

# Sato-umi in the Anthropocene

Report of a Forum  
Co-Sponsored By  
The Aquarium of the Pacific  
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## Forward

As a company committed to the environment, Honda supports efforts that address the most pressing environmental challenges. Inspired by the Japanese concept of *Sato-umi*—the convergence of land and sea where human and marine life can harmoniously coexist—Honda set out to address the impact of climate change on our oceans and intertidal areas.

In 2015, we began studying the oceanic and aquatic impacts of a rapidly changing climate, such as ocean acidification, rising sea levels, water pollution and overfishing. A group of Honda associates met with a number of marine science and management experts to determine the most meaningful ways Honda could contribute. Each meeting reinforced the magnitude of the problem but also sparked an optimism that cross-sector collaboration could facilitate successful ocean conservation and restoration.

From that optimism, the Honda Marine Science Foundation was established. We reflected on Dr. Schubel's words, "restore for the future," and kept *Sato-umi* at the forefront. While the foundation cannot restore our oceans and coastlines to their former existence, it can support research and programs that create a lasting impact for the future.

Steven Center  
Vice President, American Honda Motor Co., Inc,  
Connected and Environmental Business Development  
Chairman, Honda Marine Science Foundation





## This Forum is dedicated to the Memory of Margaret A. Davidson

This report is dedicated to the memory of the late Margaret A. Davidson. She was a leader in the coastal community for decades. She loved nothing better than a challenge and relished tackling wicked problems. She continually challenged conventional wisdom in the search for new strategies to deal with “the new normal.”

Someone once said that you can tell how smart a person is by the answers they give and how wise they are by the questions they ask. Margaret was wise. She asked rich, deep, penetrating questions. Whenever you saw her hand go up in a meeting, you wanted to seek cover, but there was never an escape. She was relentless in her pursuit of science in service to society.

Words such as vision, courage, passion, tirelessness, and irreverence all applied to Margaret. She was not one to settle for the norm. She was truly unconventional. She had a marvelous ability to connect the dots that most of us can only tackle a few at a time, and to weave and communicate a tapestry of possibility that inspired followers, and through working together, created lasting impact. She didn't just make a difference, she led the difference-making. And, she did it all with a smile and a wonderful sense of humor and perspective.

Margaret Adelia Davidson died in Charleston, on May 23, 2017. She earned her law degree from Louisiana State University. She later earned a master's degree in Marine Policy and Resource Economics from the University of Rhode Island. She served as a special counsel and Assistant Attorney General for Louisiana Department of Justice and later as the Executive Director of South Carolina Sea Grant Consortium. She joined NOAA in 1995, as the founding director, of NOAA's Coastal Service Center (CSC) where she created a customer-driven organization that accelerated the use of technology, tools, and skills required to make informed coastal decisions at all levels of government. She then served as acting director of the office of Ocean and Coastal Resources Management when that office and CSC merged to form the new office for Coastal Management. She was NOAA's senior leader for Coastal Inundation and Resilience. She served on numerous local, state and federal committees.. She was a Fulbright Fellow in Thailand, American Meteorological Society Fellow and a Zurich Fellow for climate adaptation. She was also awarded two presidential merit awards and was part of team for which Al Gore was awarded a Nobel Prize. She was a scholar in residence at Scripps Institution of Oceanography. She said that her greatest honor was the creation of the Margaret A Davidson stewardship award by The Coastal and Estuarine Research Foundation.



## Introduction

On November 13-14, 2017, the Aquarium of the Pacific and the Honda Marine Science Foundation convened and facilitated a forum on “Sato-umi in the Anthropocene.” The forum grew out of a concern that there was a lack of awareness of the changes that are happening to our coastlines now and that will accelerate over the next few decades. This lack of awareness by society is manifested in the failure of governments at all levels to move quickly enough to adapt to the changes to our coast that are imminent over the next decades. Well before the end of this century, the map of our coastlines will be redrawn by a rising sea. Towns, cities, residences, businesses and human and ‘natural’ infrastructure in many U.S. states and in other nations will be swallowed-up or rendered unusable by the sea. At this point some of this is unavoidable because of the large scales and long time frames involved with climate change, but action taken now could avoid even more dramatic dislocations and disruptions of society. No matter what we do, “the coast” will be in a different – and continually evolving – configuration in the future.

The Forum was designed to explore a number of approaches to “integrated” coastal management, in particular those that cross the land-sea boundary, some of which have been practiced for thousands of years, to see if lessons could be extracted to elevate awareness and stimulate action to reduce vulnerability in the “new normal” of rising sea level. Sato-umi is one of these approaches. It has been used in Japan for thousands of years and is deeply rooted in the Japanese culture. It is a philosophy and a concept that recognizes the intimate conceptual and practical connections between land and sea. Ahupua’a is a similar approach that was used in Hawaii for thousands of years, generally before European contact and control. It, too, is deeply rooted in culture and was used to guide coastal development there to protect living resources and to benefit society. Both Sato-umi and Ahupua’a focus on the land-sea connection.

The theme of the Forum was proposed by Mr. Takuji Yamada, former President of Honda North America, and brought together experts from Japan and throughout the U.S. to explore the applicability of the concepts and philosophies of Sato-umi, Ahupua’a, and more generally Integrated Coastal Management to assess the roles these concepts might play in achieving and sustaining a better balance between human uses and ecosystem integrity both throughout watersheds and in the contiguous water bodies in the Anthropocene.

Sato-umi, Ahupua’a and Integrated Coastal Management share a number of characteristics in common, but there are important differences. Sato-umi is a Japanese term for a mosaic of different coastal and ocean ecosystems (and the companion concept of Sato-yama, which governs the mountains) along with human settlements that are managed to produce a suite of ecosystem services for human well-being. Ahupua’a is a similar concept in Hawaii, which was based on integration from the top of watersheds to the open ocean. Integrated Coastal Management (ICM)

is the closest analog that the United States has to Sato-umi and Ahupua'a and is a relatively new concept worldwide. It is neither deeply rooted in culture nor in practice but its origin was memorialized in Rio de Janeiro at the UN Conference on Environment and Development (the so-called "Earth Summit") in 1992. Perhaps the closest examples we have of the application of ICM in the U.S. that are roughly comparable in scope to Sato-umi and Ahupua'a are to the estuaries and adjacent ocean waters that are part of the National Estuary Program (NEP), and its precursor, the Chesapeake Bay Program. The NEP recognizes the importance of managing human activities in watersheds and adjacent waters. The general success of many of these programs in the U.S. in achieving their goals has to a significant extent been conditioned by the size of the watershed, the number of different governmental units and levels involved—particularly the number of states, the relationship between the states and federal government, and involvement of local communities and constituencies—and the population and uses of the watershed.

In this report we present brief case studies of coastal systems where Sato-umi, Ahupua'a and Integrated Coastal Management have been applied successfully and search for the conditions and strategies that were essential to their success. We also identify examples of coastal systems ripe for application of the whole watershed management embodied by these three principles, as well as examples where these principles could have been implemented, but were not, resulting in environmental damage to coastal resources. We present a variety of tools developed by NOAA and others for use in Integrated Coastal Management, explore what has limited their application, and offer recommendations.



# The Anthropocene

Anthony Barnosky

We now live in the Anthropocene—a unique time in the history of our planet. It is the time defined by human influence that is every bit as powerful as the forces of nature, such as those that caused, some 11,700 years ago, our world to begin to transform from a glacial landscape into the fertile lands and favorable climates that fostered the rise of human civilization. Through our ever-more sophisticated technological prowess, we have dramatically altered the terrestrial surface of the planet by converting more than half of it to fit our needs, changed the chemistry of the atmosphere and oceans, and have altered the climate in ways that humans are beginning to feel: more intense storms, droughts, wildfires, and so on. These changes have become noticeable worldwide, especially since the middle of the 20<sup>th</sup> century when the number of people on the planet and their impacts accelerated their exponential growth. As a result, we humans have become part of a new geological process: the “rocks” taking form today contain unique, human-produced signatures every bit as distinctive as features in the deep-time rock record that allow geologists to distinguish the Age of Dinosaurs from the Age of Mammals, or the Pleistocene Ice Ages from warmer times before and after.

While it is becoming increasingly clear that the Anthropocene has begun, it is still in its early days. How this new epoch in Earth history will unfold is still an open question. It can be a time of great advancement of the human condition, where our species finds the right balance with the rest of nature and embraces the diversity that is the human condition. Or it can be a time of peril, where we inadvertently chip away at what nature has given us for survival, until it's gone. Sato-umi, Ahupua'a, and Integrated Coastal Management provide an approach that could help increase our chances of success for molding the Anthropocene coasts in productive ways, rather than settling for a less rich future with which we would be stuck by doing nothing.



## Case Studies

The case studies that follow present different biophysical, socioeconomic and socio-political situations of coastal environments in Japan, the U.S., and Mexico. In each case the coastal land- and seascapes have been altered by human presence and activity. In each case there has been a governance system which, to varying degrees and in varying ways, attempted to balance human use with environmental conservation. The type of biophysical environment; the characteristics of the socioeconomic use patterns; and the nature of the governance systems have all shaped the situations and outcomes displayed in each case.

At the beginning of the forum the question was posed: What does each of these policy and management systems imply for the future of the Southern California Bight coast and ocean area? This is a difficult question because of the high level of development and alteration of the coastal environment in Southern California and the extremely large number of uses and user group and the complex and extensive socio-political situation.

In the second portion of the forum participants decided that cases other than Sato-umi, Ahupua'a and Southern California (Upper Newport Bay; Tijuana Sloughs) would be useful, in the context of illustrating lessons learned and potentials. Thus the addition of the Chesapeake Bay, the Albemarle-Pamlico Estuary Program, and the San Francisquito Creek Watershed cases were added.



# **Sato-umi in Japan**

## **A Case Study in Akkeshi-ko Estuary and Akkeshi Bay**

Masahiro Nakaoka

Sato-umi, whose original meaning in Japanese is “Village (Sato) Sea (Umi)”, originated from the corresponding term for terrestrial ecosystems Sato-yama (Village Mountain). The term Sato-umi has been used in a wide array of definitions. In a narrow sense, it refers to a coastal area where biological productivity and biodiversity have increased through human interaction (Yanagi 2013a. b. Ministry of the Environment, Japan 2017a). In a broader sense, Sato-umi is used to indicate a traditional rural seascape which local human communities have been taken care of to maintain sustainable ecosystem services. Traditional local practices of Sato-umi for maintaining productive seas for fisheries have been known from various parts of Japan since the Edo Era (17<sup>th</sup> century). These include: managing oyster reefs near eelgrass beds where spat recruitment is high, and setting community-based no-take zones in kelp forests (Makino 2017), which are based on indigenous & local knowledge (Thaman et al. 2013).

However, as in rest of the world, coastal areas of Japan have been degraded by various types of human-induced threats and stresses, especially during the era of high economic growth after World War II (1950-1990). Conservation of existing natural habitats, as well as the restoration of damaged habitats in coastal seas have been ongoing since then through the cooperation of local communities and various types of stakeholders living inside/outside of coastal zones. The Sato-umi concept guides these restoration efforts. The Ministry of the Environment, Japan has promoted such activities by introducing good Sato-umi and Sato-yama practices (Ministry of the Environment, Japan 2017b). Some of the effective Sato-umi practices include: the oyster aquaculture in restored seagrass bed in Seto Inland Sea, environmentally-friendly ecotourism by fishers of a fishery village in central Honshu Island, a coral reef rehabilitation in Okinawa, and the forest regeneration by fishers in Hokkaido and other parts of Japan to enhance productivity of coastal resources through watershed management.

One such activity has been taking place in Akkeshi, a small town (population 9,600 as of December 2017) in eastern Hokkaido (Fig. 1). In the region the human population density is the lowest in Japan, and as a resort area, human impacts both terrestrial and marine are lower compared to other parts of Japan. However, most pristine forests were cut between the late 19<sup>th</sup> and the mid 20<sup>th</sup> centuries for the lumber and fuel. The large-scale development for farmland followed in the 1950's in eastern Hokkaido, and more than 50% of watersheds were converted from forests to farmlands for dairy cow farming.

The Akkeshi-ko estuary, located in the downstream portion of the Bekanbeushi watershed, has an area of 32 km<sup>2</sup>, mostly area with the bottom depth of most parts less than 1.7 m in depth (Momota and Nakaoka 2017). Seventy percent of the estuary is subtidal bottom, with some intertidal flats near the mouth of the estuary (Akkeshi Bay). Before deforestation, natural reefs of Pacific oyster had developed in the intertidal flats and had been harvested by local fishers for more than 200 years. In the 1930s, they started scattering oyster spat on the reef to maintain the yield, marking the start of aquaculture. However, the area of oyster reefs continued to decrease throughout the 20<sup>th</sup> century and totally disappeared by the early 1980s (Akkeshi Town 2009).

Tetsuo Inukai, a professor of Hokkaido Imperial University, pointed out in the 1930's that overexploitation and water temperature decrease attributed to logging, which inhibited reproduction were the major causes of oyster decline (Inukai and Nishio 1937). Since then, the development of farmlands in the upper watershed worsened the situation by degrading water quality. Old fishers in Akkeshi reported that they had observed more turbid rivers after heavy rains during the period when the oyster population crashed in the mid 1980's (Akkeshi Town 2009). The relationship between land use change (forest to farmland) and river water quality was analyzed and confirmed by scientists in Hokkaido University. It was shown that riverine nutrient concentration were much higher in a watershed with more cover of farmland than one with greater forest cover (Mukai et al. 2002).

To prevent further decline of oysters and other marine resources because of water quality deterioration, a forest regeneration activity started in the Akkeshi watershed by fishers and oyster farmers in 1991. The activity was started by volunteer fishers, but soon was supported by more members of the fisher's union and later by the town of Akkeshi as a municipal project, with more than 600 people (not only fishers but also of various types of town residents) participating annually to plant trees in abandoned agricultural fields. Due to these and other actions for environmental protection, such as developments of sewage treatment facilities in town and on farms, water quality remained relatively stable in the Akkeshi-ko estuary. One indication of this was the stable occurrence of the eelgrass beds that provide multiple ecosystem services beneficial to human well-being (Nakaoka et al. 2014).

After the disappearance of intertidal oyster reefs in the late 1980s, oyster farming was shifted aquaculture by suspending oysters in the subtidal waters of the estuary on ropes and in cages. This new method has been successful and the oyster yield increased up to the late 1990's, and has remained stable. With a reputation for good quality and taste, the Akkeshi oyster has become a branded product that can sell at a better price compared to oysters from other regions of Japan.

Compared to other rural coastal regions of Japan, fisheries and aquaculture in Akkeshi still remain quite productive. However, most fishers and aquaculture farmers are anxious about uncertainty in the future, as represented by recent changes in climate, such as increasing temperature and more frequent storms that can affect the status of

aquatic ecosystems (Sweke et al. 2016). In fact, long-term monitoring of water temperature by Akkeshi Marine Station, Hokkaido University has revealed that it has increased about 2°C over the last 50 years. Another big concern for the future by residents of Akkeshi Town is the decline of the human population, a concern that is true not only for this region, but for nearly every rural area in Japan. The latest statistics showed that the population decreased by 14 % over the decade (2000-2010).

To solve these problems that can be serious in future, interdisciplinary and transdisciplinary research is needed to study the structure and changes in Japan's social-ecological system (Nakaoka et al. 2018). One of such integrated studies was initiated in 2017 to evaluate how changes in the terrestrial and coastal ecosystem will occur under different future scenarios of climate and socioeconomic changes in the Akkeshi watershed (PANCES 2017). The results will be used to help the local community make wise decision to keep both sustainable fisheries/aquaculture and healthy natural systems-- forest, wetland, eelgrass beds and pristine rocky shores-- both of which are attractors for tourism which has been increasing in the area.

## References

Akkeshi Town (2009) Akkeshi: from everlasting forest to eternal sea. Challenge to sustainable development. Akkeshi Town, 143pp (in Japanese)

Inukai T. & Nishio S. 1937. A limnological study of akkeshi lake with special reference to the propagation of the oyster. Journal of the Faculty of Agriculture, Hokkaido Imperial University, 40: 1-33.

Makino M (2017) Marine protected area and sustainable fisheries in Japan. Suisan Shiko, No. 591. 75pp (in Japanese).

Ministry of the Environment, Japan 2017a. Sato-umi Net website.  
[https://www.env.go.jp/water/heisa/Sato-umi/en/index\\_e.html](https://www.env.go.jp/water/heisa/Sato-umi/en/index_e.html).

Ministry of the Environment, Japan 2017b. Linking and supporting forest, village, river and sea. <http://www.env.go.jp/nature/morisatokawaumi/>

Momota, K. and Nakaoka, M. (2017) Influence of different types of sessile epibionts on the community structure of mobile invertebrates in an eelgrass bed. PeerJ 5: e2952; DOI: 10.7717/peerj.2952

Mukai H, Iizumi H, Kishi M (2002) Material input from terrestrial areas under regular and irregular conditions in Akkeshi watershed: a case study linking forest and sea. Gekkan Kaiyo 34: 449-457

Nakaoka, M., Lee, K-S., Huang, X., Almonte, T., Sidik Bujang, J., Kiswara, W., Ambo Rappe, R., Maryam Yaakub, S., Prabhakaran, M.P., Abu Hena M.K., Hori, M., Zhang, P., Prathep, A. and Fortes, M. D. (2014) Regional comparison of the ecosystem services from seagrass beds in Asia. In: (S. Nakano et al. eds.) Asia-Pacific Biodiversity

Observation Network: Integrative Observations and Assessments. Ecological Research Monographs, Springer, pp. 367-391

Nakaoka, M., Sudo, K., Namba, M., Shibata, H., Nakamura, F., Ishikawa, S., Makino, M., Yamano, H., Matsuzaki, S.S., Yamakita, T., Yu, X., Hou, X., Li, X., Brodie, J., Kanemoto, K., Moran, D. and Verones, F. (2018) TSUNAGARI: A new interdisciplinary and transdisciplinary study toward conservation and sustainable use of biodiversity and ecosystem services. Ecological Research, in press. DOI: 10.1007/s11284-017-1534-4

PANCES (2017) Predicting and assessing natural capital and ecosystem services. [http://pances.net/top\\_eng/](http://pances.net/top_eng/)

Sweke EA, Kobayashi Y, Makino M, Sakurai Y (2016) Comparative job satisfaction of fishers in northeast Hokkaido, Japan for coastal fisheries management and aquaculture development. *Ocean & Coastal Management* 120: 170-179

Thaman, R., Lyver, P., Mpande, R., Perez, E., Cariño, J. and Takeuchi, K. (eds.) 2013. The Contribution of Indigenous and Local Knowledge Systems to IPBES: Building Synergies with Science. IPBES Expert Meeting Report, UNESCO/UNU. Paris, UNESCO. 49 pp.

Yanagi T (2013a) Japanese Commons in the Coastal Seas: How the Satoumi Concept Harmonizes Human Activity in Coastal Seas with High Productivity and Diversity. Springer Japan. Tokyo. 113 pp.

Yanagi T (2013) Proposal of Sato-umi concept: its past, its future. *Nippon Suisan Gakkaishi* 79: 1025-1026 (in Japanese).

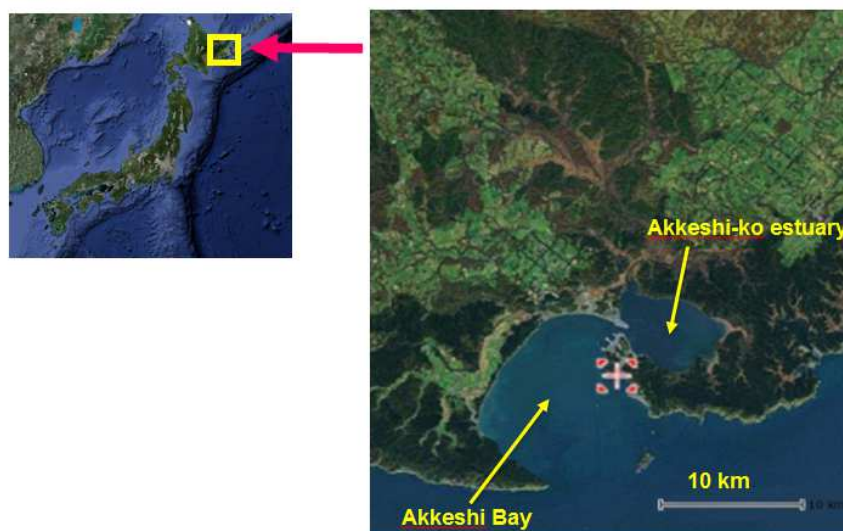


Figure 1. Location of Akkeshi, eastern Hokkaido.



# Ahupua'a

Avis Poai

## Philosophy

Native Hawaiians had no word for sustainability. Instead that concept is embedded in our very being. Indeed, the ahupua'a system exemplifies the deep interrelated connection between the health of the mountains, the ocean, and the community (Figure 1). The Kumulipo, a genealogy chant honoring the birth of a chief, begins with the birth of the sea and the recounting of coral as being the first stone in the foundation of the earth. Later, the Kumulipo describes the origin of the first chief, Hāloa, the progenitor of the Hawaiian people, who was said to be the younger brother of Hāloalaukapalili, a kalo plant. Thus the Kumulipo links the Hawaiian 'ohana, or family, to all of creation.

Ancient Hawaiians believed that 'āina, or land, is not 'āina without people—in other words, you cannot separate the people from the land. In modern times, when the land is described as “environment,” there is an assumption of separateness. An indigenous world view sees no separation. We are nature, that is our family.

While there are numerous definitions for ahupua'a, a culturally grounded description of an ahupua'a may be summarized as a “culturally appropriate, ecologically aligned, and place-specific unit with access to diverse resources.” It carefully considers the division of resources such that it makes the best use of an ecosystem that is aligned to the social system and structures of a particular location. The underlying philosophy of an ahupua'a reflects a system that allows humans and the natural world to thrive together.

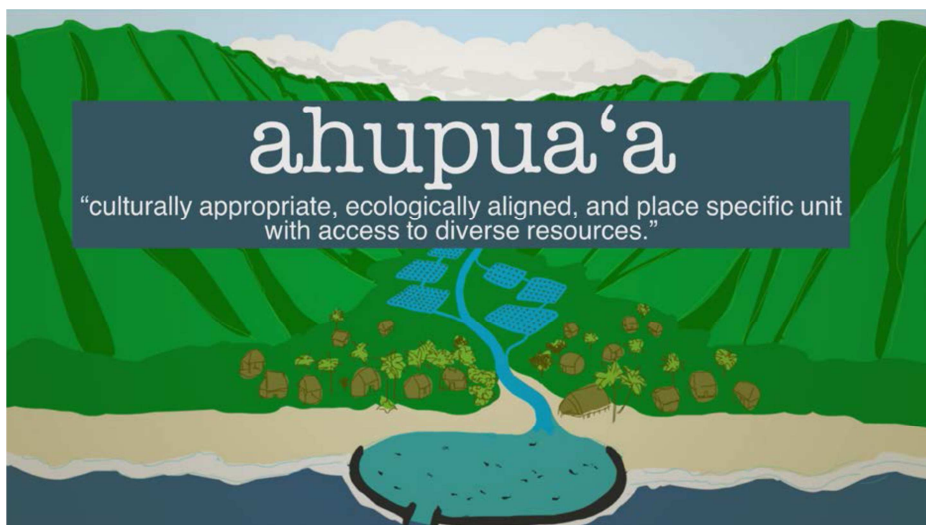


Figure 1 – Definition of ahupua'a (Gonschor & Beamer, 2014)

## Principles of Ahupua‘a

### Understanding the place-based Ahupua‘a

Principles of ahupua‘a management enabled Hawaiians to sustain large and healthy populations that some scholars have estimated as being as high as one million. In ancient times, our archipelago was known as ‘āina momona, the fat land, because we produced food in surplus and designed the landscape to harvest water passively and provide nutrient flows from mountain to sea that fed estuarine environments.

There were a total 1,825 ahupua‘a in ancient Hawai‘i. Some ran from land to sea, some from sea to sea, some were completely landlocked, and some were pockets of land split into different pieces. Some ahupua‘a were narrow, some were quite broad. Some were tiny (1.93 acres), and others were as large as one hundred thousand acres. Importantly, the ahupua‘a system was continuous. The ocean was an extension of the land, and the land was an extension of the sea. As an extension of the ‘āina, the ocean was not a barrier between islands; rather, it was a pathway connecting islands to one another. Fisheries were attached to ahupua‘a and were cared for as if they were extensions of the gardens that filled the coastal plains, stream-lined valleys, and forest clearings in the uplands.

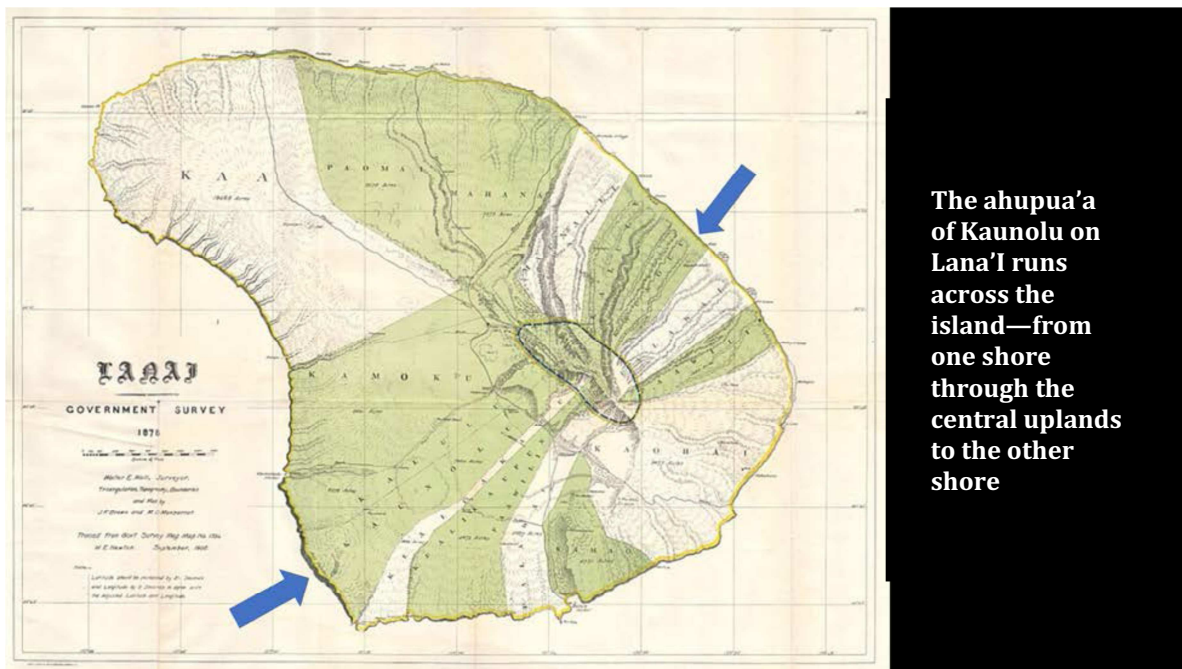


Figure 2: Map Credit, Hawai‘i State Archives

Regardless of its shape or size, each ahupua‘a was defined and managed to create maximum abundance. There was no “set design,” no “one-size-fits-all” mentality. Many believe that ahupua‘a are usually stream drainages bounded by watersheds—in other

words, they think of an ahupua‘a as a pie-shaped wedge, synonymous with valleys. But this is a fallacy, only 5.4% of Hawai‘i’s ahupua‘a can be regarded as watersheds. This is an important distinction to make because if one narrowly construes this description of an ahupua‘a, it devalues the broad based principles upon which it was founded and minimizes its current relevancy in ecosystem management.

For the purposes of this paper, I focus on the so-called “regular” ahupua‘a, or division of land that ran from the mountain down to the sea. Within a typical ahupua‘a, various bio-cultural zones existed, including, for example: Wao Akua, Wao Kele, Wao Nahele, Wao Lā‘au, and Wao Kānaka. Understanding how each of these zones worked elucidates how ancient Hawaiians managed their resources using a holistic approach. For example, Wao Akua, the place of the gods, was comprised of the “cloud forest, core watershed, native plant community.” This was an area that was traditionally kapu, or forbidden, thus preserving and protecting the source of water. Water would flow through Wao Akua and enter Wao Kānaka, or the realm of man. This area sustained agriculture, aquaculture, and other human activities. From Wao Kānaka, the water would flow out to the sea, and perhaps flow into a loko i‘a (fishpond). Within the ahupua‘a, nearly all of the resources Native Hawaiians required were provided, including:

*A fishery residence at the warm seaside, together with the products of the high lands, such as fuel, canoe timber, mountain birds, and the right-of-way to the same, and all the varied products of the intermediate land as might be suitable to the soil and climate of the different altitudes from sea soil to mountainside or top.*

In sum, because ancient Native Hawaiians lived lives that were deeply attuned to the natural environment, they drew upon their intricate knowledge to manage widely varying landscapes and ecosystems. Within each ahupua‘a, freshwater resources and wild and cultivated plants were carefully managed to provide for all of the needs of the people. Despite the complexity of this system, the underlying principle never changed—maximizing the abundance of each place.

## **Ancient Governance: The Proper Management Of Resources**

According to ancient traditions, the system of ahupua‘a divisions was created by rulers who centralized governance over their respective islands. The larger moku, or islands of Kaua‘i, O‘ahu, Maui, and Hawai‘i were divided into moku, or districts. Each district was further divided into smaller communities known as ahupua‘a. The term ahupua‘a reflects a deference to this centralized system of governance. At the boundary of a land section, the head of a *pua‘a* (pig) was placed upon an *ahu* (stone altar). At an annual ceremony, tribute for the island’s ruler and gifts to make the land productive would be deposited at this altar.

The ahupua‘a were administered by konohiki, or resource managers appointed by the ruler of large districts or entire islands. Konohiki possessed special expertise in natural resources management and their work involved overseeing agricultural activities, allocating water fairly among the people, monitoring fishery health, and enforcing all kapu. Kapu were “strictures and regulations governing human behavior in a manner that preserved resource abundance and allowed for continued renewal.” As an example, water use was regulated through k n wai, or a complex set of laws. The konohiki managed water by providing time slots among mahi‘ai (farmers), for opening and closing ‘auwai (man-made irrigation ditches), leading from the main stream to a vast network of lo‘i kalo, or plots of taro.

Kapu were similarly integrated into fisheries management and conservation. Konohiki were responsible for overseeing the fishing activities within each ahupua‘a. For example, konohiki enacted species-specific kapu which corresponded to specific spawning periods. They also ordered the people to alternate fishing spots to prevent depletion and encourage replenishment of stocks. Konohiki strictly enforced these k n wai and exacted capital punishment on transgressors.

While this system sounds draconian, one must also recognize that the Hawaiian worldview incorporated a trust relationship between ali‘i (chiefs) and the maka‘ inana (common people). Collectively, they shared a responsibility to care for the land and ocean that reflected the cosmological and genealogical relationships among the Hawaiian people, the gods, and the rest of the natural realm. In short, a trust relationship existed between the ali‘i nui and maka‘ inana that provided a foundation for reciprocity, peace, and prosperity. These understandings of reciprocal care and responsibility engendered a type of “checks and balances” between ali‘i and maka‘ inana. Further, if the ali‘i mistreated maka‘ inana or dishonored the trust relationship between them, the maka‘ inana were free to leave and find a more favorable place to live. This freedom of movement provided an incentive for the ali‘i to treat their people well, as the ‘ ina was made abundant by the people’s hands.

## **Core Tenets of an Ahupua‘a**

According to Kumu John Ka‘imikaua, the following eight principles of an ahupua‘a represent an ‘aha cord that has been tightly bound—alone each strand is weak, but together they form a strong rope:

1. Kai moana: preserve all life in the ocean extending from the shoreline to the horizon
2. Makai: respect the land and resources extending from the shoreline to the sand’s reach
3. Mauka: respect all land and resources from the sand’s edge to the highest mountain peak
4. Kamolewai: respect all water resources, including rivers, streams, and springs and life within
5. Kanakahonua: preserve and respect the laws of the land and each other to ensure the community’s health, safety, and welfare

6. Kalewalani: respect the elements that float in the sky, including the sun, moon, clouds, stars, wind, and rain, which the guide the planting and fishing seasons, provide water, and create the tides and directions for ocean navigation
7. Kapahelolona: preserve the knowledge of practitioners
8. Ke'ihl: preserve and respect the sacred elements, including deities, ancestors, the forces of nature, and ceremonial activities.

### A Case Study: He'Eia

To better understand how these ancient principles have been integrated into a contemporary framework, I examine the ahupua'a of He'eia, located in the district of Ko'olaupoko, on the island of O'ahu. On January 19, 2017, the National Oceanic and Atmospheric Administration (NOAA) announced the establishment of the He'eia National Estuarine Research Reserve, the 29th in the national system, and the only reserve located in the state of Hawai'i.



Figure 3: Photo Credits, Manuel Mejia

### **A Collaborative Framework And Community-Driven Plan**

The *He'eia Management Plan 2016-2021* states that the plan “presents an opportunity to honor the past by using the traditional ecosystem management approach embodied in ahupua'a principles, integrated with the contemporary principles of the National Estuarine Research Reserve System (NERRS, or Reserve System), to sustainably manage the He'eia estuary. According to the plan, “NERRS’ vision of resilient estuaries and coastal watersheds where human and natural communities thrive is consistent with the traditional ahupua'a where man and the environment lived in harmony: the circle of life.” The unique aspect of this system is the integration of traditional knowledges and practices with contemporary strategies to sustainably manage the estuary and the ahupua'a of He'eia.

## National Estuarine Research Reserve's Vision and Goals

The Reserve System is a partnership program between NOAA and various coastal states. NOAA is responsible for providing funding, national guidance, and technical assistance. The state partner is responsible for managing resources on a daily basis, and working collaboratively with local and community partners. According to federal regulations, the Reserve System details five specific goals:

1. Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve System resources;
2. Address coastal management issues identified as significant through coordinated estuarine research within the system;
3. Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
4. Promote federal, state, public, and private use of one or more reserves within the system when such entities conduct estuarine research; and
5. Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

## He'eia NERR Vision and Mission

**Vision--Ho'ōla:** The biological and cultural integrity of the ahupua'a of He'eia is restored to create an 'āina momona (abundant) legacy for future generations. The ahupua'a of He'eia is a global example of thriving and resilient socioecological communities.

The vision is “a **place-based**, He'eia-specific version of the national system's vision: 'Resilient estuaries and coastal watersheds where humans and natural communities thrive.'”

**Mission--Kuleana:** To practice and promote responsible stewardship and outreach consistent through the principles and values of the ahupua'a land management system. Our efforts will be supported by traditional knowledge, innovative research, education, and training that nourishes healthy and resilient ecosystems, economies, and communities.

The mission is “a **place-based** version of the national system's mission: 'To practice and promote stewardship of coasts and estuaries through innovative research, education, and training using a place-based system of protected areas.'”

## Biophysical Environment

The ahupua'a of He'eia is located on the northeastern shore of the island of O'ahu. It is an irregularly shaped ahupua'a because its eastern boundaries stretch into the neighboring watershed (See Figure 4). Historically, the ahupua'a of He'eia “was managed as a traditional ahupua'a which nurtured the Native Hawaiian community in abundance while also maintaining a healthy watershed and ecosystem.”

The He'eia NERR is located within the He'eia ahupua'a (See Figure 5). It covers

approximately 1,385 acres, includes He'eia State Park to the north, He'eia Fishpond in the center, wetlands to the west and south, the University of Hawai'i's Hawai'i Institute of Marine Biology property on Moku o Lo'e (Coconut Island), and a large expanse of marine waters with patch and fringing reefs. The types of habitats located within the He'eia NERR include both aquatic and terrestrial areas: coral reefs and open marine waters, the enclosed He'eia Fishpond, mangrove stands, landscaped areas on Moku o Lo'e and at He'eia State Park, taro patches and gardens, overgrown wetland marshes, seasonally wet grasslands, and He'eia Stream. Thus, the habitats in the He'eia NERR can be broadly categorized as uplands, wetlands, freshwater stream, estuarine and coastal, and marine (See Figure 6).

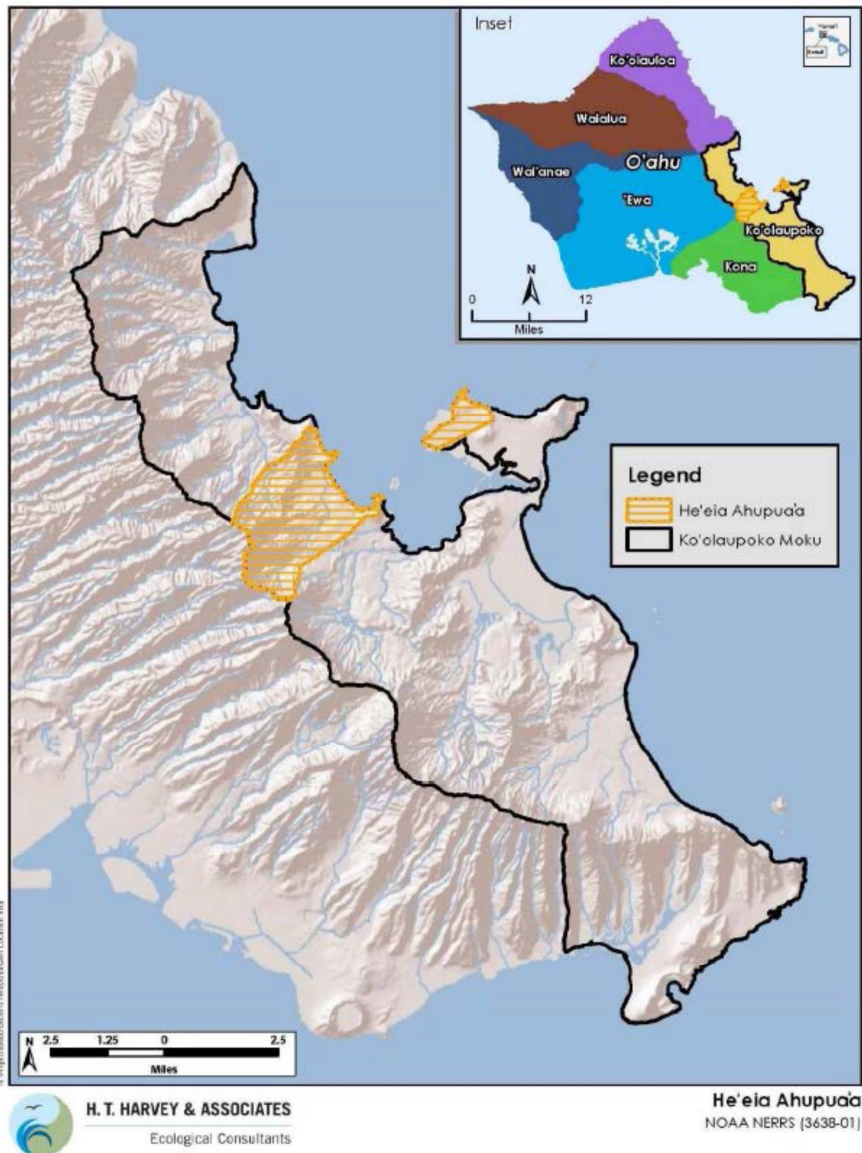


Figure 4: Map from *He'eia Management Plan 2016-2021* showing location of He'eia ahupua'a within the Ko'olaupoko moku.

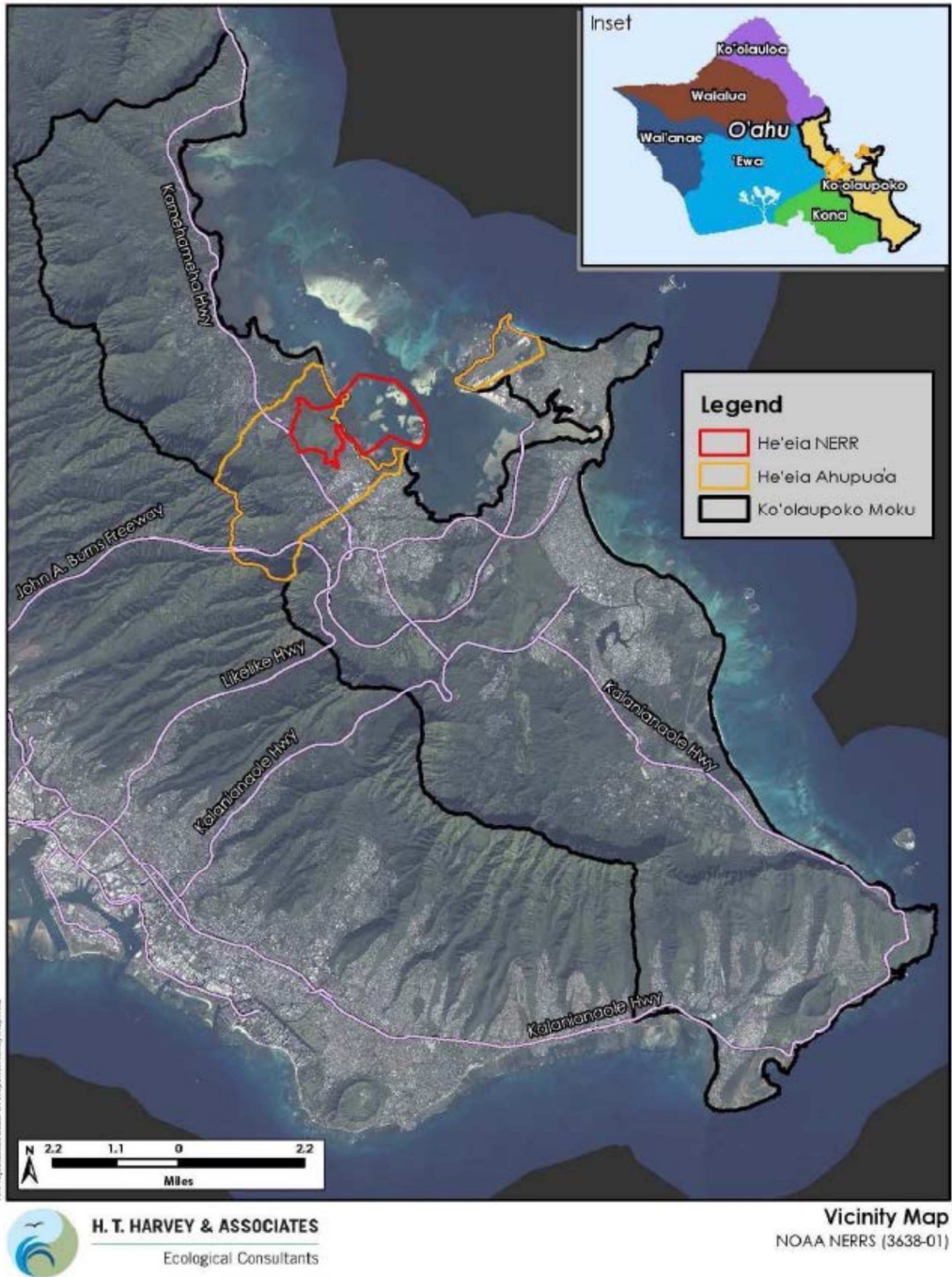


Figure 5: Map from *He'eia Management Plan 2016-2021* showing location of He'eia NERR within the He'eia ahupua'a, and larger Ko'olaupoko moku.





Figure 6: Map from He'eia Management Plan 2016-2021 showing location of various types of habitats located within the He'eia NERR.

## Uplands

The upland areas in the He'eia NERR are comprised of developed and undeveloped areas. A total of approximately 271 acres are undeveloped or natural upland areas in the Reserve. The vegetation within the upland areas is dominated by various invasive plant species. Few native plant species are found within the upland areas of the He'eia NERR. With the exception of the endangered *Achyranthus* (cultivated in a suburban neighborhood near the fishpond), no rare, threatened, or endangered plants are known to exist within these areas. Fauna found in the Reserve include common birds and mammals typically found in beachsides, gardens, parklands, and agricultural areas on O'ahu. No threatened or endangered forest birds are known to exist today. It is believed that the Hawaiian hoary bat may exist within the He'eia NERR.

## Wetlands

The wetlands in the Reserve are fed by Ha'ikū Stream and Ioleka'a Stream, which converge upstream of the wetlands to form He'eia stream. There are five types of wetlands within the Reserve: (1) estuarine and marine deepwater, (2) estuarine and marine wetland, (3) freshwater emergent wetland, (4) freshwater forested/shrub wetland, and (5) freshwater pond. Importantly, throughout its course, the He'eia Stream's flow and water quality is impeded by California grass and other invasive species.

The freshwater and emergent wetland in the he'eia nerr is comprised largely of the he'eia stream, marsh, and seasonally wet grasslands. The marsh habitat, which is overgrown with california grass, is known to occasionally provide a habitat for four endangered waterbirds. The dense overgrowth of California grass is thought to have a significant negative impact on native water bird habitat.

### **Watershed and freshwater stream**

The He'eia watershed totals 3.5 square miles, or 2,240 acres and extends beyond the boundaries of the He'eia NERR, up the Ha'ikū and He'eia valleys, to the peak of the Ko'olau Mountains. Ha'ikū and 'Ioleka'a streams merge to form He'eia stream, which runs through the He'eia NERR. The watershed contains lands that are zoned for urban, agricultural, and conservation uses. The He'eia NERR is unique because the watershed and ahupua'a are close in proximity and easily accessible to the community and researchers—the total length of the He'eia stream from the the upper reaches of the watershed to the end of the stream mouth in Kāne'ohe bay is 7.1 miles long.

He'eia stream is described as a “small perennial stream containing moderate aquatic resources.” It is noted to contain moderately important biological resources that include diverse native and introduced macro-fauna. The stream goby, as well as seven other native aquatic fish species and five introduced species are found in He'eia stream. The lower part of He'eia stream contains a total of six fish species (two endemic, one indigenous, and three introduced). Fifteen fish species and the endangered blackline Hawaiian damselfly occur in the lower and middle sections of the stream.

### **Estuarine and Coastal, and the He'eia Fishpond**

He'eia is well known today for its 600-year-old loko i'a, or fishpond. This 88-acre pond, located at the center of the He'eia NERR, is surrounded by a kuapā, or rock wall, measuring 1.3 miles long. It was constructed by the residents of the He'eia ahupua'a by passing coral and basalt hand to hand until it reached 5 feet high and 12 to 15 feet wide. At its peak, the pond fed thousands of people in the area—it is estimated that it produced 300 pounds of fish per acre, or 26,400 pounds of fish every year.

The waters of the pond receive freshwater from He'eia Stream, which drains the He'eia watershed and flows into the northwestern corner of the fishpond. The fishpond is thus comprised of brackish waters as the freshwater mixes with the tidal flux of seawater from the adjacent Kāne'ohe Bay. The fishpond is currently managed by Paepae o He'eia and it promotes aquaculture using traditional cultural practices.

The upper intertidal areas of the He'eia NERR, including the seaward portion of the He'eia fishpond and lower reaches of He'eia stream, are dominated by mangroves and estuarine mudflats. The expansion of these mangroves are said to have reduced the area of marshland habitat once used by native waterbirds, and has reduced the estuarine environment and altered water flow patterns with respect to both the stream channel locations and the extent of tidal incursions.



Figure 7: Wall restoration project at He'eia. Photo Credits: Paepae o He'eia

## **Marine**

There are three distinct physiographic zones that define the marine environment of Kāne'ōhe bay: inshore, inner bay, and outer bay. The inshore area is fronted by a shallow fringing reef. Seaward of this fringing reef and the intertidal zone lies the inner bay and lagoon which include patch reefs containing rich coral colonization, algal communities, and sand and sea grass beds. The inner bay waters support abundant planktonic organisms and a diverse group of reef-associated and pelagic fish species. The outer bay is fronted by a barrier reef complex. Kāne'ōhe Bay is considered an outstanding world-class scientific and field research setting because of the complex patch reef structure, fringing reef, well-flushed lagoon, and diversity of habitats and organisms present.

## **Socio-Economic Attributes**

In present day times, He'eia is commonly viewed as being located within Kāne'ōhe, which is situated in the Ko'olaupoko region. After World War II, the Ko'olaupoko region was transformed into a more suburban community when tunnels were created through the Ko'olau mountains connecting Kāne'ōhe with Honolulu. Residential construction increased during the 1960s and peaked in the 1970s.

Kāne'ōhe has a population total of 52,509. It has a median age of 41.5 years old, which is slightly older than the state's median age of 38.3 years. Over 70% of the population in Kāne'ōhe was born in Hawai'i—a number that far exceeds the state total of 54.5%. The ethnic mix of the population in Kāne'ōhe reflects the ethnic mix of the state as a whole. In terms of household characteristics, renters form a smaller share of the population in Kāne'ōhe than in the State . . . " however, the proportion of renters with high housing costs was higher in Kāne'ōhe than elsewhere." The share of people with low incomes is smaller in Kāne'ōhe in comparison to the state of Hawai'i—however, the area "houses a proportionate number of low-income and minority residents."

Major job centers located within the Ko‘olaupoko region include the Marine Corps Base Hawai‘i Kāne‘ohe Bay, Castle Medical Center, and several shopping centers. Approximately 5.8% of Kāne‘ohe residents are unemployed, and 7.4% are living below the poverty line. The average median household income in Kāne‘ohe is \$85,608.

In terms of the socioeconomic attributes of the He‘eia NERR, there were approximately 869 residents in 2010, representing 1.6% of the Kāne‘ohe population at the time. There are scattered residential properties among densely vegetated areas. Most residents have been living in the area for generations. He‘eia Elementary School describes its community as follows:

“We draw from an area where the sense of family and community is strong. Grandchildren and children of former He‘eia students attend the school. Alumnae have returned to work at the school. Most staff lives in Kāne‘ohe or on the Windward side. Our facilities are heavily used by youth sports and community organizations.”

The school reports its student population as 45% Native Hawaiian, 16% Caucasian, and 12% Japanese.

Within the He‘eia NERR, the largest employer is the Hawaii Institute of Marine Biology which employs approximately 40 people. Nonprofits in the area employ a small workforce, with less than 10 staff and volunteers each.

## **Community, State, And Federal Governance Issues**

### **1. Land Ownership and the Organizational Framework**

Each of the NERRs in the national system works and operates as a state and federal partnership. The federal government, represented by NOAA, provides funding, national guidance, and technical assistance. The State of Hawai‘i, through the University of Hawai‘i Institute of Marine Biology, manages the operation of the He‘eia NERR. The landowners in the He‘eia NERR have various roles in the implementation of goals, objectives, and strategies developed in the Final Management Plan. For this reason, detailing land ownership and the division of responsibilities within the He‘eia NERR is critical for purposes of understanding community, state, and federal governance issues.

The He‘eia NERR is comprised of a mix of public and private lands (See Figure 8 and Figure 9).

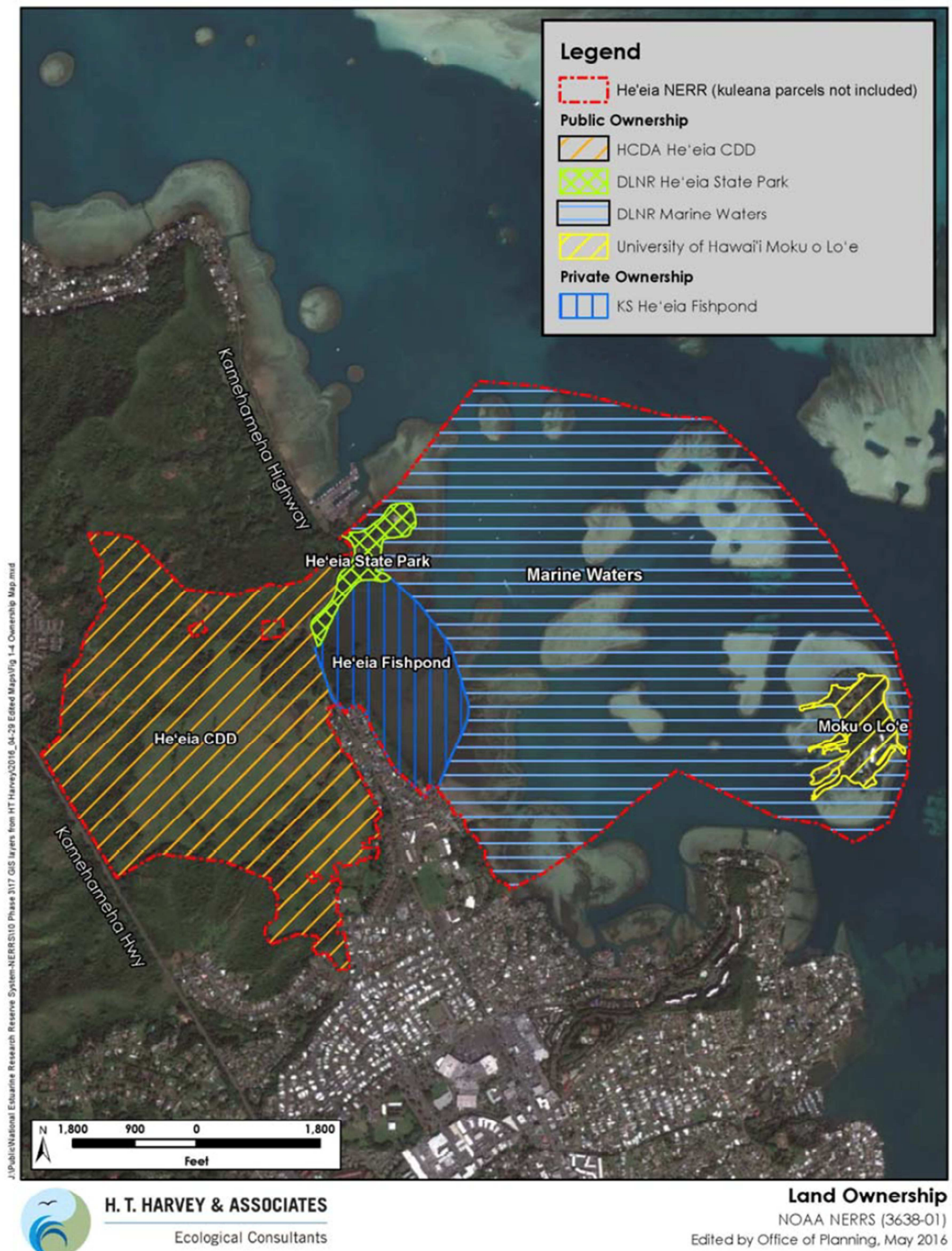


Figure 8: Map from *He'eia Management Plan 2014-2021* showing location of public and privately owned lands with the He'eia NERR

Property Name or Land Type	Landowner	Managing Entity	Approximate Area (acres)
<b>He‘eia State Park</b>	DLNR	State Parks Division Kama‘āina Kids (lessee)	19
<b>Marine waters</b>	DLNR	Division of Aquatic Resources or Land Division	822
<b>Moku o Lo‘e</b>	University of Hawai‘i Foundation	Hawai‘i Institute of Marine Biology	28
<b>He‘eia Community Development District</b>	HCDA	Kāko‘o ‘Ōiwi (lessee)	419
<b>He‘eia Fishpond – PRIVATE</b>	Kamehameha Schools	Paepae o He‘eia (lessee)	97
<b>Total Acres</b>			1,385

Figure 9: Chart, slightly modified, from He‘eia Management Plan 2016-2021 showing landownership, the managing entity, and the approximate acreage within the He‘eia NERR.

The Hawai‘i Department of Land and Natural Resources owns He‘eia State Park, coastal parts of Moku o Lo‘e, and the marine waters including the Marine Laboratory Refuge wildlife sanctuary that surrounds Moku o Lo‘e. The University of Hawaii Foundation owns the central part of Moku o Lo‘e. The State agency, Hawai‘i Community Development Authority, owns the wetland and upland areas identified as the He‘eia Community Development District. This area is leased and managed by Kāko‘o ‘Ōiwi, a non-profit organization working to restore the He‘eia wetlands under a 38-year lease. He‘eia fishpond is privately owned by Kamehameha Schools and is managed by lessee Paepae o He‘eia. Paepae o He‘eia is a non-profit organization engaged in restoring and maintaining the He‘eia fishpond. Each of these organizations are active within the He‘eia NERR, engage with the wider community, and work toward restoring the He‘eia ecosystem. How the various partners interact with HIMB and with each other is laid out in a Multi-Party Governance Charter See Figure 10 (Charter Participants).

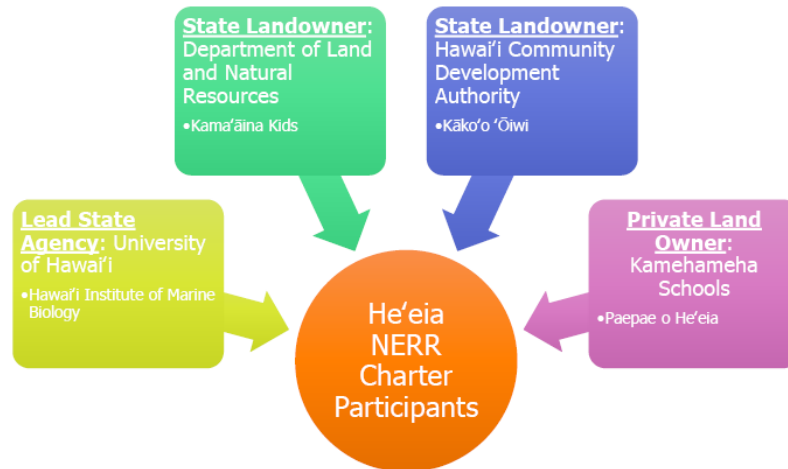


Figure 10: He‘eia NERR Charter Participants

Another important governance aspect that bears mentioning is the Reserve Advisory Board (RAB). All policies, activities, and programs of the He'eia NERR are required to be developed and implemented with input from the RAB. Additionally, the creation of committees and subcommittees were approved, as necessary, "to gather technical information or community input to implement the management plan." The organization and members of the RAB and the various committees and subcommittees are depicted in Figure 11.

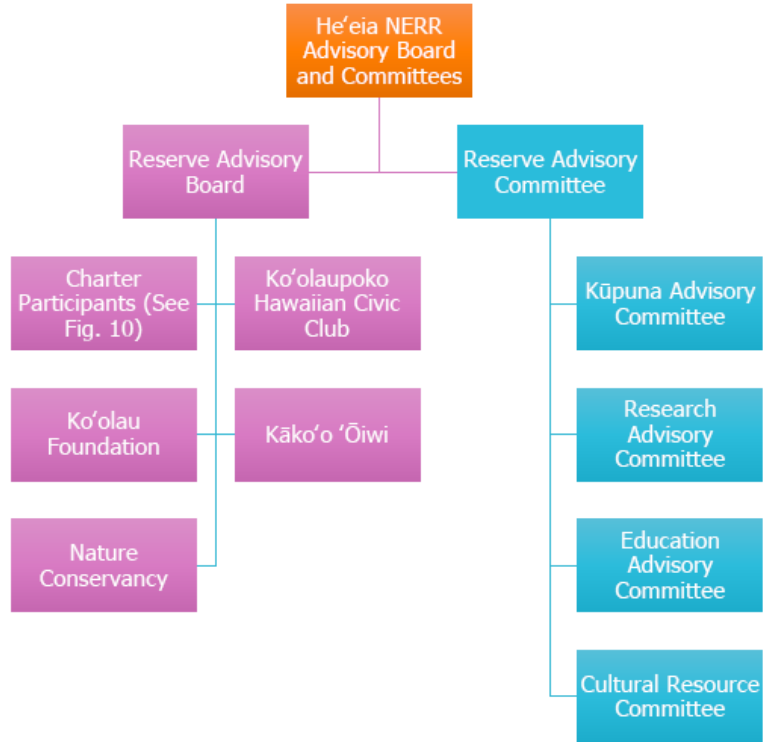
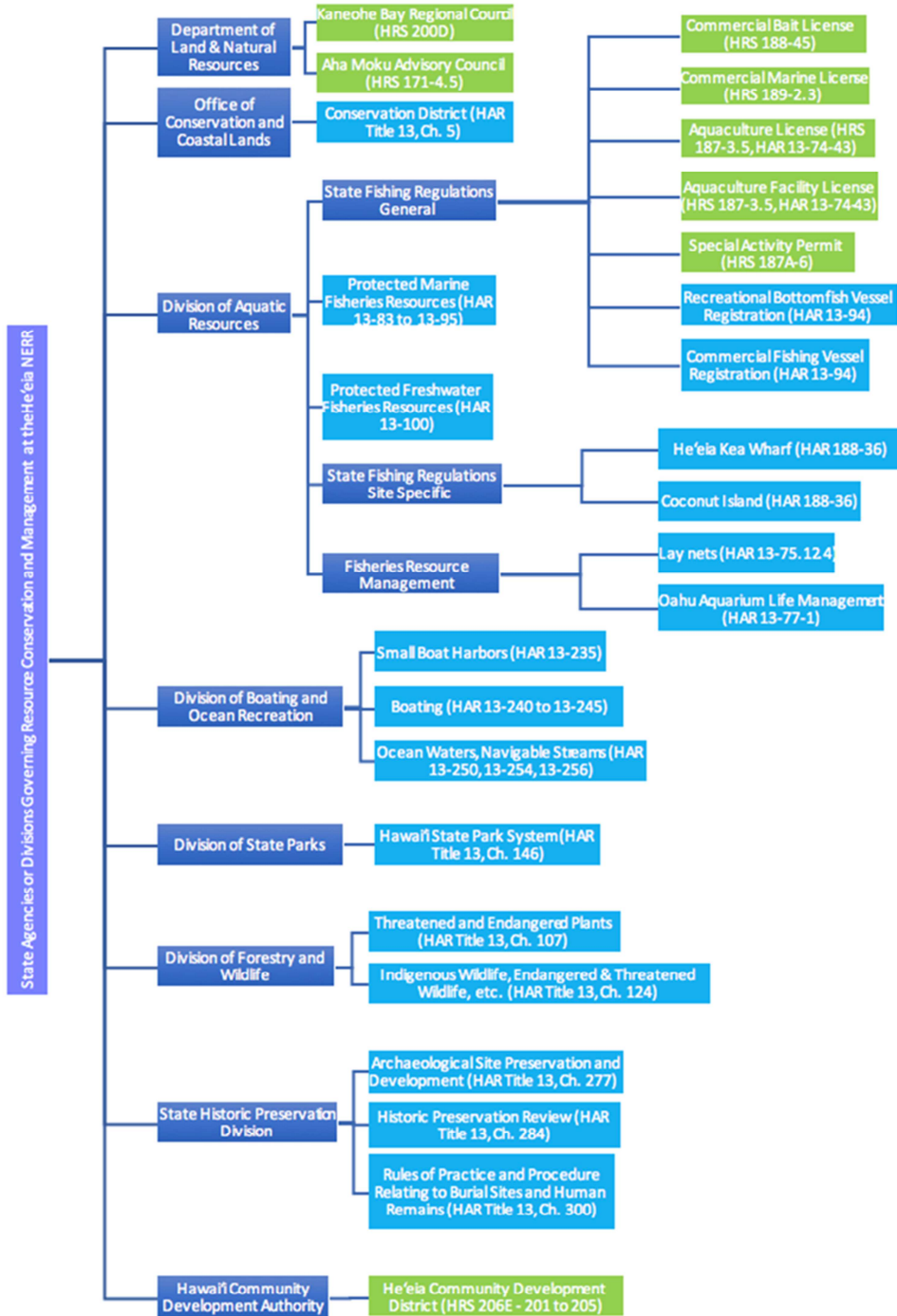


Figure 11: Advisory Board and Committee for He'eia NERR

## 2. Relevant Law

As noted above, the He'eia NERR contains a mix of private and state lands. Therefore, responsibility for land management actions, including use, manipulation and restoration activities, remains under the purview of the governmental agency and/or private landowner that has statutory authority. For purposes of providing a more approachable understanding of this unique governance system, I have created two charts that link to all relevant laws that impact the He'eia NERR ( See Figures 12 and 13).

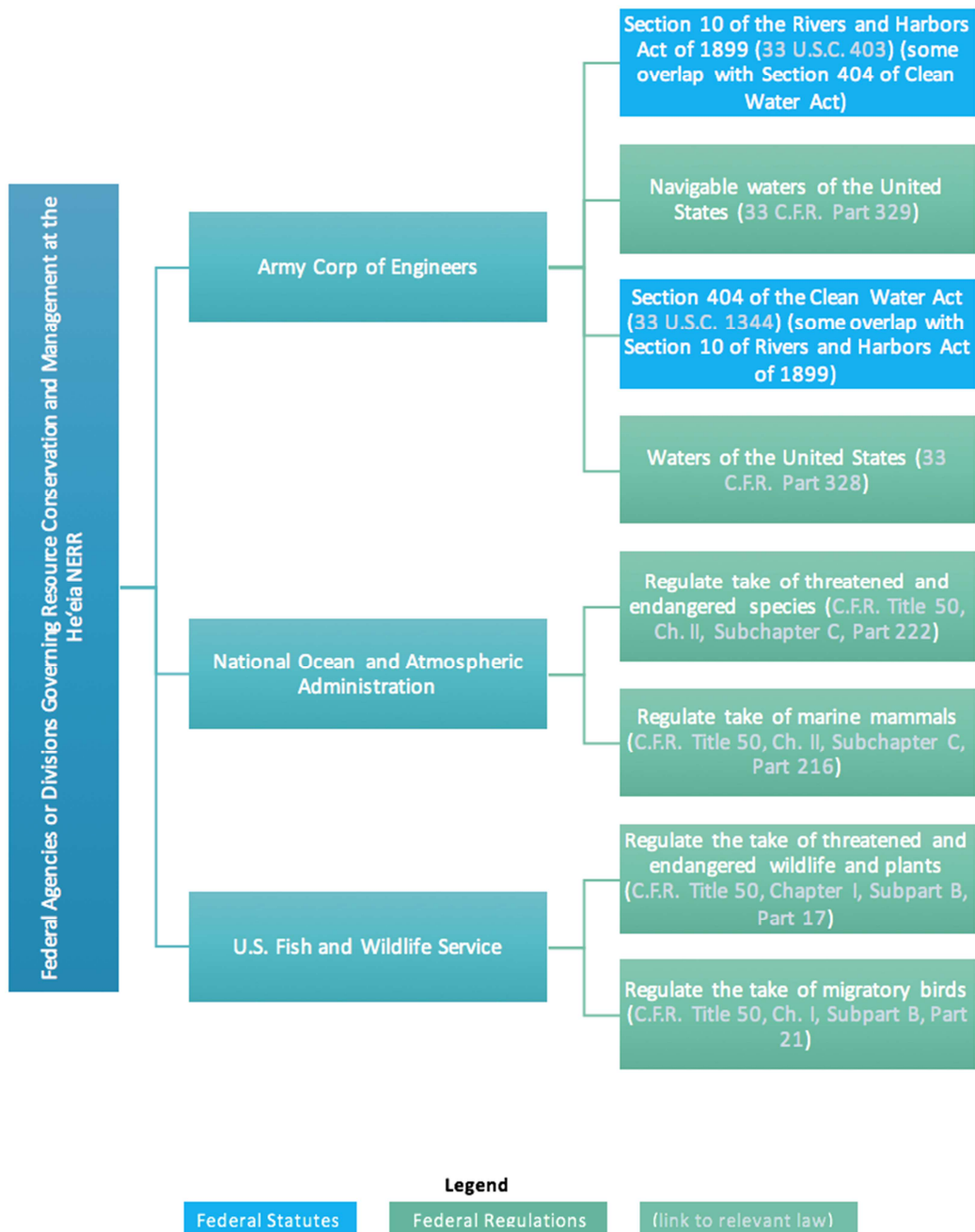
Figure 12: State Governing Bodies and Links to Relevant Laws



Legend: State Statutes State Admin. Rules (link to relevant law)



Figure 13: Federal Agencies and Links to Relevant Laws



Unique to the state of Hawai'i is the constitutional obligation to preserve and protect traditional and customary rights exercised by Native Hawaiians. The Management Plan states, "[t]he State recognizes that the ahupua'a of He'eia is a living resource where Native Hawaiians exercise traditional and customary practices, either within the He'eia NERR or within the ahupua'a of He'eia, to which the He'eia NERR may provide access. With this recognition comes the obligation to preserve and protect

those constitutionally guaranteed rights.” To meet this constitutionally mandated requirement to protect the right to exercise traditional and customary practices, the Management Plan utilized the analytical framework articulated by the Hawai‘i Supreme Court in *Ka Pa‘akai o ka ‘Āina v. Land Use Commission*. In short, this meant that the Management Plan was: (1) based on community engagement, (2) built on the extensive archival studies and research previously conducted in the area, and (3) proposes reasonable management objectives.

According to the Management Plan, “[d]esignating the He‘eia NERR does not add new regulations or restrictions on uses or activities within the He‘eia NERR.” Indeed, the “currently existing laws are enforced within the capabilities of the federal, state, and county authorities as assisted by a supportive community. Supporting these efforts, and building close working relationships with enforcement entities and the community to help protect these resources essential to meet the protection goals and objectives of the He‘eia NERR.” The list of management authorities and law enforcement partners is extensive, and includes various entities such as: NOAA’s Office of Law Enforcement, NOAA’s National Marine Fisheries Services, the Hawai‘i Department and Land and Natural Resources Division of Conservation and Resources Enforcement, the Department of Health Clean Water Branch, the Hawai‘i Community Development Authority, and the ‘Aha Moku Advisory Committee.

### **The Drivers And Potential Tradeoffs**

The main driving force that brought all of the key players to the table was the community—in short, it was a community-driven and supported plan. The Executive Summary of the Management Plan explains:

*The ahupua‘a of He‘eia has a long history of stewardship by Native Hawaiians based upon the traditional ahupua‘a principles and currently by several of the site partners who have recognized the wisdom and value of the old ways. The community discussed the benefits of greater collaboration and coordination amongst themselves but also the benefit of being part of the larger NERRS. For too long, the site partners struggled independently with limited financial resources and scientific information about the challenges affecting their own geographic areas, including impacts of the overgrowth of mangroves in the He‘eia fishpond, impacts of upland sedimentation on the stream water quality that nourished the lo‘i kalo (taro patches), impacts of the invasive algae on the health of the coral reefs within Kāne‘ohe Bay, and ultimate impacts of a rising sea level on He‘eia State Park.*

To address these issues, it was thought that working collectively, with the larger community’s support, would provide a more effective and efficient method for

managing the He'eia estuary in "a culturally appropriate way that builds upon traditional knowledge and contemporary science." In short, the He'eia NERR provides for the coordinated management of resources to collectively achieve not only local goals but the larger goals of NERRS.

Community engagement is key in a project like this. Many Native Hawaiians view state and federal agencies with varying degrees of disdain, wariness, and distrust. For some Native Hawaiians, there are huge "tradeoffs" whenever one works with governmental agencies—all too often, these agencies are seen as impinging on constitutionally protected Native Hawaiian rights. In this case, however, there was ample community support for the He'eia NERR.

## **Potential Futures**

The Management Plan lists the following primary administrative objectives for the future of the He'eia NERR:

1. Baseline environmental data informs researchers understanding of the magnitude of changes in the various He'eia ecosystems.
2. Coordinate independent research and monitoring efforts in the ahupua'a
3. Integrate traditional knowledge and research in the He'eia NERR that will better reflect and inform community decision making toward creating a sustainable ecosystem.
4. Increase student, educator, and community understanding of estuaries in general and in particular Hawaiian estuaries, coastal habitats, and the ahupua'a land management system.
5. Provide a comprehensive framework to integrate and enhance coordination and effectiveness of place-based education and training programs that have been initiated independently by the He'eia community.
6. Integrate traditional knowledge and contemporary science to effectively address climate change, habitat restoration, and water quality.
7. Become a leading repository of information for cultural biological and natural resources in the He'eia estuary.
8. Develop the tools, capacity, and connections to increase public awareness across the community, island, state, nation, and the world of the ecological and cultural significance of the He'eia estuary and ultimately the entire ahupua'a of He'eia.
9. Support restoration of key areas in the He'eia NERR to improve habitat and increase ecosystem services.

In terms of the future challenges that face the He'eia NERR, the Management Plan states that "[m]aintaining adequate control of reserve resources can be challenging." This is because there are external stressors that may degrade the resources in the He'eia NERR. Such examples include: "discharges of contaminants from surrounding urban areas, erosion, degradation of the watershed and streams caused by invasive plants and animals, loss of biodiversity, introduction of new harmful invasive species or diseases, unsustainable commercial and public recreational uses, overfishing, and changing climatic conditions."

Over the next five years, the main concerns include: (1) degradation of water quality and coral reefs from land-based erosion and pollutants, (2) introduction of invasive species and diseases, (3) climate change, (4) damage to coral reefs and fish stocks from consumptive and nonconsumptive commercial and recreational uses, and (5) vandalism, theft or destruction of natural and cultural resources.

## **Conclusion**

The He'eia NERR represents a community-driven plan to effectively manage an estuary in a culturally appropriate way, blending traditional knowledge and modern science. The key to success here was an understanding and appreciation of the connection between and the integration of the principles of an ahupua'a and contemporary science. In short, the He'eia NERR demonstrates that a collaborative working relationship with governing entities and the community is possible. The way forward may be fraught with uncertainty, but a salient lesson may be found in the He'eia NERR: any model for a sustainable estuary must be community-driven, supported, and led.

# Chesapeake Bay

J. R. Schubel

The Chesapeake Bay is North America's largest estuary, and the ratio of land (watershed) to water (Bay) is larger than for any other estuary in the United States. The water quality of the Bay is dominated by the watershed. More than 150 major rivers and streams flow into the Bay's 64,299-square-mile (166,534 km<sup>2</sup>) drainage basin, which covers parts of six states (New York, Pennsylvania, Delaware, Maryland, Virginia and West Virginia) and all of Washington, D.C. The Chesapeake Bay played a major role in the settlement of North America by Europeans and in its early history. The rivers tributary to the Bay that carried early settlers inland today bring the by-products of a growing population's activities back into the Bay, degrading the water quality and habitat.



Credit: [alldownstream.wordpress.com](http://alldownstream.wordpress.com)

Overfishing has degraded the fin-and shellfish populations, particularly the oyster population, of the Bay. Oysters have played not only an important role in the socio-economic history of the Bay, but also of its water quality. Every adult oyster filters two to five gallons of water every day, removing most of the particulates. It has been estimated that when John Smith sailed into the Bay in 1607 the oysters were so abundant that they filtered the entire Bay every few days. Today, the population is so small that it takes about a year to filter a volume equivalent to the Bay. This is a significant factor in the decline of water quality over the decades. Efforts are underway to restore some of the Bay's oyster population, but it will never recapture the situation found in 1607.

A great toll is taken on the Bay by the nutrients, particularly nitrogen, generated primarily by agriculture in the watershed that flow into the Bay. A major effort has been made to reduce the input of nutrients and they have had some success. The Bay's natural density-driven circulation compounds the effects of over-fertilization (eutrophication) by concentrating particulate nitrogen and any other contaminants associate with fine particles in the upper reaches of the tributaries and in the main body of the Bay.

Because of its location near the Nation's capital, the Chesapeake has received more attention and financial support from the Federal government than any other estuary in the U.S. Nearly \$20 billion have been spent to restore the Bay. These efforts have been frustrated by a stubborn system that includes two states that have governance over the waters of the Bay, and a large watershed encompassing six states and the District of Columbia. The watershed is the source of most of the stressors on the Bay ecosystem. Hundreds of thousands, perhaps millions, of non-point sources of pollution are the biggest threat and pose the biggest management challenge in terms of water quality.

The new major challenge that looms on the horizon is sea level rise. Within a few decades the remaining Bay islands will be submerged along with extensive swaths of wetlands and a number of coastal villages and even cities. People and infrastructure will have to move landward. Wetlands will migrate landward if there are pathways available that are not blocked by infrastructure such as highways and buildings, and if the sediment supply is adequate, but many will be lost. The over-enrichment of the Bay by nutrients which currently causes eutrophication and other negative consequences, and fishery issues may wane in importance as a priority in the face of sea level rise.

Restoration efforts are led by The Chesapeake Bay Program which was formed in 1983, and was the precursor of the National Estuary Program created under the Clean Water Act amendments of 1986. The Chesapeake Bay Program brings together members of state, federal, academic and local watershed organizations to "build and adopt policies that support Chesapeake Bay restoration." There have been improvements in some metrics of water quality over the past few years and some fish populations have been restored, but the gains, while important, have been modest. In the last annual report card prepared by The Chesapeake Bay Foundation the average grade for the Chesapeake Bay system was only a C-. Restoration of the Bay to some pre-existing condition and time will become increasingly elusive. The better - and perhaps the only realistic -- strategy will be to create the Bay for the future, one that is adaptive to a considerably higher sea level, that serves the needs of society and does not suffer any further impairment.

The Chesapeake Bay program embodies many of the principles of Sato-umi and Ahupua'a but there are important differences. While the approach is one of integrated

management, the management values of shared responsibility for the environment is not acculturated deeply throughout the residents of the Bay and its watershed.

In comparing success in the Chesapeake with Albemarle-Pamlico Sound, it's clear that systems with smaller populations, fewer chronic problems, and simpler governance systems are more amenable to rehabilitation than those with larger populations, serious chronic environmental problems, and complex and cumbersome governance systems.

One take-away lesson is that it is easier to keep a coastal system "healthy" than to rehabilitate an impaired system—particularly one as large and complex as Chesapeake Bay.





# Integrated Coastal Zone Management

Jeffrey Payne

In the United States, almost 40 percent of the population lives in coastal shoreline counties and more than 180 million Americans visit the coast each year (National Ocean Service 2017a,b). People rely on oceans and coasts for food, employment, protection from storms, transport of goods, water filtration, and many other services. They reside at and visit the coast for recreation and enjoyment and for cultural and spiritual fulfillment.

In addition to their social and economic importance, coastal ecosystems are dynamic biophysical environments that represent an interface of land and sea with flows of materials and energy across system boundaries. Furthermore, coasts are changing. In the Anthropocene epoch, coasts have proven especially vulnerable to climate change and are already experiencing the effects of rising sea levels, warming waters, erosion, changes in precipitation, and increasing storms, among other effects (USGCRP 2017). Managing the coast has always presented unique challenges, but climate change and other anthropogenic impacts make it increasingly imperative that management is coordinated and effective.

In recognition that coasts are important, dynamic, and vulnerable places, Integrated Coastal Zone Management (ICZM) seeks to balance environmental, economic, and social objectives over the long term and within sustainable limits (European Commission 2000). While ICZM has several definitions, it is essentially a framework or process that brings in all those involved in using and managing the coast in a coordinated manner that integrates their interests and needs. It emerged on the international stage at the Rio Earth Summit in 1992, which called for ICZM implementation globally in the Agenda 21 Chapter 17 agreement. Since that time, efforts around the world have defined key principles, operationalized the framework, and instituted ICZM programs and policies at various geographies and scales.

There are a few things that differentiate the ICZM approach from more traditional single-sector management. First, the integration component of ICZM is multidimensional. While there has been a focus on the need to integrate management across sectors, ICZM also includes integration across spatial scales (cross-ecosystem), levels of governance, multiple stakeholders, and temporal scales (multiple generations) (Portman et al. 2012). Second, data are foundational for the ICZM process because information is needed to understand the environment and how it may change, to identify coastal uses and demands, and to evaluate the effectiveness of management techniques and their application. This information arises from many stakeholders and sources and includes biophysical, social, and economic data as well as traditional forms of knowledge.

ICZM shares many of the same core tenets with Sato-umi and ahupua'a approaches. Each considers many coastal uses and the need to mediate among stakeholders, relies heavily on environmental and social information, considers land-sea linkages, and accounts for the services that ecosystems provide. But perhaps most crucially, all three approaches acknowledge the central role of people in coastal ecosystems. Sato-umi and ahupua'a are lasting forms of management that are adaptive to human impacts in dynamic coastal environments. Drawing from these approaches, ICZM was developed more recently as a response to the global-scale human impacts on coasts and oceans. All three approaches will become increasingly critical as we face the need to manage resources and balance uses in rapidly changing Anthropocene.

### **References**

European Commission. 2000. Communication from the Commission to the Council and the European Parliament on integrated coastal zone management: a strategy for Europe, COM(2000) 547 final. Brussels: European Commission.

<http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52000DC0547>.

NOAAa. 2017. "What percentage of the American population lives on the coast?" National Ocean Service website. <https://oceanservice.noaa.gov/facts/population.html>.

NOAAb. 2017. "Coastal Zone Management." National Ocean Service website. <https://oceanservice.noaa.gov/tools/czm/>.

Portman, M.E., L.S. Esteves, X.Q. Le, and A.Z. Khan. 2012. "Improving integration for integrated coastal zone management: An eight country study." *Science of the Total Environment* 439: 194-201.

USGCRP. 2017. "Climate Science Special Report: Fourth National Climate Assessment, Volume I." Edited by Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: U.S. Global Change Research Program. doi: [10.7930/J0J964J6](https://doi.org/10.7930/J0J964J6).

# GIS Data, Analysis and Visualization

Mimi D'lorio

A cornerstone of collaborative, integrated coastal management is access to scientific data and tools to make informed planning decisions. This often includes geospatial *data* about the environment, ecosystems and human uses of the ocean and coasts, *tools* that help visualize and analyze data under different planning scenarios and *strategies* that promote community engagement through collaborative and iterative discussion. The appropriate data, tools and strategies differ from place to place based on the target community and its management priorities, but recent years have seen great advancements and versatility in decision support tools designed to support a wide range of marine planning and management needs.

The establishment of the National Ocean Policy (NOP) in 2010 helped garner support for implementation of integrated coastal management and marine planning across the United States. Through the “Framework for Effective Coastal and Marine Spatial Planning” developed under the NOP, essential components to marine planning were identified, including specifically those related to spatial data and analysis.

The U.S National Ocean Policy’s “Framework for Effective Coastal and Marine Spatial Planning” identifies several key data types important for inclusion in marine planning efforts. These include data on:

- Important physical and ecological patterns and processes including their response to changing conditions;
- The ecological condition and relative ecological importance of areas
- The economic and environmental benefits and impacts of ocean and coastal uses
- The linkages within and among regional ecosystems and the impacts of anticipated human uses on those connections;
- Important ecosystem services and their vulnerability or resilience to the effects of human uses, natural hazards, and global climate change;
- The spatial distribution of, and conflicts and compatibilities among, current and emerging ocean uses in the area;
- The contributions of existing place-based management measures and authorities; and,
- Future requirements of existing and emerging ocean, coastal, and Great Lakes uses.

In support of the NOP, U.S. coastal states have been working to build on their longstanding state-based efforts to develop more regionally-focused ocean and coastal priorities. Through the development of regional planning bodies, these states are advancing the structure and process for regional integrated coastal management, and custom tailoring the best suite of tools and resources to meet their regional ocean priorities. These efforts are driving the development of regional data repositories or

portals that provide spatial information from a wide range of sources to address regional planning needs. Portals provide hubs for accessing and visualizing geospatial data and create forums for connecting ocean agency, industry and community leaders who are working collaboratively to shape the future of the coastal ocean.

### Spatial Data

Integrated coastal management promotes efficient use of marine space while sustaining ecological, socio-cultural, and historical values over the long-term. Most management efforts involve analyses of the status and uses of the ocean and coasts and their potential changes over time, requiring (at a minimum) spatial data representing non-living and living resources, ocean uses, governance structure and infrastructure (Table 1). While most of these data exist to some extent, coordination is required to curate, format and compile them in a commonly accessible location.

Table 1. Data Categories for Marine Planning from USGC Open File Report 2015-1046

<p><b>Nonliving Resources</b></p> <ul style="list-style-type: none"> <li>Energy Resources <ul style="list-style-type: none"> <li>Oil Resources</li> <li>Natural Gas Resources</li> <li>Wind</li> <li>Tides</li> <li>Ocean Currents</li> <li>Geothermal Resources</li> <li>Ocean Thermal Resources</li> <li>Solar Radiation</li> </ul> </li> <li>Material Resources <ul style="list-style-type: none"> <li>Sand Resources</li> <li>Mineral Resources</li> </ul> </li> <li>Physical/Chemical Features <ul style="list-style-type: none"> <li>Physical Habitats and Geomorphology</li> <li>Bathymetry and Elevation</li> <li>Substrate</li> <li>Water Column Features</li> <li>Water-Quality Parameters</li> </ul> </li> </ul>	<p><b>Ocean Uses—Continued</b></p> <ul style="list-style-type: none"> <li>Harvesting Living Resources <ul style="list-style-type: none"> <li>Pelagic Fishing</li> <li>Fishing with Benthic Mobile Gear</li> <li>Fishing with Benthic Fixed Gear</li> <li>Kayak Fishing</li> <li>Dive Fishing</li> <li>Fishing from Shore</li> <li>Gathering from Shore</li> <li>Offshore Seaweed Harvest</li> <li>Hunting</li> </ul> </li> <li>Energy Production <ul style="list-style-type: none"> <li>Wind Energy Production</li> <li>Wave Energy Production</li> <li>Ocean Current Energy Production</li> <li>Tidal Current Energy Production</li> <li>Ocean Thermal Energy Conversion</li> <li>Offshore Oil and Gas Production</li> </ul> </li> <li>Transportation <ul style="list-style-type: none"> <li>Shipping</li> <li>Cruise Ships</li> <li>Military Vessels</li> </ul> </li> <li>Other Commercial/Industrial Uses <ul style="list-style-type: none"> <li>Mining and Mineral Extraction</li> <li>Offshore Aquaculture</li> <li>Coastal Aquaculture</li> <li>Seawater Intake</li> <li>Sewage Discharge</li> <li>Ocean Dumping</li> <li>Underwater Transmission Cables</li> </ul> </li> </ul>
<p><b>Living Resources</b></p> <ul style="list-style-type: none"> <li>Habitat</li> <li>Ecological Functions and Services <ul style="list-style-type: none"> <li>Biological Production</li> <li>Biodiversity</li> </ul> </li> <li>Biological Occurrence <ul style="list-style-type: none"> <li>Fishes</li> <li>Invertebrates</li> <li>Flora</li> <li>Mammals</li> <li>Birds</li> <li>Reptiles</li> <li>Invasive Species</li> </ul> </li> </ul>	<p><b>Governance</b></p> <ul style="list-style-type: none"> <li>Marine Protected Areas (MPAs)</li> <li>De Facto MPAs</li> <li>Commercial Leases</li> <li>Jurisdictional Boundaries</li> <li>Tribally Governed Areas</li> <li>Regulatory Use Restrictions</li> </ul>
<p><b>Ocean Uses</b></p> <ul style="list-style-type: none"> <li>Recreational Nonextractive /Cultural Use <ul style="list-style-type: none"> <li>Scuba/Snorkeling</li> <li>Swimming</li> <li>Surface Board Sports</li> <li>Paddling</li> <li>Sailing</li> <li>Motorized Boating</li> <li>Wildlife Viewing at Sea</li> <li>Tide Pooling</li> <li>Shore Use</li> <li>Cultural Use</li> </ul> </li> </ul>	<p><b>Infrastructure</b></p> <ul style="list-style-type: none"> <li>Ports</li> <li>Cables, Pipelines, and Power Grids</li> <li>Buoys and Navigational Aids</li> <li>Structures</li> </ul>

Online data portals are becoming an increasingly popular way to meet these needs by linking data from various sources and providing customized maps and visualizations that highlight particular management issues. For example, the Mid-Atlantic Regional Council on the Ocean (MARCO) was established in 2009 to coordinate ocean planning

efforts that help enhance the health and sustainability of the region's ocean ecosystem and economy. MARCO developed the [Mid-Atlantic Ocean Data Portal](#) as an on-line platform to engage stakeholders across the region with the objective of improving their understanding of how ocean resources and places are being used, managed, and conserved.

Key data sources for portals include federal, state and local government (see Table 2) for select examples of NOAA data sources) academia, non-governmental organizations (e.g. Marine Conservation Institute, The Nature Conservancy) and increasingly more citizen science or crowdsourcing. Some portals may offer select spatial analysis functions, but most simply provide access and visualization for a curated set of spatial data layers.

*Table 2: Select examples of NOAA Geospatial data resources*

<a href="#">MarineCadastre.Gov</a>	Authoritative marine boundary and cadastral data
<a href="#">Digital Coast</a>	Coastal resource management data and tools
<a href="#">ERMA</a>	Static and real-time data for environmental response
<a href="#">nowCoast</a>	Real-time coastal environmental observations and forecasts

### Analysis Tools

Beyond data and visualizations, there are also a variety of specialized tools designed to help analyze spatial patterns, evaluate trade-offs, conduct scenario planning and assess cumulative impacts, as well as resources that address the human dimensions of coastal management through social science research. Some of these are proprietary desktop applications intended for use by GIS experts and planners, while others are free online tools that serve a broader audience but often with more limited functionality. In 2011, the [Center for Ocean Solutions](#) published a guide that detailed a range of available decision support tools, highlighting their functionality and utility to support various stages of a marine planning process (see examples in Table 3).

*Table 3 Select examples of marine planning analysis tools*

<b>NAME</b>	<b>Purpose</b>
<b>Aries</b>	Ecosystem service assessment and valuation for decision making
<b>Atlantis</b>	Ecosystem model to support strategic fisheries management
<b>InVEST</b>	Integrated valuation of ecosystem services and trade offs
<b>Marxan</b>	Spatial analysis for marine protected area designation
<b>MIMES</b>	Assessment of ecosystem services
<b>SeaSketch</b>	Participatory marine spatial planning processes

As decision support tools become increasingly more accessible and user-friendly, they help catalyze more collaboration among stakeholders and promote a better

understanding of the socio-economic trade-offs and related costs/benefits of different kinds of planning strategies.

### Engagement Strategies

Essential to all marine planning initiatives are effective stakeholder engagement strategies that promote open, transparent and proactive planning for current and future economic, cultural and environmental uses of the ocean. These strategies, when implemented early on and managed throughout the duration of planning initiatives, help build trust and create a forum for collaborative discussion. Citizen science and crowdsourcing can also help engage communities in coastal management efforts by soliciting personal insights and surveyed information relevant to the local marine issues. Gathering traditional knowledge and community perspectives through participatory mapping, like [NOAA's Ocean Use Mapping](#) process, or collaborating on design of marine plans through interactive online mapping tools like [SeaSketch](#), can provide opportunities to voice, address and discuss community concerns, as well build networks of informed and engaged stakeholders. Finding the right balance between virtual and in-person engagement and the best suite of tools for connecting with diverse groups is essential for success but often challenging as each marine community is unique. Local context is important and planning processes need to recognize the individual and unique needs of each affected community and their local management history and priorities.





# The Albemarle-Pamlico Estuarine Study (Management Conference)<sup>1</sup>

M.K Orbach

In 1987, pursuant to the 1987 Amendments of the Clean Water Act (CWA) which created the National Estuary Program (NEP) modeled on the Chesapeake Bay Program, the Albemarle-Pamlico Estuarine Study (APES) was created. APES, technically termed a “Management Conference” under the CWA, was an agreement among North Carolina, Virginia (both of whom have portions of the watershed under their jurisdiction. See Figure 1) and Region 4 (Atlanta) of the Environmental Protection Agency (EPA), which has the responsibility of managing the NEP.

APES was one of the first twelve programs to be created under the NEP. North Carolina, through its senior Congressional Representative Walter B. Jones, then Chairman of the powerful Merchant Marine and Fisheries Committee in the U.S. House of Representatives, had to argue strenuously for the program to be included in the first round of programs. Other members of Congress felt that the Albemarle-Pamlico system had relatively few serious problems compared to other U.S. Estuaries such as Boston Harbor, the Corpus Christi ship channel or Puget Sound. North Carolina, however, ultimately won its case by pointing out that it would be good to develop a NEP before more serious degradation occurred, an argument that held sway.

APES involved 81 cities and counties in two states, North Carolina and Virginia. Each NEP was allowed to develop its own detailed policy and management structure under certain conditions laid out in the CWA. Those conditions were:

- 1) The programs were intended to be five years in duration, with the end result being a Comprehensive Conservation and Management Plan (CCMP) for each designated estuarine system.
- 2) Each CCMP was to be preceded by a Status and Trends document summarizing the best available interdisciplinary science related to the estuary and its human constituents.
- 3) All levels of government, from federal through state to local, which had authority or responsibility for, along with citizens, private industry and organizations which had involvement with, portions of the estuarine system must be included in the policy and management structure of the Program. The CWA specifically required organized and prominent involvement by citizens who worked or resided in or who were concerned with the system.

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<sup>1</sup> The material for this section comes from the author’s experience as a member of the Technical Committee of the APES program and Chair of the Public Involvement Subcommittee through out the duration of the program, and Korfmacher, K.S. 1998. Invisible successes, visible failures: Paradoxes of Ecosystem Management in the Albemarle-Pamlico Estuarine Study. *Coastal Management*. 26(3): 191-212.

4) Each designated system received approximately \$1,000,000/year from the EPA, which was required to be matched by state and other funds.

In the case of APES, the resulting structure was as follows:

1) A Policy Committee of 11 members, co-Chaired by the Regional Administrator (Region 4, Atlanta) of EPA and the North Carolina (as the state with the preponderance of the estuary within its boundaries) Secretary of Environment and Natural Resources. This Policy Committee included representatives of other state and federal agencies and scientists from the states' universities and the Chairs of the two Citizen's Advisory Committees, one for the Albemarle and one for the Pamlico Sound region.

2) A Technical Committee of 25 members, co-chaired by the Assistant Administrator of EPA Region 4 and the North Carolina Deputy Secretary of Environment and Natural Resources. The Technical Committee also included representatives of state and federal agencies, scientists, and the Vice Chairs of the two Citizens Advisory Committees. The Technical Committee, along with the staff, actually served as the central management function of the program.

3) Two 30-member Citizens Advisory Committees with member representing towns, cities, counties, and citizens and user group representatives from the Albemarle and Pamlico Sound watersheds.

The program was staffed by personnel in Raleigh and Washington, North Carolina, all affiliated with the NC Department of Environment and Natural Resources, although the staff – in particular the Executive Director -- technically reported to the APES Policy Committee.

The first two years were devoted to collecting and funding science and scientific data and information relevant to the management of the estuary. In the third year a "Status and Trends" document was produced covering both biophysical and human processes and activities in the estuary. In the fourth year proposals were developed and considered for action related to the future policy and management of the estuary, and in the fifth year the CCMP was produced. The program stretched out a bit at the end because of a partisan change in the Governorship in 1992, with the new Governor wanting to put his imprimatur on the CCMP and in particular its policy and management recommendations. The final Albemarle-Pamlico Comprehensive Conservation and Management Plan (APCCMP) was signed by the Governors and the Regional Director of the EPA in 1994.

The CWA is silent on the extent to which both land- and sea-based issues and activities should be addressed in the NEP, but in the case of APES the decision was made to consider all activities on both land and sea under state jurisdiction, which in the case of fisheries for both North Carolina and Virginia extends out three miles from the ocean shoreline. Thus the APES program and its recommendations spanned from the heads of the Albemarle and Pamlico watershed to three miles offshore.

The APCCMP recommendations spanned topics from agricultural practices and development setbacks from the shoreline to wastewater disposal, aquaculture and fisheries. In all, 151 recommendations were made covering activities under the jurisdiction of dozens of federal, state and local government agencies. It is important to note that no new policy or management authorities were created under the CCMP; all recommendations were to be carried out by existing agencies under their existing authorities<sup>2</sup>. As originally envisioned in the CCMP planning process, implementation of the recommendations were projected to take 10-15 years. In fact, virtually all of the recommendations had been implemented after ten years.

The APES program arguably stopped much degradation of the estuary and promoted recovery of significant resources and habitats. Along with subsequent activities such as EPA Stormwater Regulations and the North Carolina Fisheries Reform Act of 1996 (which implemented several of the recommendations of the APCCMP), the policy and management structure for the Albemarle-Pamlico estuary and adjacent state waters has been significantly improved.

Figure 1 – The Albemarle-Pamlico Estuarine Management Conference Study Area (Note that state jurisdiction over fisheries under the CCMP extends to three miles offshore.)

### Comparison to Sato-umi and Ahupua'a

The APES case is different from the Sato-umi case in that Sato-umi arguably has a deep cultural basis in Japanese society, while the APES is a product of the national coastal governance changes resulting from the environmental legislation of the 1960s, 70s and 80s. Also, the Akkeshi case in particular was relatively small-scale, with two significant uses (aquaculture and forestry) in the mix. The APES program involved dozens of different counties in two different states, and dozens of uses and user groups vying for their interests in the region. The Akkeshi case was driven by local interests in the two sectors, while the APES case was driven 'top-down' by federal legislation.

With respect to Ahupua'a, the most notable differences are (1) that the Ahupua'a developed in a period of pre-European contact and relatively, simple, low-level technology and a functioning biophysical system (as opposed to most U.S. coastal systems, which are dominated by human presence and infrastructure). Similar to Sato-umi, the cultural concepts of Ahupua'a concerning the human-environment relationship were quite sophisticated and developed over thousands of years; (2) The Ahupua'a system, although forged through an intimate relationship between the ruling Hawaiian classes and the "people", was essentially a Monarchy, with power

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<sup>2</sup> The only one of the original 12 NEP programs that created a new policy and management authority was Puget Sound with the creation of the Puget Sound Water Quality Authority (PSWQA). The PSWQA was disbanded after a year due to political and administrative issues with the new comprehensive policy structure.

emanating from single points of control (Ali'i, the Chiefs), with control over both the land and the sea. The Ahupua'a system largely disappeared after European contact, although as is noted above aspects of the systems are now becoming more integrated into 'modern' law and policy.

# Tijuana River and Estuary

James Fawcett

The Tijuana River and Estuary (TRE), among the 25 most threatened coastal estuaries in the world, drains 1730 square miles of watershed in the arid coastal Southwest in both the United States and Mexico (See Figure 1). For more than 40 years, the two countries have recognized that sewage and surface runoff from the high coastal mesas and suburbs such as Cañon Los Laureles of the City of Tijuana, immediately south of the border, drain into 2293 acres of tidally flushed wetland in coastal San Diego County, a prized resource for intertidal fishes, birds resting along the Pacific Flyway, and for the 3.2 million residents of San Diego County, the southwestern most county in the continental U.S. Siltation, toxic heavy metals, pesticides, and trash all have smothered portions of the wetland and provided a nursery ground for invasive plants, squeezing out native vegetation from this valuable resource. Yet, for the impoverished residents of Cañon Los Laureles and other Tijuana residents living in the watershed, earning a meager living in the maquiladoras that have bloomed on the Mexican side of the border, their impact on the Tijuana River cannot be their first concern as they struggle to feed and house their families.

Poverty, land speculation and minimal government oversight in Tijuana has created this problem that affects both countries. In recent decades, developers cleared and graded building sites on the mesas and highlands of Tijuana but failed to provide paved roads, sewage systems and other urban infrastructure to adequately support the city's rapidly urbanizing population of more than 1.5 million. Residents in the neighborhood of Colonia San Bernardo at the top of Cañon Los Laureles were attracted by minimal land prices when they came to work in the city and were happy to have home sites close to their work. Yet, affordability of the land was offset by the lack of infrastructure and the consequence was that sewage, erosion, toxic chemical runoff all flowed downhill into the Tijuana River and its tributaries, all little more than open sewers. When the rains come to this arid community, erosion and flooding are the consequence for the residents of Colonia San Bernardo. Moreover, in the majority of the year when weather is dry and in the summer and fall months when it is also hot, the lack of vegetation and the unpaved roadways create a health hazard in the form of dust and respiratory disease. These are the consequences of poor land management practices at the terrestrial end of the watershed that create terrible consequences not only for residents but also farther downstream in the Tijuana River Estuary.

Unlike most watershed systems, the downstream portion is not far away from the majority of the sources of local pollution in the mesas of Tijuana -- just 6.5 miles. But the estuary where the river meets the Pacific Ocean is in a different jurisdiction and, indeed, another country, the U.S. Years of wrangling between the U.S. and Mexico have failed to reach an agreement over management of the estuary. Offers from the Comisión Estatal de Servicios Públicos de Tijuana (CESPT) to treat the city's wastewater to secondary standards were rebuffed by the US EPA and the California

Water Resources Control Board because the proposed system might not be able to handle raw sewage overflows during rainy events. Now with concerns over an expanded border wall, one wonders about the fate of a project as politically fragile as wastewater treatment.

In the estuary, siltation has claimed 30 acres of formerly viable tidal marsh and left it smothered by silt, killing native vegetation that is food for migrating birds who stop to feed as a waystation on the Western Flyway. Birds from as far away as South America use the estuary on their travel to northern climes in the summer months, and the 2,400 acres that remains is desperately challenged every time a rain event washes more silt, pollution and debris into the low-lying marsh.

What is to be done? We know the biology of the estuary as well as the sources and nature of the contaminants that challenge it, thus, remediation is a political matter in that the US Government, representing the estuary, has the responsibility to advocate to both the US Congress and the Administration why and how, as representatives of the public, we should resolve the pollution issues. It is easy to say that it's a matter of funding but the issue is far more complex. The North American Free Trade Agreement (NAFTA) has created an incentive for manufacturing to take place in northern Mexico where labor is cheaper and environmental regulation is thin and where jobs are plentiful. Mexican citizens seeking employment have every reason to migrate to border cities like Tijuana seeking employment. Yet, their living accommodations degrade environmental quality because of lax governance. Moreover, industrial waste such as tires (as well as many other wastes) are transported from the US to Mexico to either extract the last measure of utility from them or to be used for apparently beneficial but ultimately hazardous uses such as retaining walls where heavy metals from them are leached into surface runoff and into the estuary.

Acting through the U.S. Environmental Protection Agency, the U.S. Government has made strides toward remediating these impacts by funding the International Wastewater Treatment Plant on the U.S. side of the border that serves 800,000 people in Tijuana and by creating two siltation basins in the floodplain of Goat Canyon, downstream of Tijuana and upstream of the Tijuana River National Estuarine Research Reserve, capturing sediment before it reaches the estuary. Both require maintenance funding on an annual basis yet this is a means only of treating the impacts of poor resource and land use management decisions by Mexico, not yet an integrated multinational plan to achieve the ambitions of Satoumi or ahupua'a.

Environmental management philosophies such as ahupua'a or Sato-umi rest on the principle that landside and waterside issues must be managed in an integrated way because they are inherently interconnected. Moreover, acceptance of a common philosophy of environmental management is important if not essential in coming to agreements over how to effectively manage coastal resources. Yet, where two nations share responsibility for environmental management, cooperation (both fiscal and political) is essential to resolve a dilemma such as we find at the Tijuana River and Estuary. And, over the years, the US and Mexico have stared at one another over the

borderlands at Tijuana, commonly acknowledging the resource issues on both sides of the border yet unable to join with one another in managing their joint resource: two neighbors staring at one another over a common fence. The Tijuana River Estuary is a marvelous site for the two nations to come together to solve this common problem yet what is missing is an appreciation that they have a shared future in making this corner of the world a bit better. Thus, while the problem is environmental, the ultimate solution is political cooperation. Time will tell if our two nations can find a way to recognize the importance of this site and forge an alliance to improve the lives of residents of both nations.



Figure 1 – The Tijuana River Estuary





# The Upper Newport Bay Nature Preserve

M.K. Orbach

“James Irvine and partners acquired the [Newport] Bay in 1864, for 37 cents an acre. These holdings supported a salt works from the 1930s until 1969 when it was destroyed by floods. Shellmaker Island was home to several companies until the late 1980s. Shell material was dredged and sold as a chicken feed supplement, and dredging spoils were deposited by the Arches, on Shellmaker Island and at Big Canyon, among other locations.”

(OC Parks, 2017), (material in [] added)

Shortly after the turn of the 20<sup>th</sup> century (circa 1905) the dredging and channelization of Newport Harbor in Newport Beach, California, began. Over the next 60 years Lower Newport Harbor (downstream of the Pacific Coast Highway (PCH) Bridge, Highway 101) rapidly developed into a commercial, residential, and leisure-tourism location. During this time, the area upstream of the PCH (Upper Newport Bay, See Figure 1) was host to various commercial endeavors (cement production, salt works, all of which eventually failed) but remained largely undeveloped. The area surrounding the Upper Newport Bay began to develop, very rapidly after WWII. San Diego Creek, the source of the Newport Estuary fresh water flow, north of the Jamboree Road Causeway degraded significantly during this period, in part due to the development of the University of California, Irvine (opened in 1965) and the adjacent City of Irvine which developed in this same time period (Figures 2 and 3).

By the 1960s, Lower Newport Harbor was fully developed, with associated water quality and habitat degradation. Development had been planned and permitted north of the PCH bridge, and the first developments had begun. The environmental movement of the late 1960s and early 1970s resulted in state and federal law and policy that led to significant improvements in Newport Harbor water quality, and to concern for the future development of the Upper Bay.

“Preservation of Upper Newport Bay began with a fight for survival in the 1960s when the area was designated from development to provide a water-skiing area. Approximately ten years of lawsuits ensued by environmentally concerned citizens, and ended in 1975 with the undeveloped portions of the Upper Newport Bay becoming a 752 acre ecological reserve under the jurisdiction of the State of California Department of Fish and Game. In the mid 1980's Orange County initiated negotiations to obtain title to bluffs surrounding the reserve. In 1989, the county accepted the 135-acre Upper Newport Bay Nature Preserve.”

(OC Parks, 2017)

Significant in this “fight for survival” were several local citizen groups including Friends of Newport Bay and Stop Polluting Our Newport (now “Still Protecting Our Newport”), which had a significant hand in both the preservation of the Upper

Newport Bay and the development of the Peter and Mary Muth Interpretive Center, the Newport Bay Conservancy, and the Back Bay Science Center.

Today, "The Upper Newport Bay (known to locals as "The Back Bay") is a large coastal wetland (an estuary) in Newport Beach, Southern California and a major stopover for birds on the Pacific Flyway. Dozens of species, including endangered ones, can be observed here. Upper Newport Bay Nature Preserve and Ecological Reserve represent approximately 1,000 acres (4 km<sup>2</sup>) of open space. The Upper Newport Bay was purchased by the state in 1975 for its Fish and Wildlife Department's Ecological Reserve System. In 1985 the upper west bluffs and lands surrounding the bay became part of an Orange County regional park, which offers outdoor activities such as bird-watching, jogging, bicycling, hiking, and kayaking. The Peter and Mary Muth Interpretive Center, located at 2301 University Drive, is open to the public Tuesday through Sunday from 10:00 AM to 4:00 PM. An organization known as the Newport Bay Conservancy (NBC) provides volunteers to answer visitors' questions and guide them through the various activities."

(Wikipedia, 2017)

Although the activity involved with the Upper Newport Bay is primarily on the 'land side' of the land-sea interface, the preservation of the Upper Bay has yielded significant benefits for both land and sea resources in the Newport Harbor area.

The important features of the Upper Newport Bay case are 1) that the case demonstrates that it is possible to establish and re-establish 'connections' between the land and the sea and to other important environment features; and 2) That as in both the Sato-umi and Ahupua'a cases, the concept of humans being intimately aware of and involved with their natural environment is critical. With respect to 'connections', the UNB demonstrated both the re-establishment of a 'link' between the lower Newport Harbor and the upper San Diego Creek watershed, and the addition to a wildlife preserve along the Pacific coast flyway. In terms of the awareness and involvement of local people, the UNB case demonstrates that an educated, involved local group of people with knowledge of both the biophysical and the socio-political context of the situation can make significant progress. It is important to note that the UNB area was purchased from private owners and given to the County and State for protection and management. This is similar to the approach used often by the Nature Conservancy: Don't try to push private owners into conservation action through regulation – simply buy the property!

Figures

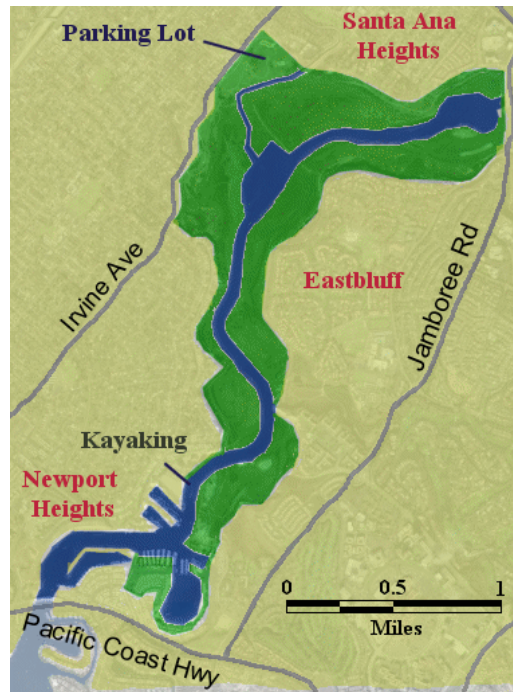


Figure 1 -- Upper Newport Bay Nature Preserve

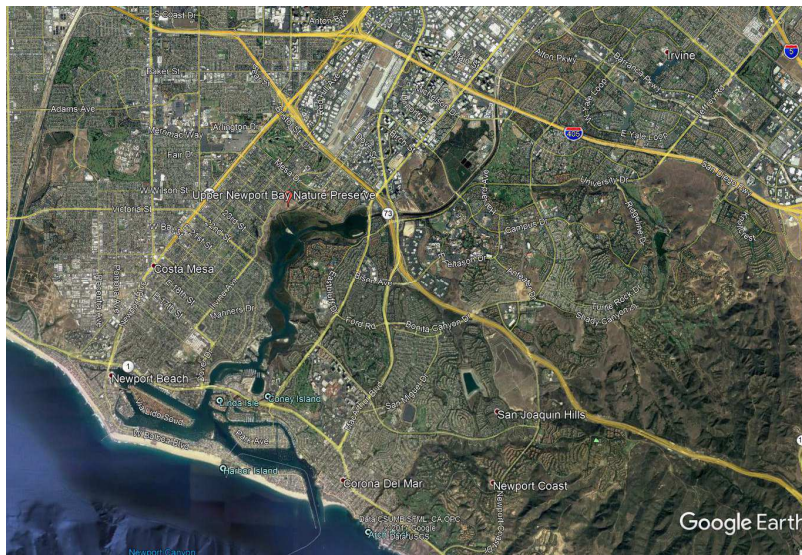


Figure 2 – Upper Newport Bay Nature Preserve in the context of the surrounding Cities of Newport Beach (south and west), Costa Mesa (northwest), and Irvine (northeast)



Figure 3 – Detail of the UNBNR between the PCH and Jamboree Road



Figure 4 -- San Diego Creek upstream of the Jamboree Road Causeway



Figure 5 -- Lower Newport Harbor



Figure 6 -- UNBNR from the Interpretive Center, towards Lower Newport Harbor



Figure 7 -- Eastern Cliffs of the UNBNR, towards Jamboree Road



Figure 8 -- UNBNR Muth Interpretive Center (not visible from adjacent land development, by design)



Figure 9 -- Back Bay Science Center





# Sato-umi and the San Francisquito Creek Watershed

Anthony D. Barnosky

Sato-umi broadly defined refers to humans managing coastal areas—the land-sea interface—at the watershed scale in ways that both benefit people and promote or even enhance biodiversity and ecological health. The concept has been advocated by Japanese policy-makers as a way to weave together ecological conservation, sustainable use of ecological resources, and community engagement in management of coastal areas that have a heavy human footprint. Sato-umi has proven effective in managing various coastal areas in Japan, and therefore provides a model that may well enhance coastal management in other regions of the world.

A crucial ingredient to success is the involvement of local communities in developing and implementing management plans, as well as stakeholders' appreciation for the value of a healthy ecosystem, both on land and in the adjoining sea.<sup>3</sup> Therefore, implementing Sato-umi as a philosophy of coastal management probably has the greatest chance of success in areas where those two ingredients already are present, or where the capacity to educate residents about the importance of stakeholder involvement and ecological vibrancy can rapidly be emplaced. Applying the Sato-umi concept may be particularly appropriate and feasible when stakeholders who have a diversity of interests are drawn together by a common problem that requires considering the watershed as a whole, and when the geographic size of the watershed is of manageable size.

## The San Francisquito Creek Watershed

A key example of such a place is the San Francisquito Creek Watershed located approximately 30 miles south of San Francisco, California. Covering an area of about 123 km<sup>2</sup> (47.6 miles<sup>2</sup>), the watershed encompasses approximately 25 tributaries that coalesce into San Francisquito Creek (Fig 1), which then flows into the south end of San Francisco Bay through the communities of Menlo Park, Palo Alto, and East Palo Alto. Upstream communities include Portola Valley, Woodside, Ladera, and Los Trancos Woods.

The uniting issues center around San Francisquito Creek itself, which harbors one of the last remaining steelhead runs in central California, and Searsville Reservoir and Dam located on Stanford University's Jasper Ridge Biological Preserve, an 1193-acre ecological-research and nature preserve through which much of the San Francisquito Creek drainage funnels (Fig 1). Ideal watershed management from an ecological perspective includes restoring steelhead passage upstream of the dam (also important from the legal perspective because of the endangered status of steelhead), maintaining the ecological integrity of Jasper Ridge Biological Preserve, enhancing the river-to-the-

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<sup>2</sup> JoannèsBerque and Osamu Matsuda, 2013, Coastal biodiversity management in Japanese *Sato-umi*. *Marine Policy* 39: 191-200.

sea corridor for native plant and animal species that require riparian and nearshore estuarine habitats, and providing much-needed sediment transport downstream into San Francisco Bay. Ideal watershed management from the downstream community perspective is to guard against flood risk, as well as maintaining an attractive landscape where San Francisquito Creek flows through neighborhoods. A complicating factor is that the reservoir and dam have for the past century-and-a-quarter provided a modicum of flood protection to downstream communities, but due to geological conditions upstream—steep-sided valleys and friable rock that shed enormous amounts of sediment into the creeks with each of the heavy winter downpours that typify the region’s Mediterranean climate—the reservoir is projected to completely fill with sediment within fifty years, at which point any existing flood protection will be gone and both sediment loads and flood risk may increase downstream.



**Figure 1.** The San Francisquito Creek Watershed (outlined in white). The upper (approximately the western two-thirds) of the watershed is comprised largely of green space and residential properties that generally are situated on large lots. The lower watershed (approximately the eastern third) runs through densely populated Menlo Park, Palo Alto, and East Palo Alto. Stanford University’s Jasper Ridge Biological Preserve is outlined in yellow, which contains Searsville Reservoir in its western sector. Illustration courtesy of Trevor Hébert and Nona Chiariello.

How might the Sato-umi concept help in guiding the future of this watershed? First, the critical ingredients already are in place: stakeholder engagement and an appreciation for ecological health. The former arose through the efforts of Stanford University’s convening of the Searsville Alternatives Study that began in 2011, which brought together representatives from the spectrum of concerned constituencies representing the downstream and upstream communities, academia, NGOs, and federal, state, and local governments.<sup>4</sup> The successful engagement of stakeholders

<sup>4</sup> Stanford University, 2015, Searsville Alternatives Study Steering Committee Recommendations. [https://news.stanford.edu/searsville/Searsville\\_Steering\\_Committee\\_Recommendations\\_April\\_2015.pdf](https://news.stanford.edu/searsville/Searsville_Steering_Committee_Recommendations_April_2015.pdf)

identified eight options by which steelhead passage upstream might be accomplished, which presently are under examination by relevant permitting agencies.

The latter ingredient, ecological awareness, has long been important in managing the watershed. For example, green space abounds, comprising 30-40% of the lands in the counties that makeup the drainage basin—and both upstream and downstream communities have emplaced numerous policies, regulations and programs designed to enhance ecological health and to promote appreciation for nature.

The missing piece of the Sato-umi concept in in the San Francisquito Creek watershed, however, is dialogue at *the water-shed level* that identifies and deals with both ecological and societal needs and realities, maximizing vibrancy of both. For instance, the reality of the natural system is threefold. First, the riparian and wetland habitats in the watershed harbor most of its native biodiversity, including habitats for species at risk and protected by law—not only steelhead but also red-legged frogs and western pond turtles, for example. Second, San Francisco Bay is starved for sediment, resulting in decreasing wetland and tidal habitat and inhibiting restoration efforts along the coast.<sup>5</sup> And third, inevitably, considerably greater sediment loads will be flowing through the downstream communities into San Francisco Bay within 50 years—no matter the ultimate fate of Searsville Dam. There is no stopping Mother Nature on this: the topography, geological history, and weather dictate the sediment load, and that load will either fill up the reservoir and flow over the top of the dam if the dam remains in place, or flow downstream sooner if the dam is opened for the passage of steelhead into their historic range.

At the same time, communities are grappling with how to minimize flood risk (especially downstream in the watershed) while also maintaining neighborhood aesthetics, property values, and the ecological health and viability of natural areas such as Jasper Ridge Biological Preserve in the upstream reaches and Palo Alto's Baylands Nature Preserve in the coastal reaches.

Sato-umi can provide an effective way forward, by coupling the engineering solutions downstream to the realities of the natural systems in the upper part of the watershed and incorporating design principles that maximize ecological health from its uppermost reaches into San Francisco Bay. Here, as elsewhere, the challenges for such whole-watershed management can appear daunting, but the tools clearly are available: engaged citizens, social awareness, technical, scientific, and engineering expertise (including tools to calculate economic tradeoffs that take into account the value of ecosystem services<sup>6</sup>), and a culture of innovation. These ingredients provide a rare opportunity to understand whether the Sato-umi concept can be as effective in promoting societal and ecological health in a California as it has been in Japan.

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<sup>5</sup> Patrick L. Barnard, David H. Schoellhamer, Bruce E. Jaffe, Lester J. McKee. 2013. Sediment transport in the San Francisco Bay Coastal System: An overview. *Marine Geology* 345:3-17.

<sup>6</sup> InVEST: Integrated Valuation of Ecosystem Services and Tradeoffs. The Natural Capital Project. <https://www.naturalcapitalproject.org/invest/>



## The Way Forward

It's clear that our coasts will be dramatically different from today well before the end of this century. The single most important feature of the Anthropocene that will affect our coasts is the increasingly rapid rise of sea level driven in large part by our appetite for fossil fuels. Most of our coastal regions were settled during a period of relatively stable sea level that lasted from 6,000 years ago to perhaps 100 years ago, and virtually all of our relevant law and policy was also developed during the latter portion of that period. The pace of global sea level rise doubled from 1.7 mm/year throughout most of the twentieth century to 3.4 mm/year since 1993. Global average sea level is expected to continue to rise by at least several inches in the next 15 years and by 1-4 feet by 2100. A rise of as much as 8 feet by 2100 cannot be ruled out, assuming rapid loss of the West Antarctic ice sheet. (Climate Science Special Report, Volume 1: <https://science.2017.global.change.gov>). This pattern is 'baked in' – at least for the next century or so, because of CO<sub>2</sub> already in the atmosphere and other anthropogenic effects, regardless of how much we might eventually reduce the emission of heat-trapping gases and these other effects. The scales are large and the time frames long, both for the effects to be manifested and for remediation to take place. For example, flooding associated with global sea level rise has already affected the United States; the incidence of tidal “sunny-day” or “nuisance flooding” is accelerating in more than 25 Atlantic and Gulf Coast cities. Nuisance flood days in San Francisco, California, increased 364 percent since 1960 <https://toolkit.climate.gov/topics/coastal-flood-risk/shallow-coastal-flooding-nuisance-flooding>

Local and regional sea level rises may be either greater or less than the global average because of vertical movements of coastal land forms (uplift and subsidence) and differing hydro-, geo- and bio-morphology. But, sea level will rise on most of the world's shorelines and coastlines will be redrawn, in some areas dramatically well before the end of this century. The time to begin planning for this is now, while there is still time. Make no mistake about it, this will cost many trillions of dollars, but the economic and societal costs of not acting would be far greater. It is not a matter of “if” we will have to adapt, but when will we begin that adaptation process to the ‘new normal’?

Both ahupua'a and Sato-umi teach that adaptation is effective only when it is accompanied by an educated, aware, and involved public and *acceptance* of the need to adapt. Our case studies have shown us that the role of culture and human treatment of natural systems is one part of that acceptance, but economics and politics also play critical roles, in particular when coastal private landholders have large financial stake in ownership and development of flood- or erosion-prone coastal lands. If we are to begin implementing the principles of ahupua'a and Sato-umi, the challenge for policymakers is twofold: first to inspire us to recognize the integrated value of coastal land and waters and second, to develop a means of managing the economic

and social disruption that loss of valuable coastal lands will impose on individual landowners, businesses and coastal communities.

We have perhaps 20-30 years to begin seriously to reframe and establish a new relationship with the coastline before the major effects of sea level rise will begin to require major adaptive behavior. The map of the coastline will be redrawn. Changes are inevitable. They are foreordained regardless of how much we reduce the emission of heat-trapping greenhouse gases. This is not an excuse for failing to aggressively combat climate change. How much we do to reduce emission of heat-trapping gases and how fast we do it will set the upper bounds on how much temperature and sea level will rise. The best available science makes it clear that we will have to adapt to the new normal that is barreling toward us and we have no time to waste. Following every major coastal storm our goal should be not only to get back to “current normal” as quickly as possible, but also to move ahead to the “new normal” that looms on the horizon which itself will be a moving target.

Our challenge is to create the coast FOR the future, one in sync with a significantly higher and rising sea and more frequent and intense coastal storms resulting in more billion dollar disasters, and changes in heavy precipitation leading to additional risks of coastal flooding.. We have the tools and the knowledge to do this. We need to apply them. This is a design problem and it requires design thinking and scenario planning—the exploration of alternative pathways to the future. It also requires comprehensive analysis and management of human activities in the watershed as is done in Sato-umi and ahupua’a. Finally, it requires an educated, aware, involved populace, and a great deal of political will. A new approach is needed and the Sato-umi and ahupua’a examples have much to teach us.

Appendix A

**Sato-umi Participants**

Anthony Barnosky	Professor	Stanford University
Steven Center	Vice President	Honda
Mimi D'Iorio	Manager	National Marine Protected Areas Center
James Fawcett	Professor	University of Southern California Sea Grant
Jessalyn Ishigo	Secretary	Honda Marine Science Foundation
Raminta Jautokas	Treasurer	Honda Marine Science Foundation
Amber Mace	Deputy Director	California Council on Science and Technology
Masahiro Nakaoka	Professor	Hokkaido University
Michael Orbach	Professor emeritus	Duke University
Jeffrey Payne	Director	Office for Coastal Management, National Oceanic and Atmospheric Administration
Teresa Phillips	Coordinator	Honda - Corporate Relations
Avis Poai	Professor	University of Hawaii, Richardson School of Law
Jerry Schubel	President	Aquarium of the Pacific





Appendix B

**Sato-umi in the Anthropocene**

A Forum

Co-sponsored by

The Aquarium of the Pacific

The American Honda Motor Company

13-14 November 2017

- 9:00 Welcome and Overview of Forum Goals  
Jerry R. Schubel, President of the Aquarium of the Pacific
- 9:20 What is Sato-umi? An introduction to the concept  
Steve Center, Vice President, American Honda Motor Co., Inc.
- 9:30 Sato-umi in theory and in application  
Masahiro Nakaoka, Professor, Hokkaido University
- 10:30 What is the Anthropocene—what are its characteristics and future?  
Anthony Barnosky, Professor, Stanford University
- 11:00 Break
- 11:15 Perspectives on Sato-umi and similar concepts in the Anthropocene  
(30 minutes each)
- Ahupua`a, the Hawaiian analog of Sato-umi  
Avis Kuuipoleialoha Paoi, Professor, University of Hawaii,  
Richardson School of Law
- 12:15 - 1:30 Lunch break
- 1:30 Integrated Coastal Management  
Jeffrey Payne, Director, NOAA's Office for Coastal Management
- 2:30 Some Tools for Designing and Tracking Sato-umi and similar approaches
- The role of marine spatial planning in the application of Sato-umi,  
Steven Gaines, Dean, Marine Sciences, UC Santa Barbara
  - The role of Geospatial tools in accommodating uses of the environment by Nature and  
by Humans,  
Mimi D'Iorio, National Marine Protected Areas Center
- 4:00 Comments on Designing the Coast for the Future  
Jerry R. Schubel, Aquarium of the Pacific
- 4:45 Adjourn until 7:00 pm Synthesis Session

7:00 Putting the Pieces Together: Sato-umi and its analogs as a concept for shaping the future of the Southern California coastal region.

A Panel Discussion “This is What I Heard and How it Might Apply in the Southern California Bight”

**Moderated** by Jerry Schubel, President of the Aquarium of the Pacific

**Panelists:**

- James Fawcett, Professor USC
- Michael Orbach, Professor emeritus, Duke University
- Amber Mace, Deputy Director, California Council on Science & Technology
- Alfredo Gonzalez, Resources Legacy Fund (INVITED)



