Coastal Management, 37:1–19, 2009

ISSN: 0892-0753 print / 1521-0421 online
DOI: 10.1080/08920750902851096

Taylor & Francis
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Hawaiian Islands Marine Ecosystem Case Study: Ecosystem- and Community-Based Management in Hawaii

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The Hawaiian Islands comprise a large and isolated archipelago that includes the largest reef area in the United States. Managing nearshore fisheries in this archipelago is a major challenge compounded by the difficulty of coordinating multiple agencies to provide governance across a broad series of islands with substantial social and political differences. There has been interest in, and progress toward, key elements of ecosystem-based management (EBM) in Hawaii, including networks of MPAs and community-based co-management. However, progress has been slow and largely driven by increased attention to the risks facing coral reef ecosystems, enabling both legislation and emergence of local engagement in fishery issues. Key elements of EBM in Hawaii include enhanced coordination among multiple agencies, establishment of place-based and community-based (or Hawaiian ahupua'a'-based) co-management, and acquisition of data on both the ecology of the nearshore system and the role of human impacts for use in management decisions. The development of community-based co-management and an MPA network along the western Kohala-Kona coast of the island of Hawaii (West Hawaii) illustrates a unique approach demonstrating an incremental approach toward EBM. Nonetheless, there are major challenges to scaling up the West Hawaii model to other islands within the state. These challenges include (1) the limited extent of community involvement, as well as legislative and administrative support, of community-based co-management and MPAs, (2) the complexity of conflicts that develop on more populated islands with diverse stakeholders, (3) weak enforcement of fishing regulations, and (4) whether synergy among federal, state, and local governments, nongovernmental organizations, and the scientific community will be sustainable.

Keywords community-based management, ecosystem-based management, fishery management, Hawaii, marine protected areas

Introduction

This review examines marine resource governance and management in the Hawaiian Islands Large Marine Ecosystem (LME) and how it is progressing toward the development of

This article was greatly improved by comments from Patrick Christie, Dave Fluharty, Kem Lowry, Todd Stevenson, Alan White, three anonymous reviewers, and the members of the NCEAS Working group.

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ecosystem-based management (EBM). In this article EBM is defined as "... integrated approaches to study and manage the resources of an entire ecosystem. This approach considers the cumulative impacts from various sources and the balance of conflicting uses. Using an ecosystem approach to manage aquatic resources, including fisheries, includes multiple factors such as pollution, coastal development, harvest pressure, predator/prey and other ecological interactions, and watershed management" (NOAA, 2007).

Unlike most large marine ecosystems, the Hawaiian Islands are a large, isolated area completely within the jurisdiction of a single country. The focus of this case study is the development of collaborations among multiple U.S. agencies, the challenges of developing and articulating resource management among a diverse group of stakeholders, and issues involving the local community in substantive co-management that, in some cases, integrates traditional Hawaiian management practices with modern ecosystem science. Community-based management and co-management in this article refer to both consultative and cooperative co-management models as described in Pomeroy (1995).

The Hawaiian large marine ecosystem extends from the Island of Hawaii at 19° N northwest to Kure atoll at 28° N, a distance of over 2,500 km (Figure 1). The area includes the basaltic, more geologically recent main Hawaiian Islands (MHI) and the older islets, atolls, and pinnacles of the NW Hawaiian Islands (NWHI). Coral reefs are generally well developed in the region and vary from fringing reefs on the younger islands to barrier reefs and atolls on the older islands. The region is influenced by equatorial currents, a complex eddy system, and ocean temperatures ranging from 21–29°C. Due to its isolation, the biota is characterized by a moderate to low diversity of marine species relative to other tropical Indo-Pacific regions, but a high percentage of endemic species (18–25%) (Eldredge & Evenhuis, 2003).

About 85% of the coral-reef area of the United States lies within the Hawaiian LME, with the majority located within the NWHI. The Hawaiian LME supports approximately 5,000 species of invertebrates (including 50 species of corals), 680 species of fish, and

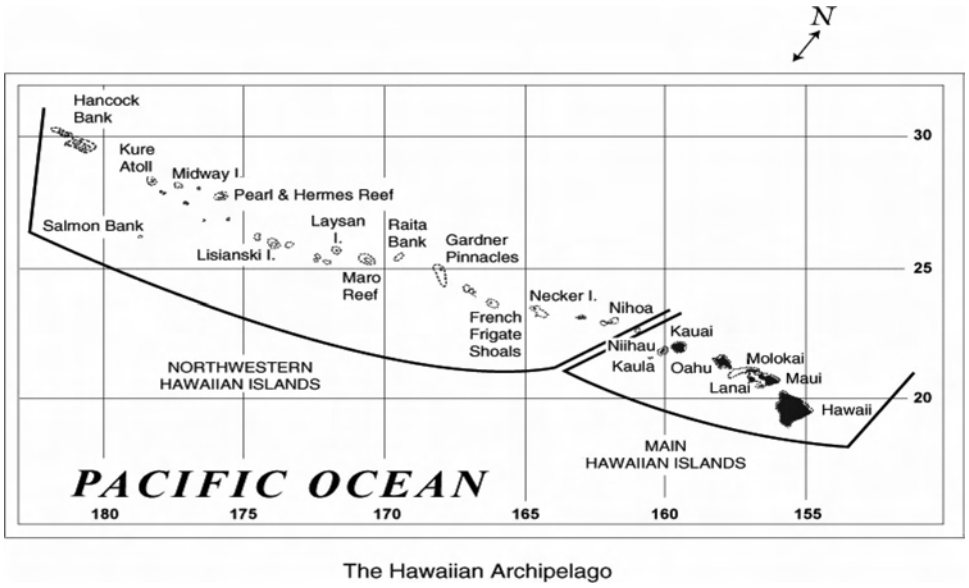

Figure 1. The Hawaiian Large Marine Ecosystem, delineating the main and NW Hawaiian Islands.

8,000 species of marine algae and plants (Eldredge & Evenhuis, 2003). Inshore fisheries are largely concentrated on the narrow shelf areas of coastal waters and target bottomfishes, reef fishes, invertebrates, and seaweeds. A migratory pelagic fishery is the region's most valuable resource and is largely comprised of ono (*Sphyraena barracuda*), mahimahi (*Coryphaena hippurus*), yellowfin tuna (*Thunnus albacares*), albacore tuna (*T. alalunga*), bigeye tuna (*T. obesus*), and skipjack tuna (*Katsuwonus pelamis*). Other important fisheries in the MHI include a live-caught aquarium fishery and a small-scale recreational and subsistence fishery (Friedlander et al., 2005). The Hawaiian LME is largely within the jurisdiction of the United States and the State of Hawaii, although transboundary fishery issues occur outside of the eclusive economic zone (EEZ) with regard to pelagic fisheries.

This study examines the development of EBM in nearshore coral-reef ecosystems of the Hawaiian Islands LME, especially the evolution of resource management in the MHI and particularly on the Kohala-Kona coast of the Island of Hawaii (hereafter West Hawaii). West Hawaii serves as an informative case study of the development of a bottom-up community-based EBM approach that can serve as a model for the rest of the state and other tropical regions.

Threats to Coastal Resources

Overfishing is a major issue in Hawaii, especially on nearshore reef ecosystems, which are facing unprecedented overexploitation and severe depletion (Shomura, 1987; Gulko et al., 2000; DeMello, 2004; Friedlander et al., 2005; Williams et al., in press). Factors contributing to overfishing include human population growth, habitat destruction, the development and introduction of new fishing techniques (e.g., inexpensive gill nets, GPS to repeatedly target specific sites), and the loss of traditional conservation practices (Friedlander et al., 2005). Although 80% of commercial fisheries focus on coastal pelagics, 113,325 kg of coral-reef fish were landed in 2007, including common and ecologically important surgeonfishes, goatfishes, and parrotfishes (Division of Aquatic Resources (DAR), unpublished data). Moreover, it is generally thought that commercial landing are underreported by as much as 50% (Zeller et al., 2005). One of the major inshore commercial fisheries includes trade in live-caught aquarium fishes, an industry that has grown rapidly in the last two decades (Walsh et al., 2003) and can have significant effects on regional populations of targeted species (Tissot & Hallacher, 2003). In addition, there is a large and widespread recreational and artisanal fishery in Hawaii for which there are no catch statistics, although there is evidence that it is four times larger than the reported commercial fisheries (Zeller et al., 2005).

Other major threats to Hawaiian marine ecosystems include coastal development, coral bleaching, disease, invasive alien species, shipwreck damage, reef trampling, and point- and non-point pollution and runoff of nutrients and sediments (Clark & Gulko, 1999; Friedlander et al., 2005). Marine debris is also a problem, particularly in the NWHI. Overall, overfishing is considered by scientists to be the largest threat to nearshore marine ecosystems in the MHI (Harman & Katekaru, 1988; Grigg & Birkland, 1997), although the general public views land-based pollution and coastal development as the greatest threats (QMark Research & Polling, 2004).

Socioeconomic and Demographic Context

The eight islands of the MHI are contained within four counties, which vary broadly in size, reef area, population density, and tourist arrival rates (Table 1). Oahu is the most populous island, has the largest reef area, and receives the largest numbers of visitors compared to the

Table 1
Geographic and demographic characteristics of the principal counties of Hawaii

	County			
Islands	Kauai Kauai & Ni'ihau	Oahu O'ahu	Maui Maui, Moloka'i, Lāna'i, Kaho'olawe	Hawaii Hawaii
Population[1]	58,463	876,156	128,094	148,677
Population density (no/km^2)[1]	41	567	62	14
Island area (km^2)[2]	1,430	1,545	1,883	10,433
Reef area (km^2)[4]	266	504	398	252
% High school degree[1]	83	85	83	85
% Below poverty[1]	10.5	9.9	10.5	12.4
% Urban[3]	55	96	78	61
% Hawaiian/part Hawaiian[3]	25	16	26	28
Total annual visitors[2]	529,560	4,606,438	837,590	781,307

[1]U.S. Census Bureau (2000).
Q4 [2]Hawaii Department of Business, Economic Development & Tourism (2004).
Q5 [3]Atlas of Hawai'i, third edition, 1998.
Q6 [4]Cesar and van Beukering (2004) [0–3 nm].

neighboring islands. Levels of education and wealth are similar across the MHI, yet there is substantial social, economic, and ethnic variation among regions within islands (Juvik & Juvik, 1998). Although the proportion of native Hawaiians is similar among counties, Hawaiian communities tend to be concentrated in several distinct areas across the state.

Tourism is the primary industry of Hawaii and generated $11.4 billion in 2004 (Friedlander et al., 2005). Over 80% of the state's tourists participate in some form of marine recreation and most of that activity occurs around coral reefs (Cesar & van Beukering, 2004). Diving and snorkeling are among the top five activities enjoyed by visitors to the islands and supported over 1,000 ocean tourism companies in 1998 (Clark & Gulko, 1999).

One of the principal management challenges in Hawaii is providing state governance across a series of islands with significant social and political differences as a result of variability in population density, ethnicity, demography, climate, and the availability and use of marine resources.

Governance Context

Hawaii has a strong central government, with most of the political power located on Oahu. Although the state government delegates some functions to county governments, it maintains full jurisdiction over many issues, including fisheries, harbor access, and boat use (Cooper & Daws, 1990).

Management of marine resources is overseen by the state and several federal agencies. In the NWHI, jurisdiction is shared among the State of Hawaii, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (USFWS). These agencies currently act as co-trustees of the NWHI under a memorandum of

understanding. The State of Hawaii, through the Department of Land and Natural Resources (DLNR), manages all land and reefs out to 3 nm except the island of Midway, which is managed by the USFWS. The remainder of the NWHI is located within the Papahānaumokuākea Marine National Monument, which was established by presidential executive order in 2006. Within the monument, USFWS manages islands and submerged lands from 3 to 20 nm offshore; the NOAA National Marine Sanctuary program is responsible for the Coral Reef Ecosystem Reserve from 3 to 50 nm offshore; the NOAA National Marine Fisheries Service manages fisheries and essential fish habitat through the Western Pacific Fishery Management Council; and both NOAA and USFWS are responsible for protecting endangered birds and mammals through the Endangered Species Act.

In the MHI, marine resources are largely managed by the Division of Aquatic Resources (DAR) within the DLNR. DAR regulates fisheries through its administrative rulemaking authority, primarily using species-specific size and seasonal limits, catch quotas, gear restrictions, aquaculture-base stock enhancement, and a variety of marine protected areas (MPAs). The Hawaii Division of Conservation and Resources Enforcement (DOCARE) is responsible for enforcing DLNR administrative rules. One of the major weaknesses in marine resource management is that DOCARE is largely ineffective, either through chronic underfunding (Friedlander et al., 2005) or lack of political will.

The state Coastal Zone Management program (CZM), which is run through the Office of State Planning, assists in coordinating resource management in coastal areas, especially land and water use. The CZM program works with federal, state, and local agencies, nongovernmental organizations (NGOs), and private sector businesses to address coastal problems. Other marine issues, such as water quality, are managed through the Hawaii Department of Health through state water quality standards. The development of large state projects that can potentially harm the environment require compliance with the Hawaii Environmental Policy Act. The University of Hawaii (UH), which has 10 campuses spanning the state, is involved in substantial education and research activities on marine resources. The UH Sea Grant College program, which is supported by both state and federal funds, promotes research, education, and outreach activities across the MHI and the Pacific.

There are a wide variety of NGOs and private sector organizations located or based in Hawaii that are involved in various efforts relating to the management of marine resources. The most prominent of these organizations include the large, international NGOs: The Nature Conservancy, National Audubon Society, Marine Biodiversity, Community Conservation Network, Conservation International, Marine Aquarium Council, Reef Check, REEF, and the Sierra Club. There are also many smaller and more locally based NGOs that play important roles in local marine resource issues, such as The Ocean Recreation Council of Hawaii, Malama Kai Foundation (West Hawaii), LOST FISH Coalition (West Hawaii), Kula Naia Wild Dolphin Foundation (West Hawaii), Pacific Whale Foundation (Maui), and Save our Seas (Kauai).

Context Leading to an EBM Approach

Ecosystem-based management (EBM) is in the early stages of development in Hawaii. Implementation of key elements of EBM, primarily networks of MPAs and community-based co-management approaches, has been a slow process. Interest in EBM has largely been precipitated by the emergence of local community-based solutions to conflictive fishery issues, increased attention to coral reef ecosystems both nationally and internationally, and national and state legislation that increased management and research opportunities. This context has created a catalyst for more collaboration among state, federal, and local organizations.

In response to long-term pressure from Hawaiian communities to promote local co-management of marine resources, the Hawaii legislature passed the Community-Based Subsistence Fishing Area (CBSFA) Act in 1994 (Minerbi, 1999). This law established a legal process whereby DLNR could designate areas as CBSFAs to allow local communities to assist in the development of enforcement regulations and procedures and fishery management plans that incorporate traditional knowledge. These communities contain a high proportion of native Hawaiians and are generally organized around traditional Hawaiian *ahupua'a*, or former geopolitical land divisions located within individual watersheds (Friedlander et al., 2002; Tissot, 2005). Since 1995, three such areas have been designated as CBSFAs in Hawaii. However, the designation for Moomomi Bay on Molokai was repealed due to inaction, and no management rules have yet been drafted for the CBSFAs at Milolii (West Hawaii) and Haena (Kauai).

Federal and international effort to conserve coral reef ecosystems created synergy for several existing groups within the state (primarily the Sierra Club, the University of Hawaii, the CZM, the Pacific Whale Foundation, Save Our Seas, and the *Malama Kai* Foundation) to begin activities that subsequently gave rise to the Hawaii Coral Reef Initiative (HCRI). These activities were formerly validated in 1994 by a legislative resolution (H.R.379) calling for community-based approaches to education, conservation, and research on coral reef ecosystems. The 1997 International Year of the Reef, followed by the 1998 executive order establishing the U.S. Coral Reef Task Force, and the approval of the Coral Reef Protection Act (Craig, 2000), provided momentum for the development of the Hawaii Coral Reef Initiative Research Program (HCRI-RP). HCRI-RP was established in 1998 as a partnership between the UH and DAR, and has provided flow-through funding from NOAA to support management-driven research projects across the state. These projects have resulted in major increases in the understanding in the biology and ecology of reef fishes, invertebrates, and seaweeds; have identified important threats to nearshore resources; and have helped develop a state-wide assessment of seaweeds, invertebrates, and fishes in both the MHI and NWHI (Hamnett et al., 2004). These projects, combined with earlier research from UH and the legislatively mandated Main Hawaiian Islands Marine Resource Investigations program (e.g., Smith, 1993) have contributed substantially to the knowledge base on marine resources on which EBM efforts have begun.

In 2000, President Clinton created the NWHI Coral Reef Ecosystem Reserve. While planning for the reserve was in process in 2006, President Bush designated the area as a national monument under the Antiquities Act. The area was subsequently named the Papahānaumokuākea Marine National Monument, creating one of the largest MPAs in the world. These remarkable events not only dramatically increased the attention state and federal agencies gave to the NWHI, but also required closer collaboration among the multiple agencies in Hawaii to resolve jurisdictional issues and develop joint management and research plans to address emerging threats. One of the major findings of initial research conducted in the monument was the stark contrast between the huge number of apex predators in the NWHI compared to the MHI, which provided new insights on the extent and impacts of overfishing in the MHI and the importance of MPAs (Friedlander & DeMartini, 2002).

EBM in Hawaii

Of the multiple agencies that have jurisdiction in Hawaii, only NOAA has adopted an explicit EBM policy (NOAA, 2005) and is implementing an ecosystem approach to fisheries management (Christie et al., 2006). The state (CZM, DAR, DLNR, Department of Health

and others), local counties, along with other federal agencies, have adopted some EBM principles in their most recent ocean resource cooperative agreements (Hawaii Ocean Resources Management Plan [ORMP], DBEDT, 2006) and in their research plans (Hawaiian Archipelago Marine Ecosystem Research [HAMER], NOAA, 2008).

The ORMP was first developed in 1991 and has evolved over time with status reports to the legislature in 1998 and 2006 (DBEDT, 1998, 2007). The most current version of the plan (DBEDT, 2006) is based on three guiding perspectives: (1) connecting land and sea (i.e., the a*hupua'a* concept); (2) preserving ocean heritage; and (3) promoting collaboration and stewardship. Overall, the ORMP strives to develop new perspectives on relationships between people and the land and sea, which build on traditional Hawaiian management principles and lessons learned from past efforts. This approach clearly encompasses many aspects of NOAA's ecosystem approach to fisheries as it involves an integrated, place-based approach to both natural and cultural resource management that encourages greater collaboration among jurisdictional authorities and promotes community involvement and stewardship.

In contrast, the Hawaiian Archipelago Marine Ecosystem Research (HAMER), which was developed collaboratively with DAR, the Papahānaumokuākea Marine National Monument, NOAA, UH, USFWS, and the Western Pacific Fishery Management Council, outlines a 10-year place-based ecosystem research initiative focused on understanding broad-scale, archipelago-level, ecosystem processes (NOAA, 2008). The plan identifies six research themes important to management, including: (1) ecosystem indicators and metrics; (2) native biodiversity and invasive species; (3) connectivity; (4) human interactions; (5) resilience and recovery; and (6) modeling and forecasting. These themes represent important research components in both the NOAA ecosystem approach to fisheries and the Hawaii ORMP. Thus, all of the major state and federal agencies operating in Hawaii are focused on some aspects of EBM, although the details and priorities among them are different.

If EBM can be viewed as a set of tools to promote sustainable resources, then there are several aspects of fisheries and coastal management in Hawaii that are prominent components of that toolbox. These include better coordination among multiple agencies, establishment of community-based or watershed (a*hupua'a'*)-based co-management, and acquisition of detailed ecological data for use in management decisions, including the incremental impacts of humans in a broader context. Surprisingly absent from these plans are explicit reference to the development and use of MPAs as an EBM tool, despite the existence of 52 MPAs in Hawaii, broad acceptance of MPAs from the scientific community (MCBI, 1998; Murray et al., 1999; NCEAS, 2001), and strong evidence of the effectiveness of MPAs to improve management of marine resources (NRC, 2001), particularly on coral reefs ecosystems (e.g., Pollnac et al., 2001, Russ & Alcala, 2003, McClanahan & Graham, 2005, Friedlander et al., 2007).

EBM in West Hawaii

The development of community-based management in West Hawaii illustrates a unique approach within the state that provides an informative example of an incremental approach toward EBM. The overall management goals in West Hawaii, which have emerged over time with community involvement, are to promote sustainability of marine resources, reduce user conflicts over resources, and involve the community in collaborative decision-making (Maurin & Peck, 2008).

The West Hawaii community has a long history of collaboration regarding resource conflicts, primarily concerning the aquarium fishery, which extends back into the late 1980s

(Walsh, 2000; Maurin & Peck, 2008). Through informal agreements and working groups, various management strategies were developed over time in conjunction with increasing interest by several institutions and organizations (in particular DAR, the University of HawaiI, and other universities, the *Malama Kai* Foundation, the LOST FISH Coalition, and several dive tour boat operations). The LOST FISH Coalition is a local NGO that was initially focused on the banning of aquarium collecting in West Hawaii (Capitini et al., 2004), but has since served as a consistent, long-term lobbying group focused on the broad goals of managing fisheries effectively, ensuring sustainability, minimizing user conflict, and enhancing near shore marine resources (Maurin & Peck, 2008). Synergy among these organizations, along with high community involvement and support, eventually created a critical mass for effective co-management through Act 306 of the Hawaii State Legislature in 1998 (Hawaii Revised Statutes 188F).

Act 306, which was sponsored by representative David Tarnas (D–N. Kona/S. Kohala, 1994–1998), a marine resource planner and former Sea Grant Extension Service agent for West Hawaii, established the West Hawaii Regional Fishery Management Area, which provided a flexible administrative framework through DLNRs rulemaking authority that promoted an adaptive, co-management approach to resource management. Act 306 promoted the input and consideration of ecological information as well as local knowledge into a co-management process for creating a network of MPAs along the West Hawaii coast and developing management plans to deal with current and emerging threats. Thus, one of the key ingredients for success in West Hawaii is the presence of both top-down (government-driven) facilitation and bottom-up (community-driven) involvement, resulting in effective community-based co-management.

Assessing Effectiveness of EBM

A list of criteria used to define and measure progress by ORMP, HAMER, DAR, and Act 306 is listed in Table 2. The ORMP has multiple criteria for success, most of them focused on social and institutional measures (DBEDT, 2007). In contrast, HAMER is focused on ecological criteria but explicitly includes EBM criteria, including understanding the response of human impacts to marine ecosystems using the NWHI as a comparison for the MHI. Apart from its role in the ORMP and HAMER, DAR has no formal management plans for managing its fisheries, although common metrics discussed in research reports (e.g., DAR, 2000) and educational outreach material are included in Table 2 and include a range of ecological, economic, social, and institutional criteria.

The specific mandates of Act 306 required: (1) substantive involvement of the community in resource management decisions; (2) designation of $\geq$30% of coastal waters as "Fishery Replenishment Areas" (FRAs) where aquarium fish collecting is prohibited; (3) establishment of a portion of the FRAs as marine reserves, or no-take areas, where fishing is prohibited; (4) evaluation of the effectiveness of these FRAs after 5 years; (5) establishment of a day-use mooring buoy system; and (6) designation of areas where the use of gill nets as set nets shall be prohibited. Here, we will primarily focus on goals 1–4. The measures of effectiveness associated with these goals include ecological, economic, social, and institutional criteria (Table 2).

EBM Progress

Elements of EBM have been present in multiple planning documents since the 1990s at the state level; however, there has been little progress toward these goals in the MHI. Although

Table 2
Effectiveness indicators as defined by the Hawaii Ocean Resources Management Plan (ORMP), Hawaiian Archipelago Marine Ecosystem Research Program (HAMER), Hawaii Division of Aquatic Resources (DAR), and ACT 306, which created the West Hawaii Regional Fishery Management Area

	Institution			
Metric	ORMP	HAMER	DAR	Act 306
Ecological criteria				
Change in abundance of targeted species		X	X	X
Change in reef health (% cover, bleaching, disease)		X	X	X
Change in water quality (nutrient content, turbidity)	X			
Change in introduction & spread of invasive species	X	X	X	
Change in ecosystem resilience & recovery		X		
Degree of connectivity among islands		X		
Develop models and forecasting for long-term planning		X		
Economic criteria				
CPUE & value of targeted species		X	X	X
Revenue of marine industries (dive tourism, hotels)	X			
Expand ocean science & technology	X	X		
Social criteria				
Degree of participation in co-management	X		X	X
Incident of conflicts among stakeholders	X		X	X
Degree of compliance to regulations	X		X	X
Number of reported incidences	X		X	X
Extent of human impacts to marine systems	X	X	X	X
Develop community-base frameworks to minimize conflicts	X		X	X
Develop integrated natural/cultural planning process	X		X	X
Build capacity for community participation	X	X	X	X
Institutional criteria				
Development of integrated shoreline policy	X		X	
Reduction in failed wastewater collection systems	X			
Strengthen & expand MPA management				X
Develop EBM approaches for nearshore fisheries	X	X	X	X
Improve enforcement capacity & voluntary compliance	X		X	X

Table 3

Q7 Organizations involved in community-based fishery management in West Hawaii

Organization	Role
State institutions	
DAR	Oversee implementation of Act 306
	Facilitate West Hawaii Fishery Council
	Conduct research
Univ. of Hawaii SeaGrant	Education & outreach
	Volunteer monitoring networks
	Research grants
Univ. of Hawaii (Hilo & Manoa)	Conduct research
	Education & training
Other universities	Conduct research
	Education & training
DOCARE	Enforcement of regulations
DBOR	Boating regulations for day-use mooring system
Federal institutions	
NOAA	Research funding
	Education
USGS/NPS	Conduct research (in National Parks)
	Research funding
	Education
USFWS	Research funding
	Education
Nongovermental organizations	
LOST FISH Coalition	Political pressure on DAR & Legislature
	Community support
Malama Kai Foundation	Support (Big Island Reef Fund)
	Education
Community Conservation Network	Support (Big Island Reef Fund)
	Education & outreach
Nature Conservancy	Education & outreach
	Community support
Marine Aquarium Council	Training & certification
Conservation International	Research funding
	Education

317 DAR has been part of the ORMP since 1991, little progress has been made toward ORMP
318 goals, specifically the development of a comprehensive plan for assessment, monitoring,
319 and management of nearshore fisheries in 1998 (DBEDT, 1998). DAR has not developed
320 management plans *per se* for any nearshore species, but instead regulates fisheries through
321 traditional species-specific restrictions on place, gear, size, and season. DAR has established
322 species-specific fishery regulations for 22 marine fishes (12 pelagic, 7 reef, and 3 bottomfish
323 species), 8 marine invertebrates (including all corals and "live rock"), and two seaweeds.
324 Overall, less than 0.1% of the state's fish species have specific regulations. DAR is currently
325 engaged in a process to expand regulation to a wide range of nearshore marine species.

DAR also uses a system of MPAs to regulate human activities throughout Hawaii (Figure 2), including 11 marine life conservation districts, 18 fishery management areas, 12 bottomfish restricted fishing areas, 2 public fishing areas, and several additional area designations, some of which are co-managed with other state and/or federal agencies. Marine life conservation districts provide the highest level of protection and in some cases function as fully protected marine reserves. Fishery management areas provide specific species and/or gear restrictions while allowing other activities. Although there are 52 MPAs in the MHI, less than 1% of coastal areas are fully protected and thus MPAs do not currently represent an important resource management tool at the state-level.

A legislative report on the progress of the ORMP in 2005–06 made the following recommendations based on extensive feedback from a variety of institutions, organizations, and public meetings:

- increases in or better allocation of funding, personnel, resources, and equipment;
- greater community involvement and input in the management of ocean resources;
- more collaborative governmental efforts and procedures, including the permitting process;
- establishment of additional MPAs; and
- more education and integration of *ahupua'a* and/or place-based management concepts and resource protection measures. (DEBEDT, 2006, 6–7)

This evaluation reveals several of the major challenges facing Hawaiian marine resource management in general, and EBM in particular. These include underfunding, consequently weak management and enforcement, lack of community involvement, and lack of state support for MPAs.

Role of Governance

Although the State DAR has legal jurisdiction over activities in all state waters, in practice, a large amount of the actual management is in fact initiated at the local level, which is largely island-, community-, and/or watershed-based (modeling the traditional Hawaiian *ahupua'a*). In some cases these local efforts are largely community driven; in others they may be substantially influenced by NGOs.

Although governance is strongly centralized in Hawaii, there are significant social and political differences among islands and among different regions of islands due to variability in population density, demography, climate, and the availability and uses of marine resources. These differences result more from the traditional place-based Hawaiian ways of managing resources, rather than true resource or ecosystem boundaries, and they usually involve some level of community involvement. In other words, islands are fairly isolated from each other in terms of community, which tends to drive more local, rather than central, solutions to emerging problems, at least on marine resource issues.

Weak enforcement by the Hawaii Division of Conservation and Resources Enforcement (DOCARE) is a major problem in marine resource management. DOCARE generally does not issue citations unless contacted with a specific complaint. In areas that have active community-based management, community members may serve to facilitate enforcement of regulations by reporting to DOCARE, and this approach has been shown to be effective (CNN, 2006). However, there are few data on rates of compliance so it is difficult to evaluate the effectiveness of regulations. DLNR has recently proposed new administrative rules to develop a Civil Resources Violation System, which would establish civil penalties for

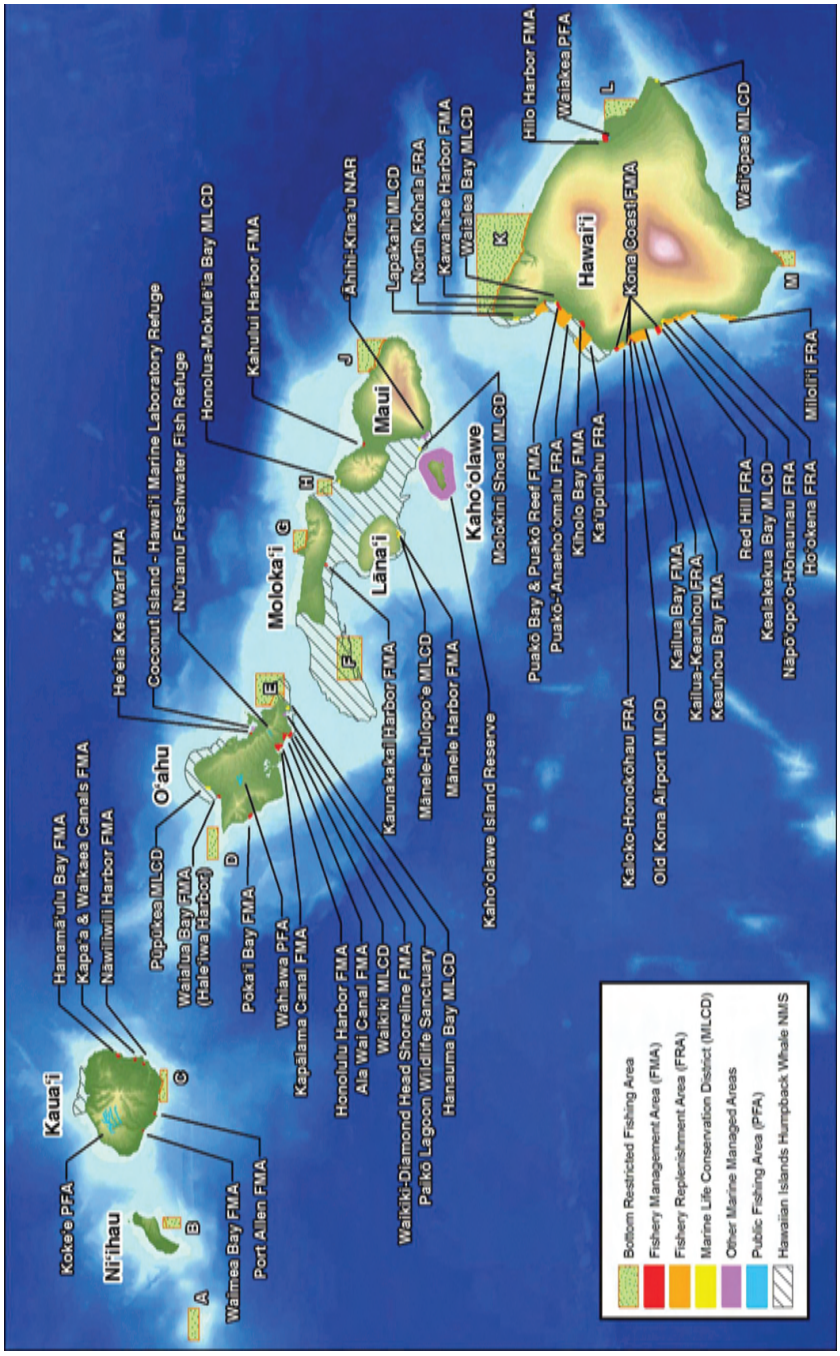

Figure 2. Marine protected areas in the main Hawaiian Islands.

natural resource violations and could potentially provide improvement in marine resource enforcement issues.

NGOs and the UH Sea Grant College Program play a strong role in marine education and management in Hawaii and have been largely responsible for initiating and/or supporting local community-based initiatives at several levels. NGO-initiated activities include conferences, educational outreach programs, restoration projects, organizing volunteer reef monitoring, providing funds for day-use boat moorings and reef monitoring, organizing community support of enforcement activities (e.g., Mauka-Makai Watch), and partnering in the development of community-based marine protected areas and CBSFAs. Activities in the latter category are increasingly important in Hawaii.

Progress in West Hawaii

EBM *per se* was not an explicit goal of Act 306, nor of the community in West Hawaii. However, the progress made over the last 20 years illustrates an incremental approach building on a suite of existing and new management tools to address current and emerging threats with substantial DAR, scientific, and community involvement.

Two collaborative programs were launched to implement Act 306: (1) the West Hawaii Fisheries Council (WHFC) was created in 1998 to develop and recommend management plans to DLNR; and (2) the West Hawaii Aquarium Project (WHAP) was started in 1999 to study the effectiveness of the FRA network to replenish aquarium fish populations and the effects on the aquarium fishery.

In conjunction with the University of Hawaii Sea Grant, DAR assembled the WHFC using members from diverse geographic areas that represented the various stakeholder, community, and user groups in West Hawaii (Walsh, 1999; Capitini, et al., 2004; Maurin & Peck, 2008). Forty percent of the initial WHFC members were native Hawaiians, and regional representation was designed to overlap with traditional a*hupua'a* (Tissot, 2005, Maurin & Peck, 2008)

The WHFC, through a collaborative, environmental dispute resolution process, developed operating rules and procedures that eventually led to a plan for the location of nine new FRAs in West Hawaii (Capitini et al., 2004). When combined with previously designed MPAs, the FRAs collectively prohibited aquarium collecting in 35.2% of the West Hawaii coastline (Tissot et al., 2004). Because there was little biological information on the targeted aquarium fishes or habitat distributions on which to base FRA design, the network was spread out relatively evenly across the coastline, with new FRAs being placed next to existing MPAs whenever possible (Figure 3).

During a public meeting in 1999, the FRA plan received overwhelming support (93.5% of 876 testimonies) from a wide range of community sectors (Capitini et al., 2004) and was signed into law in December 1999 as HRS 188F. However, as of 2008 the establishment of a fully protected marine reserve has not been realized due largely to vast disagreements among stakeholders and strong resistance from the recreational fishing community (Maurin & Peck, 2008).

WHAP was started in 1999 to study the effectiveness of the FRAs to replenish aquarium fish populations, but has also provided an unprecedented long-term time series of data on a wide range of reef species. Prior to the FRA network closure, WHAP established 23 permanent study sites of three kinds: (1) within the nine FRAs; (2) in eight adjacent areas open to aquarium fish collection, which served as reference "open-control" sites; and (3) in six nearby marine life conservation districts and fishery management areas previously closed to collectors, which served as reference "closed-control" sites. WHAP

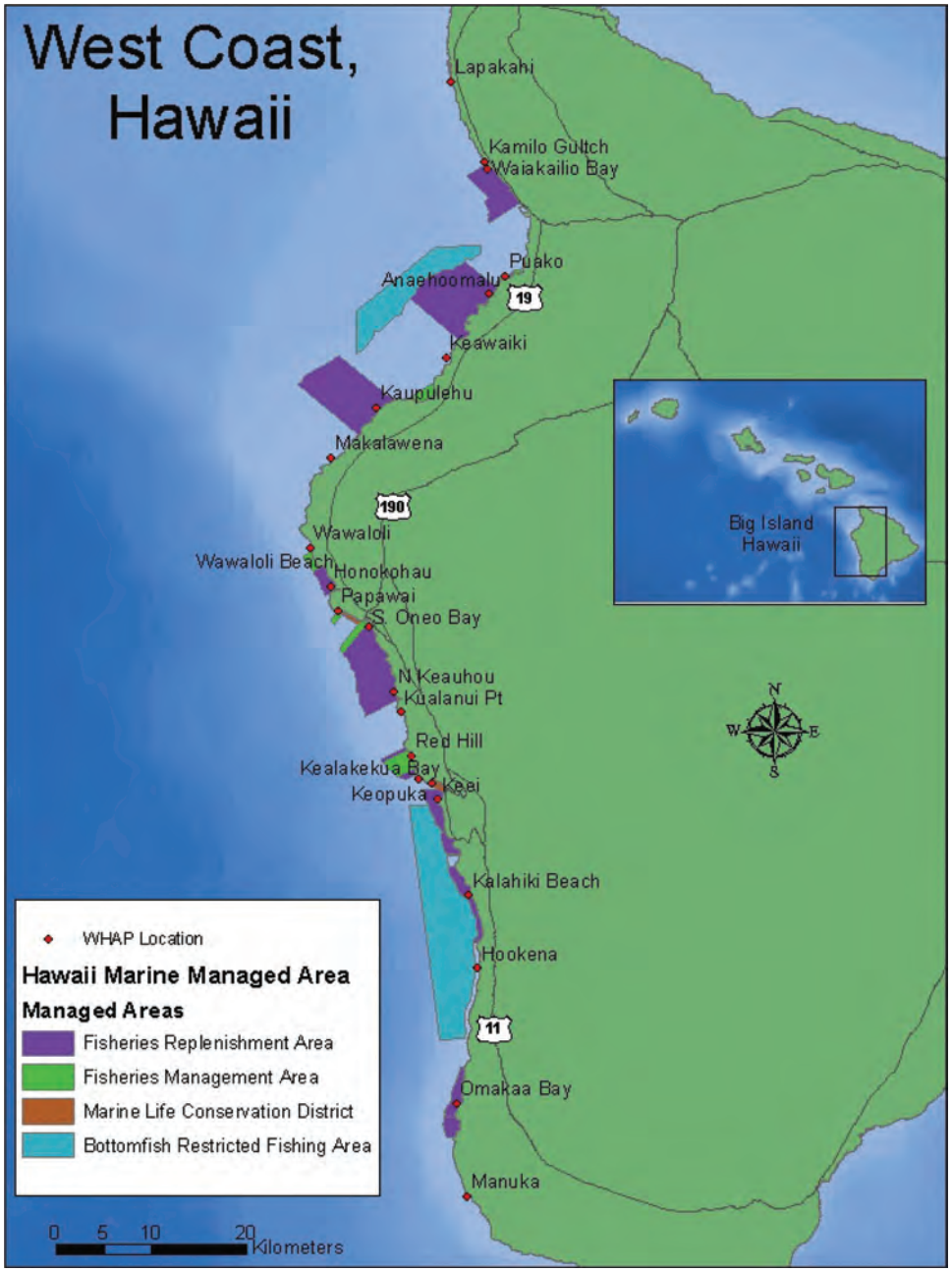

Figure 3. Marine protected areas in West Hawaii, with Fishery Replenishment areas indicated in blue.

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418 was designed as a statistically rigorous "doubled controlled" before-after-control-impact
419 design to detect long-term changes in the fish communities within and outside the FRAs and
420 to measure effectiveness (Tissot et al., 2004). The monitoring program was a collaborative
421 effort between DAR and UH and largely utilized college students trained by university

faculty and DAR (Tissot, 2005). The program was initially funded (1999–2004) by the HCRI-RP with funds from NOAA and DAR and has since been partially institutionalized within DAR, with continued NOAA support since 2004.

The WHFC and WHAP are coordinated to some extent with several education programs in West Hawaii to articulate the results of these efforts to the greater public. These are coordinated by several institutions and NGOs including the UH Sea Grant, the *Malama Kai* Foundation, and UH-Hilo. In addition, there are several ad hoc volunteer monitoring networks that have been involved in education and science with K–12 and college students and local community members for many years (Maurin & Peck, 2008) (Table 2).

Assessment of Effectiveness

Act 306 specifically mandated a five-year review of the FRA network along with recommendations for future changes in management. This review was completed, disseminated to the state legislature, and the results have been communicated to the WHFC and to the public and through educational programs and brochures (Walsh et al., 2004).

At the time of the initial five-year evaluation of the FRA network, seven of the ten most heavily collected species (representing 94% of all collected fish) had increased in overall density (Walsh et al., 2004). The FRAs have been particularly effective in significantly increasing the abundance of two species between 1999 and 2004: Yellow tang (*Zebrasoma flavescens*), which increased 49% and is by far the most heavily targeted aquarium fish, and chevron tang (*Ctenochaetus hawaiiensis*), which increased 141% (Walsh et al., 2004). While specific FRAs varied in their effectiveness to increase fish stocks, overall seven of nine of the MPAs showed a positive effect on the abundance of yellow tang, with four FRAs showing statistically significant increases in abundance.

The effectiveness of the FRA network has been associated with an increase in the productivity of the aquarium fishery. Based on aquarium collector catch reports, the total catch, and the catch of the top two species, yellow tang and goldring surgeonfish (*Ctenochaetus strigosus*), was higher in 2004 than in its previous 38-year history. The price per fish received by collectors for yellow tangs also increased by an average of 33% subsequent to FRA establishment (Walsh et al., 2004). Moreover, catch per unit effort (CPUE) of aquarium fish is higher in West Hawaii than elsewhere in the state and has maintained an upward trend. Some of the increased could be due to spillover of fish swimming out of the FRAs (Williams et al., in press). There has also been an increase in permit holders and number **Q8** of active fishers that could also account for some or all of these changes (Todd Stevenson, unpublished data).

Surveys of the abundance and distributions of key reef fish habitats within two FRAs has shown that effective FRAs generally had high coverage of high-relief finger coral (*Porites compressa*) adjacent to open areas of high algal abundance (Ortiz & Tissot, 2008). Finger coral has been shown to be an important habitat for the survival of juvenile reef fishes, particularly yellow tang, which mature adults generally prefer open, algal-rich habitats (Walsh, 1984). This type of information is key to the design of future effective MPAs in Hawaii.

In addition, recent research on larval dispersal around the island of Hawaii provides a possible explanation for the documented increases in abundance and catch of yellow tang: larval "seeding" and replenishment of fished areas by spawning in FRAs and other unfished areas. During the peak recruitment season in 2006, hundreds of adult fish (potential parents) and young-of-the-year fish (potential offspring) were sampled by fin clipping at 10 sites around Hawaii (Christie et al. in preparation). Sampled sites included 3 FRAs **Q9**

and 3 adjacent monitoring sites along the west (Kohala-Kona) coast, as well as 2 sites each along the northeast (Hamakua-Hilo) and southeast (Puna-Kau) coasts. Genetic analyses (parentage based on microsatellite DNA) have thus far revealed 4 parent-offspring pairs, demonstrating both general northward within-island larval dispersal, and especially, seeding via larval connectivity between local populations of yellow tang. Such studies of population connectivity are crucial for understanding both how MPA networks function at the metapopulation level and how to design effective MPA networks at both island- and archipelago-level scales.

Social dimensions of resource management in West Hawaii were equally important in promoting sustainability in the aquarium fishery. Given the limitations of existing marine resource enforcement, it was recognized early in the FRA process that widespread community involvement and "buy in" were essential if rules recommended by the WHFC and adopted and implemented by DLNR were to be effective. Active involvement is reflected in substantial increases in enforcement actions after FRAs were established (2000–2003: 18 actions) relative to before FRAs were established (1996–1999: 6 actions). Many if not most of these enforcement actions were initiated by members of the community. Overall, compliance by collectors has generally been good and by all accounts, incidents of harassment and conflict between collectors and other ocean users have been markedly reduced (Walsh et al., 2004).

The West Hawaii community's formation of the WHFC and WHAP with continued support from DAR has been, and continues to be, invaluable and instrumental in achieving the objectives of Act 306. The WHFC is an effective co-management system for the resolution of conflicts surrounding reef fishery resources and coral reef conservation, and is a major step toward EMB in West Hawaii and a model for the State of Hawaii and the broader tropical Pacific in general.

Conclusions: The Evolution of EBM in Hawaii

Improved management in West Hawaii has been noted throughout the state and attempts have been made at several levels to implement similar solutions in other areas. In 2004, a bill (H. B. 2056) was introduced to the Hawaii state legislature to create state-wide community-based co-management area councils and management plans. The bill touted successes in Moomomi Bay, MiloliI, and West Hawaii and other areas in the Pacific, but did not include specific recommendations to develop and implement MPAs. Although the bill had moderate support within the legislature and state-wide, fishing groups, primarily recreational and artisanal fishers, a much larger group than aquarium collectors, rallied together and defeated the bill. Despite this opposition, a community-based fishery council was established on Maui in 2008 modeled after, and with the assistance of, the WHFC.

Thus, there remain major challenges to scaling up and implementing the West Hawaii model in other islands within the state. These challenges include (1) the varying degree of community involvement in and support for community-based management; (2) the political influence of fishing organizations and the perceived threat to their way of life; (3) the complexity of conflicts that develop in larger communities; (4) the constrained ability of DAR to support community-based efforts and MPAs; (5) the limited effectiveness of DOCARE to enforce fishing regulations; and (6) the uncertain degree of necessary synergy among various authorities and organizations that can reasonably occur in other regions of Hawaii, including the NWHI.

Due to the limitations of funds within DAR, which ranked 48 out of the 50 states for revenues to fish and wildlife agency budgets in 1995, the current arrangement in West

Hawaii has depended on outside financial support through state and federal agencies and NGOs, and on several key individuals. Expanding this model to the rest of the state would incur substantial additional costs in a financially stressed agency. Adequate enforcement also continues to be a major problem with the management of marine resources throughout the MHI, although there have been recent efforts to increase the budget to DOCARE to expand their capabilities.

To achieve EBM throughout Hawaii will take large amounts of time and resources. The first challenge is to support existing community-based fishery management and research efforts throughout the state, learn from their experiences, and help them achieve financial sustainability. This goal in itself is a major challenge due to the vagaries of state and federal funding and the shifting priorities of NGOs. An additional task is to scale up and extend these models, in conjunction with the development of MPA networks, to the rest of the MHI. To do this, the state would need to:

1. establish local fishery councils on each island to develop collaborative fishery management plans;
2. develop a coordinated state-wide system of MPAs;
3. develop a state-wide monitoring program within DAR that addresses critical data needs; and
4. use ecosystem principles and information to coordinate and integrate management strategies among islands and between the main and NW Hawaiian islands.

The actions outlined in both the ORMP and HAMER, if implemented, represent important elements of EBM. These actions, if incorporated with locally emerging solutions, would represent an important step toward the development of EBM throughout Hawaii that could serve as a model for tropical island nations worldwide.

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