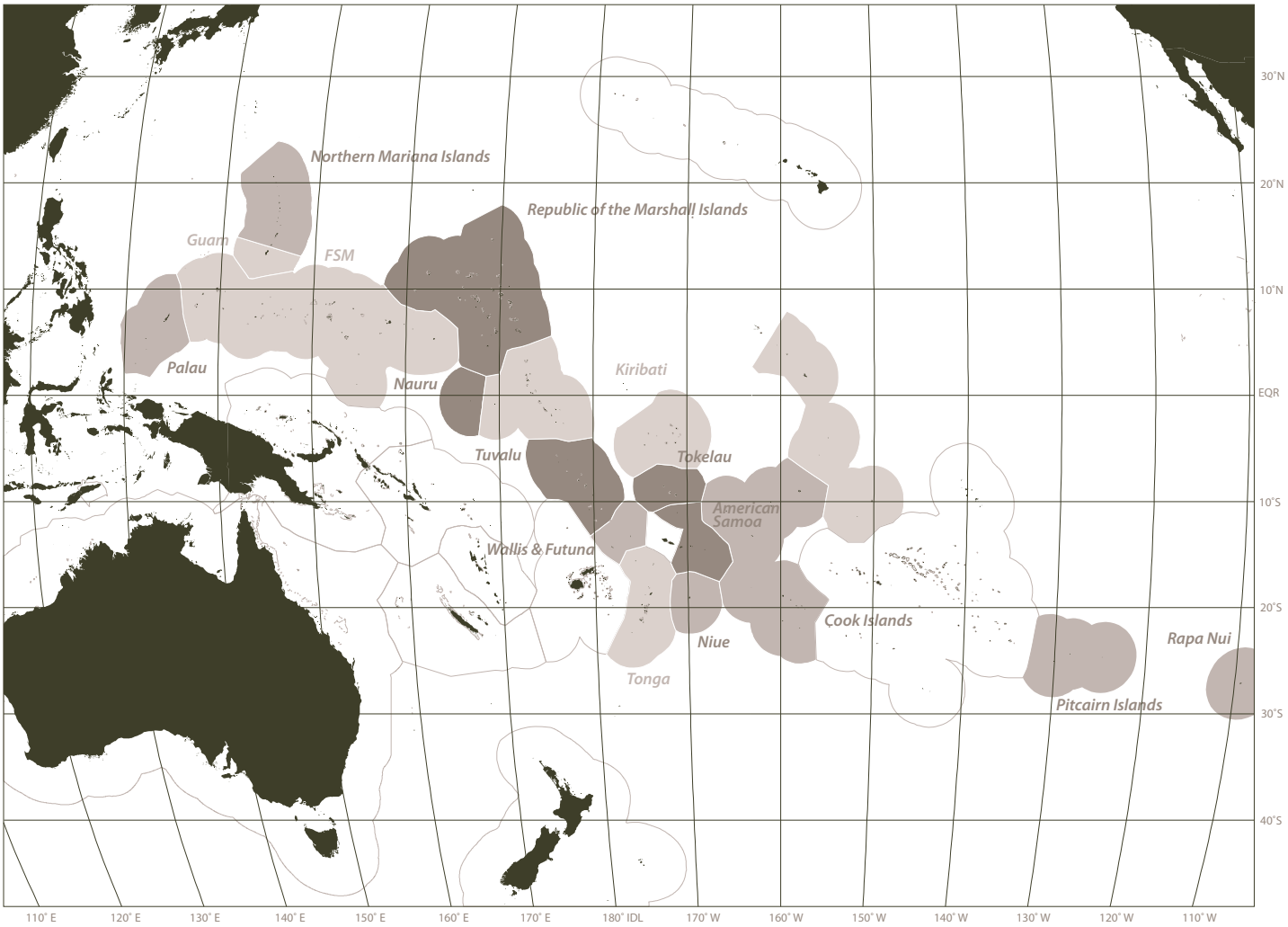


AOSIS

United Nations "Small Island Developing State"

"Alliance of Small Island States" Global Climate Change Alliance Members

Oceania – Sovereignty



Small Island States

Territories with less than...

200km² Land Area

500km² Land Area

1000km² Land Area

"We say the map is different from the territory. But what is the territory? Operationally, somebody went out with a retina or a measuring stick and made representations which were then put on paper. What is on the paper map is a representation of what was in the retinal representation of the man who made the map; and as you push the question back, what you find is an infinite regress, an infinite series of maps. The territory never gets in at all. [...] Always, the process of representation will filter it out so that the mental world is only maps of maps, ad infinitum."[1]

1 Bateson. (1972): pp318-328.

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