

CHAPTER 3

STATE OVERVIEW, THREATS, AND CONSERVATION ACTIONS

Due to its extreme isolation, Hawai‘i is characterized by high levels of endemism in its aquatic animals. The islands also have a large human population. As a result, Hawai‘i presents both tremendous opportunities and challenges for conservation. To fully understand these opportunities and threats requires a detailed understanding of the background conditions and issues in the State. The goal of this chapter is to provide this background and then develop the major conservation objectives to deal with the challenges raised.

SOCIAL OVERVIEW

Human Landscape

The population of the State of Hawai‘i was estimated at 1,262,840 people in 2004, with the majority (70%) found on O‘ahu, in the City and County of Honolulu (899,593). The nearly seven million visitors in 2004 contributed an additional average of 170,000 people per day, mostly on O‘ahu and Maui. Hawai‘i has four local governments: the City and County of Honolulu (island of O‘ahu and the Northwestern Hawaiian Islands), the County of Kaua‘i (islands of Kaua‘i and Ni‘ihau), the County of Maui (islands of Maui, Moloka‘i, Lāna‘i and Kaho‘olawe), and the County of Hawai‘i (island of Hawai‘i). Hawai‘i also has a fifth county, Kalawao County, which does not have a separate government unit. Kalawao County covers the former Hansen’s disease settlement at Kalaupapa (Moloka‘i) and is managed by the National Park Service (NPS) under a cooperative agreement with the State Department of Health.

Based on a 2004 “Wildlife Values in the West” survey, 71 percent of Hawaii’s residents strongly agree that it is important to prevent the extinction of endangered species and 94 percent find it acceptable to close some areas to human use to protect wildlife (Teel & Dyer, 2005). In 2001, an estimated 20 percent of the population participated in some type of wildlife-associated recreation (e.g., fishing, hunting, wildlife watching), with a large proportion of the \$10 billion dollar tourism sector indirectly related to the viewing of marine wildlife. One study estimates that snorkeling and diving alone generate \$364 million dollars each year in added value for the State.

Fishing is another industry with economic ties to the aquatic environment. Total recorded commercial landings for marine species in 2003 for Hawai‘i (most recent statistics) was over 22 million pounds with a direct value of over 50 million dollars. Of that, approximately 5 million pounds were caught in the Main Hawaiian Islands (MHI), approximately 300,000 pounds in the Northwestern Hawaiian Islands (NWHI), and 17 million pounds in “other areas,” which includes mid-ocean and records of catch that did not specify area. The total commercial landings include approximately 13.6 million pounds of tuna, just under three million pounds of bill and swordfish, just under four million pounds of pelagic fishes, 520,000 pounds of deep bottomfishes, and 750,000 pounds of akule and opelu. Total commercial landings also include approximately 64,000 pounds of invertebrates (lobsters, crabs, shrimps, octopus, squid, and opihi) and 9,000

pounds limu or seaweed species. Recreational and subsistence catches are poorly known but likely to be in this range as well.

Water and Land Use

Hawai‘i withdraws about two billion gallons per day of water, with just over 500 million gallons coming from groundwater sources, and the rest from surface water diversions and withdrawals. Water consumption is about 550 million gallons per day (mgd). Freshwater resources are managed by a number of different State and Federal agencies. The DLNR-Division of Aquatic Resources (DAR) and the U.S. Fish and Wildlife Service (USFWS) are responsible for managing freshwater animals. The Hawai‘i Department of Health and the U. S. Environmental Protection Agency are responsible for managing water quality and pollution under the Clean Water Act and other legislation. Coastal zone management, including development permits in Special Management Areas, is the joint responsibility of the State Department of Business, Economic Development, and Tourism Coastal Zone Management Program and the U. S. National Oceanographic and Atmospheric Administration (NOAA). The DLNR Commission on Water Resources Management is responsible for water quantity and stream alterations.

Nearly half of Hawaii’s 1.66 million hectares (4.1 million acres) are managed by the State or Federal government. The largest landowner, the State of Hawai‘i, manages over 467,000 hectares (1,155,900 acres) for watershed protection, preservation of natural resources, agricultural use, recreation, transportation, and public safety. The Federal government owns or manages, through leases or cooperative agreements, more than 270,000 hectares (671,579 acres) for a variety of purposes, including conservation of natural and cultural features, protection of wildlife habitat, military support and training, and public safety. The remaining land is in private ownership and much of this land is controlled by a few owners. Some of these lands are managed in cooperation with adjacent landowners for conservation purposes as part of a watershed partnership. There are nine watershed partnerships on six islands, involving more than 50 public and private partners and covering over 344,000 hectares (850,000 acres) of forested watershed.

Unlike many other states, Hawai‘i has statewide land use classifications, with all land being zoned in one of four categories: Conservation, Agricultural, Urban, and Rural. A significant portion of the State (31%) has been designated for long-term resource protection and receives varying degrees of management, especially in the Conservation District. In addition, in Special Management Areas located along the shoreline, each county provides special control of development, even for land already subject to Conservation District restrictions. The Hawaiian Islands Humpback Whale National Marine Sanctuary (NOAA and DLNR) protects an additional 364,200 hectares (900,000 acres) of marine waters, while the NWHI Coral Reef Ecosystem Reserve protects submerged lands and waters in the NWHI. Over 40 additional marine areas have conservation protections or restrictions on various forms of fishing.

Tourism, of which a large part is related to use of the marine environment, is the primary economic activity in the State, with more than 6.9 million visitors and \$10.3 billion in expenditures in 2004 alone. Agriculture, primarily pineapple cultivation and diversified agriculture, and military expenditures are important secondary economic drivers.

However, over the last decade, major land use trends include the transition from agriculture (e.g., sugar cane, pineapple cultivation) to resort-residential development and large-lot residential subdivisions on agricultural lots. This affects Hawaii's watersheds because although there has been a decrease in agricultural non-point source pollution, there has been an increase in domestic and commercial non-point and point source pollution.

Cultural Use of Native Wildlife

Wildlife in Hawai'i play a significant role in Native Hawaiian culture. Historically, whale ivory, shells, and shark's teeth were used for necklaces and other adornments. Fish and sea turtle bones were used as kitchen implements, tools, and fishhooks, while sea turtle shells and scutes were used as containers. Koa (*Acacia koa*) trees were used for the ocean-voyaging canoes. Numerous other examples of the use of native plants and animals in both daily life and ritual exist (see articles by Titcomb in references). In present day Hawai'i, the link between Native Hawaiian culture and native species has not been lost and continues to be practiced in belief systems, as well as in traditional practices such as gathering of native wildlife for hula, traditional medicines, carving, weaving, and ceremonies.

The belief system of the Native Hawaiians links people with all living and non-living things. Native Hawaiians, as *kanaka maoli* (native people), see themselves as guardians of ecosystems and their well-being is directly related to the well-being of these ecosystems. Many species such as sea turtles, sharks, and several terrestrial animals are believed to be 'aumakua (ancestors or guardians) of certain Hawaiian families. Hawaiian names have been given to many native and Polyensian species, and they have been incorporated into *oli* (chants) and *mo'olelo* (legends). Native Hawaiian land ownership and resource management were often based on a unit called the *ahupua'a*, which typically corresponded with what we today call watershed areas. This understanding of the link from uplands to the ocean was ahead of its time. *Kapu* (taboo) systems that limited certain classes or sexes from eating certain animals or fishing in certain places or at certain times may have aided in the conservation of some species (e.g., only men were allowed to eat honu (green sea turtle) and only royalty could eat certain fishes). Today, Native Hawaiian teachings play an increasing role in natural resource management, especially in areas of cultural significance like Kaho'olawe or Wao Kele o Puna (island of Hawai'i). The SAWCS recognizes that the State and its agencies are obligated to protect the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible, in accordance with *Public Access Shoreline Hawaii versus Hawaii County Planning Commission* and subsequent case law.

Conservation Funding

Hawai'i ranks near the bottom (48th) in the nation for state spending on fisheries and wildlife, though the State boasts the largest area of marine protected areas in the United States. In Fiscal Year 2006, the State Department of Land and Natural Resources was allocated approximately \$76.8 million of the State's \$8.9 billion dollar executive budget. With less than one percent of the State's budget, the Department must manage the State's marine and freshwater resources (e.g., commercial fisheries, aquaculture, aquatic resources protection, recreational fisheries), protect threatened and endangered species, manage State-owned lands (both those for lease and those set aside as forest reserves, natural areas, plant and wildlife sanctuaries, and parks), manage statewide ocean recreation and coastal areas programs (i.e., boating), oversee permitting

associated with the Conservation District, implement the State's historic preservation mandates, maintain the statewide recording system for title to real property, and enforce the Department's rules and regulations. Just implementing the conservation measures described in endangered species recovery plans for endangered whales, monk seals, and sea turtles would cost tens of millions of dollars per year. And there are thousands of more species in the state, including at least 1,000 aquatic species that are endemic so that the State has most responsibility for ensuring their continued existence.

Funding levels from Federal sources are also inadequate and inequitably apportioned. With more than 30 percent of the nation's imperiled species, Hawai'i receives less than 15 percent of the national appropriation under the Endangered Species Act, Traditional Section 6 Program and only one percent of the national appropriation under the State Wildlife Grants Program. Clearly, unprecedented efforts are needed to increase the funding base for the protection of Hawaii's wildlife and their habitats. Comprehensive and integrated strategies are needed to ensure that limited funding for wildlife conservation is used wisely and for maximal benefit.

ECOLOGICAL OVERVIEW

The Hawaiian Archipelago spans over 2,400 kilometers (1,500 miles) and is comprised of eight main islands and approximately 124 smaller islands, reefs, and shoals that vary in size from fractions of hectares to thousands of square kilometers. The archipelago was formed over the last 70 million years through volcanic eruptions from a relatively stationary hotspot beneath the slowly moving seafloor. The island of Hawai'i is the youngest island, with island age increasing to the northwest as the Pacific plate carries the older islands away from the hotspot. Millions of years of erosion, subsidence, and reef building resulted in the formation of the atolls which form the NWHI and the submerged seamounts which used to be islands even further northwest.

Located over 3,200 kilometers (2,000 miles) from the nearest continent, Hawai'i is the most remote island chain in the world. Despite its relatively small area (less than 1.7 million hectares or 4.1 million acres), an elevation range from sea level to 4,205 meters (13,796 feet) results in Hawai'i containing all the major known ecological zones. With a wide temperature range due to the elevational gradient and with average annual rainfall ranging from less than 40 centimeters to over 1,200 centimeters (15 inches to over 480 inches) per year, Hawai'i displays most of the earth's variation in climatic conditions. Finally, Hawai'i has many natural wonders: the most active volcano in the world, the wettest place on earth, the tallest seacliffs, and extensive coral reefs.

Aquatic Habitats

Aquatic habitats ecologically link together most of the terrestrial habitats. Over geologic time, the flow of water and wind has carved the topography of the mountains and valleys creating microhabitats in which many plants and animals have evolved and adapted. The flow of water that rains down on the high mountaintops transports nutrients, organic matter (energy), and water down through the various forested and shrubland habitats into estuaries and wetlands at low elevations and then finally into the sea. This organic energy from dead plants and animals fertilizes the growth of other plants and animals in lower elevation habitats, while the streams and groundwater flow play an important role in providing water for plants and animals

throughout the ecosystem. Many of Hawaii's native freshwater aquatic animals migrate between the ocean, estuaries, and upper reaches of streams as part of their life cycle.

Streams

Small streams usually join together to form larger and larger streams and rivers until finally the largest stream in a system or watershed enters the ocean. A map of the smaller streams that are interconnected with the single bigger stream usually looks like the branches on a tree. This interconnected network of streams and the adjacent land areas share much of the same nutrients, energy, and water and often becomes the home area of populations of living things. This network and the habitat it encloses is called a watershed, similar to the traditional Hawaiian land division of the *ahupua'a*. Activities or threats that affect one part of this interconnected system will affect some other part or the whole of the system. Thus, to effectively protect watersheds, often the entire *ahupua'a* must receive adequate protection and attention.

Hawaiian streams, or sections of streams, are either perennial or intermittent. Perennial streams flow year round. Some perennial streams flow continuously, discharging into the ocean, while others are "interrupted", not flowing continuously along their length, at least for part of the year. Perennial streams are important to most of Hawaii's endemic freshwater fauna, because these species depend on the ocean for part of their larval life stage and would not survive without this connection to the sea. Perennial streams are habitat to all of Hawaii's freshwater fauna including five native stream fishes or 'o'opu, invertebrates including mollusks and shrimps, algae, and mosses. Intermittent streams, or sections of streams, flow only seasonally, typically with high rainfalls, when these streams may reach the ocean. These streams may have water in their upper sections year-round, while their lower sections are dry. Although some recent studies suggest that viable populations of stream animals can survive in intermittent streams, intermittent stream fauna is more limited and primarily consists of oligochaete worms, several crustaceans, and algae. Hawai'i has 376 perennial streams.

The biology and ecology of stream systems also are defined by the "order" of a stream. First order streams are the smallest initial streams at the highest altitudes in an *ahupua'a*. They are often in the steepest gradient areas and have the coolest waters with least amounts of nutrients and energy. Many freshwater species cannot inhabit the upper reaches or parts of these streams in Hawai'i because of these limiting factors. Some native fishes, however, are highly evolved at climbing waterfalls and can exist in these upper reaches. Second order streams are stream sections downstream from the junction of two first order streams and third order streams are sections below the junction of two second order streams, and so on down to fourth and higher order stream sections. Hawai'i does not have many streams higher than fourth order because of the steep terrain and short distance to the sea. Streams in flatter areas have more nutrients and energy in them and are bigger and easier to inhabit for stream fishes and invertebrates. These areas also have the highest number of threats from sedimentation caused by grazing animals at higher elevations, nearby development, water diversions and dams, channelizing or concreting of the stream bottom and sides, and introduced gamefish. Streams in disturbed areas also do not typically have native vegetation along their banks, reducing shade, nutrient inputs from decaying plant matter, and shelter provided by tree roots. In some streams, non-native vegetation adjacent to streams provides excessive shading and nutrient input, leading to declines in native aquatic organisms. These threats are often most acute in the middle sections of streams as the areas

nearest the ocean receive greater protection through zoning and coastal zone management requirements.

Estuaries

As streams near the ocean, the streambed often becomes dominated by finer grain sediments and salty seawater intrudes with the tides. The area where seawater from the ocean mixes with freshwater is an estuary. Most estuaries in Hawai'i are small. Nevertheless, estuaries in Hawai'i typically have a unique group of species that can tolerate the variable conditions and the large amount of sediments and sand in the water and on the bottom. Too much sediment, however, can be harmful even here. In addition, many marine animals also can inhabit these areas where the salinity is not too low, so the overall diversity of species is high in many estuaries. Many of the same threats occurring in the middle sections of streams such as sedimentation, development, and invasive species occur in estuaries as well, though coastal zone regulations provide some degree of protection. Because estuaries are often calmer areas of water, boat harbors and other sources of human disturbance are often concentrated in these areas.

Sandy Bottom Marine Systems

The amount of sediment moving into the open ocean largely determines the presence of various types of marine habitats in Hawai'i. Too much sediment limits the presence and growth of corals, so coral reefs can only occur away from estuaries. Instead of coral reefs, these areas close to estuaries are dominated by various sandy bottomed habitats that are rich in animals that live in the sand, like many worms or shelled animals, and in fishes like rays and flatfishes that feed in or on top of soft sediments.

Coral Reefs

Coral reefs develop in most of the rest of the shallow water fringe around the high islands. This results in the formation of "fringing reefs" that have coral growth near the surface of the water, very close to shore, with limited shallow water lagoons inshore of the reef. Reefs in areas with relatively recent lava flows, such as on the island of Hawai'i, have poorly developed fringing reefs. Kāne'ōhe Bay on O'ahu and a small area of Kaua'i also have "barrier reefs," where the development of coral occurs further offshore. There is a more extensive shallow water lagoon inshore of the barrier reef that has a higher degree of development of what are called patch reefs, or small sections of coral interspersed in sandy habitat in waters of one to ten or even 20 meters (three to 65 feet) deep. Many of the low islands in the Northwestern Hawaiian Islands are "atoll reefs." These reefs are the tops of drowned and submerged volcanic peaks that result in a ring of coral that can be many miles in circumference. They may or may not surround a small sandy island or islands somewhere inside a very extensive lagoon that also usually contains numerous patch reefs. Kure Atoll and Pearl and Hermes Reef are classic examples of atoll reefs. Coral reefs are threatened by human impacts, invasive species, disease, and global climate change.

Bathypelagic, Mesopelagic, and Pelagic

Because the Main Hawaiian Islands are the tops of steep volcanic peaks, waters off these islands become very deep very quickly so that even within the three mile (five kilometer) boundary of State waters, the water is thousands of meters or feet deep with many unique species living on the bottom here. In the bathypelagic or deep zone waters, the water is cold and dark, with many unusual fishes and swimming invertebrates about which little is known. In the mesopelagic or

middle realm (waters of only around 100 to 300 meters (330 to 1,000 feet) depth), there is some small amount of light and the species that occur here are often different from both the shallower and deeper species. Many species in this zone are important food sources for marine mammals in Hawai‘i. The pelagic or nearshore waters on the surface above these deep water areas are home to some of the most desirable gamefishes including ono, mahimahi, ‘ahi (tunas), and marlins, which increases the importance of this habitat. Offshore aquaculture is a potential new threat to these areas.

Additional Marine Habitats

Tidepools and rocky beaches provide important habitat for many of Hawaii’s invertebrate species and larvae of many fishes. Desirable species, including ‘opihi (limpets) and some shelled invertebrates, occur here. Some species are adapted to the strong wave action in these areas. Seagrass beds provide foraging areas for sea turtles as well as habitat for endemic invertebrates, though true seagrasses are rare in most areas of Hawai‘i. Beaches are essential nesting grounds for sea turtles as well as areas where monk seals haul out, give birth, and protect and feed young. Threats to these habitats include direct and indirect human impacts due to proximity to the coast.

Anchialine-ponds

Anchialine ponds are found in geologically young lava fields. The lava in these areas has fissures that connect the ponds to the ocean. The subterranean water system reaches the surface through natural or man-made connections and where the salinity of seawater intrudes to at least some degree. Thus these ponds are always close to the sea and have varying salinity levels and tidal influence. Most ponds are less than 100 square meters in size and less than 1.5 meters in depth. Anchialine ponds are home to numerous animals. Anchialine pond shrimp are found in the water column and on the substrate of anchialine ponds as well as in the interstitial spaces that are part of the system linking the pond’s water to oceanic influences. Amphipods, ostracods, snails, worms, and various fishes can also be found in the pools. Many ponds have been filled or had non-native species introduced. Threats to the ponds themselves include excessive use, filling in or alteration of ponds for alternate use or development, and the introduction of invasive predatory fishes and invertebrates. Needed conservation actions include better managing human access, ensuring protection of pond habitats, and finding effective methods to prevent and control invasive species.

Aquatic Taxa

Because of the extreme isolation and distance, relatively few life forms successfully colonized the Hawaiian Archipelago over its 70 million year history. Hawai‘i displays some of the world’s premier examples of evolution, with the creation of countless new lineages of plants and animals. Rates of endemism (i.e., percent of species found nowhere else on earth) are high for aquatic fauna, typically 15 to 20 percent. Although thousands of Hawaiian species have yet to be described, the estimated number of aquatic indigenous species is thought to include more than 100 freshwater and 6,400 marine taxa. Examples of this unique evolutionary history are the many species of wrasses, eels, and marine stomatopods (snapping shrimps). Additionally, there are species with unusual characteristics or life-histories, such as amphidromous fish that scale 300-meter (1,000-foot) waterfalls. It is important to note the species that are not here as well. Throughout many parts of the world, shallow reefs are inhabited by fishes in the snapper and

grouper families; however, in Hawai‘i, these families are rare. Instead, other species have taken over and filled their usual niches.

Beginning with the arrival of Polynesians to Hawai‘i around 1,600 years ago, and accelerating with the arrival of Westerners after the 1780s, humans have taken a dramatic toll on the biota of the Hawaiian Islands. The effects of novel pressures on the native biota of the islands resulted in rapid declines and extinctions among hundreds if not thousands of native species, although extinctions of aquatic species are less well documented. Some species were exterminated by Polynesians for food or jewelry, some species were lost because of degradation or destruction of their unique habitats, and others persisted in more remote areas only to be weakened or overcome by non-native predators. Particular harm to aquatic systems is likely to have come from the extensive alteration of the land and watersheds for the cultivation of taro and from the construction of numerous fishponds that alter water flow and change aquatic habitat.

The following species or taxa are covered in the Statewide Aquatic Wildlife Conservation Strategy (SAWCS) as Species of Greatest Conservation Need (SGCN): 23 freshwater invertebrates, five freshwater fishes, 24 species of endemic freshwater algae, 20 anchialine-pond associated fauna, 26 marine mammals, six marine reptiles, 156 marine fishes, 1424 marine invertebrates, and 90 species of endemic marine plants or algae. A brief discussion of each species group is presented below, with more specific information presented in Chapter 7 (Species of Greatest Conservation Need).

Aquatic Plants and Algae

Hawai‘i has an endemic marine plant, the seagrass *Halophila hawaiiiana*, which is host to an endemic snail. Threats to the seagrass include limited habitat, as it occurs in discrete patches on sandy substrate off a few islands, limited sexual reproduction as male and female flowers occur on separate plants and male plants are seldom found, and nearshore disturbance (e.g., dredging or sedimentation).

Little is known about Hawaii’s endemic algae and their role in the ecosystem. Red algae are the dominant group. Many species of calcareous algae are important to maintaining the physical structure of coral reefs, and in death become a large proportion of local beach sand. Algae are an important food source for some marine fishes, invertebrates, and green sea turtles and are eaten by many native Hawaiians and immigrants.

Freshwater Species

Streams in Hawai‘i have a relatively small number of native species. There are five native fishes or ‘o‘opu, that occur in freshwater streams and evolved from two families of marine fishes. These ‘o‘opu are mostly small herbivores or omnivores. There are 35 freshwater invertebrates of conservation need, including two omnivorous shrimps, at least eight species of herbivorous snails, ten rotifers, one endemic worm species, and one sponge species. Some of these invertebrates spend a brief part of their larval stage in the ocean before returning to the freshwater streams as juveniles. Threats include insufficient instream flow standards, stream diversions, dams, and channelizations, and sedimentation and pollution of streams. Needed actions include reversing or mitigating these destructive impacts and organizing management for stream animals along continuous stream corridors from the mountain to the ocean.

Marine Species

Marine ecosystems in Hawai‘i support over 1,200 species of fishes, with around 500 species adapted to live on coral reefs, and the rest adapted to the open ocean waters, deep habitats, estuaries, or areas characterized by sandy bottoms. These fishes occupy a range of niches from herbivores to carnivores that specialize on microscopic plankton, seashells, crabs, shrimp, or other fishes. At the top of the food chain are the apex predators such as the many sharks and large ulua (jacks) of Hawai‘i. Over 4,000 marine invertebrates are known from Hawai‘i, including over 100 species of hard, soft and precious corals, as well as hundreds of types of seashells, crabs, and shrimps and small numbers of worms, jellyfish, sponges, starfish, and tunicates. Many commercially or recreationally fished species are protected by Fishery Management Plans developed under the U.S. Magnuson-Stevens Fishery Conservation and Management Act. Stony corals, black corals, lace corals, seahorses, and some sharks are protected by the Convention on International Trade in Endangered Species (CITES) Appendix II.

A small number of marine reptiles occur in Hawai‘i. Two sea turtles are common residents here, and three others are more occasional visitors. All sea turtles are listed as threatened or endangered by the USFWS. The honu (green sea turtle, *Chelonia mydas*) is an herbivore and the hawksbill sea turtle (*Eretmochelys imbricata*) specializes on eating sponges. Both lay eggs on Hawaii’s beaches. There are two species of sea snake reported from Hawaiian waters, although these are rarely seen.

About 26 species of marine mammals are resident or occasional visitors to Hawai‘i. All are protected by the Marine Mammal Protection Act. These include the popular spinner (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*), resident year-round, and the migratory humpback whales (*Megaptera novaeangliae*) which spend a few months each year in Hawaiian waters to birth and breed. Humpback whales and the Hawaiian monk seal (*Monachus schauinslandi*) are the more commonly occurring marine mammals in Hawai‘i that are also listed as endangered under Federal and State law. Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawaii’s coasts.

Anchialine-pond Fauna

Eight species of anchialine shrimps are hypogeal, which means they live in subterranean aquatic habitats in the water that occurs in cracks and slits between rocks. Six of these species are candidates for listing under the Endangered Species Act. These shrimps can be found in anchialine ponds. It is not clear whether anchialine ponds are necessary for the survival of any of the eight shrimp species, as one shrimp has also been found in the open ocean, and many species have been found in artificially created ponds, some many miles from the nearest naturally formed pond. However, the importance of the little-understood hypogeal system is clear, and the anchialine ponds may greatly increase the amount of energy in the hypogeal systems because of the access to photosynthetic organisms in the pools. Anchialine ponds are also home to eleven species of amphipods, two of which have also been found in the open ocean. Little is known about their biology or ecology. One snail species is also often commonly found

in anchialine ponds and other estuarine habitats. Many other marine species can be occasionally found in anchialine ponds.

STATEWIDE THREATS

This section discusses the major threats affecting aquatic species statewide, followed by seven objectives to address the major threats outlined. The adoption of these seven objectives and the associated conservation strategies outlined in Chapters 4 to 6 by the people and institutions of Hawai‘i will ensure that a legacy of healthy biodiversity is left for future generations.

Loss and Degradation of Habitat

Alterations of streams, non-point source pollution, sedimentation, and storm water runoff have decreased, fragmented, or degraded freshwater habitats. Marine systems downstream are affected by changes in stream systems, especially by any increase in sediment load. Corals, in particular, are susceptible to both pollution and excessive sedimentation. Anchialine ponds are threatened by the filling and trampling of the ponds, and the photosynthetic organisms (algae) that form the base of their food chain are easily disturbed. More specific examples follow.

Many important wetland and coastal habitats are threatened by residential development. The limited amount of shoreline and the constant demand for beach-front housing has resulted in the division and conversion of formerly open coastal areas to homes and residential landscaping. Shoreline alterations, including dredging, the building or expansion of harbors, seawalls, and other structures and inland commercial and residential areas damage marine habitats for corals and other species directly or indirectly by changing water flows or sediment deposition. The closure of sugar plantations has resulted in many former fields being subdivided for residential use. As housing demand increases, development constitutes a threat away from the coast as well in areas formerly considered “remote,” such as Ka‘ū on the island of Hawai‘i. Prime areas for development are often near middle reaches of streams, which are important ecologically and sensitive to development, but have few protections.

Alteration of hydrology, which includes watershed development, stream diversions, channelizations, and excessive water withdrawals that lower the aquifer, degrades or destroys habitat used by native fishes and invertebrates. Insufficient instream flows with a lack of set flow standards threaten many streams that have diversions or alterations. Inadequate zoning in riparian zones threatens aquatic ecosystems by allowing agriculture, grazing, or development to occur too close to streams.

The cumulative impact of human interaction with native species and habitats is a growing concern. Attention recently has centered on marine activities, including the potential for dolphin and whale watching and shark feeding tours to change the behavior of these species. Turtle feeding is another area where increased human-interactions may change behaviors. Excessive trampling of coral reefs, tidepools, and other shoreline areas by recreational users directly kill many marine organisms or indirectly kill their algal or invertebrate food sources. Many sensitive habitats such as anchialine ponds, coral reefs, and offshore islands are compromised or outright

destroyed by the presence of people. Off-road vehicles in coastal dune ecosystems degrade habitat for nesting turtles.

Hurricanes and tsunamis can be particularly devastating to nearshore habitats as debris, pollution, and sedimentation are washed off shore. Lava from volcano eruptions flows into the sea destroying all it covers and other alterations to water chemistry and temperature can harm nearby areas.

Global climate change is anticipated to have multiple and disastrous effects on Hawaiian aquatic wildlife. First, sea level rise will inundate the NWHI, reducing habitat for nesting monk seals and sea turtles and alter coastal habitats throughout Hawai'i. Second, Hawai'i could experience increased frequency of El Nino/Southern Oscillation (ENSO) events that may have implications for marine wildlife. Third, increases in ocean temperatures could impact invertebrate and fish populations. Increases in seawater temperature also contributes to the phenomenon of coral bleaching, in which corals temporarily or permanently lose their symbiotic algae, potentially resulting in the death of the corals. Although Hawai'i was spared the reef bleaching events of the 1980s and 1990s, some bleaching in the NWHI has recently been documented. Increased carbon dioxide has caused the acidity of the ocean to increase, making it more difficult for corals and mollusks to form skeletons and shells. Finally, increased ultraviolet radiation could also harm native wildlife. Many of the above mentioned impacts are known or currently anticipated effects of global climate change; additional impacts that are not currently anticipated or understood may also occur.

Introduced Invasive Species

Hawaii's aquatic species are particularly susceptible to the threats posed by the introduction and spread of introduced invasive species and pathogens. Invasive species are species whose introduction does or is likely to cause environmental or economic harm or harm to human health. Virtually no native habitat is free from the threat of introduced (also called "non-native," "alien," or "exotic") species, and most native habitats experience some negative effects related to non-native species. Non-native species may outcompete native species or may directly harm native species through predation or infection. Non-native species may also threaten native species through interbreeding and hybridization, leading to the loss of the native species as a unique species.

No longer isolated, Hawai'i is highly vulnerable to human-assisted alien introductions due to its role as a central military, trade, and tourist hub. Before human arrival, the estimated rate of successful new colonizations was one species every 25,000 years. Over the last two centuries alone, the rate of plant introductions alone has been more than 40 species per year. It is estimated that over 400 introduced aquatic species are now established. Some were purposeful introductions for fishing or aquaculture, while others were accidental releases, or hitchhikers on ships or other wildlife, such as for parasites. In addition to the already established introduced species, numerous species currently not found on the islands are poised to invade island ecosystems.

No other region of the United States has experienced a similar invasion of non-native competitors, predators, and vectors of infectious disease and pathogens. Invasive algae species

have become a threat in recent years. These organisms can outcompete and overgrow native algae species and kill corals, altering the structure of local coral reef communities. Nearshore eutrophication (water pollution caused by excessive nutrients that stimulate excessive plant growth) from non-point source pollution or leaking cesspools and sewage systems may contribute to the explosive growth of these algae. Leeward areas of Maui and areas in Kāneʻohe Bay, Oʻahu and Waikīkī, Oʻahu have experienced algal blooms or have growing invasive algae populations. Another marine invasive, snowflake coral (*Carijoa*), outcompetes and overgrows native coral species, possibly including the precious black corals found in deeper waters off Maui. Introduced fishes such as smallmouth bass have been documented to prey on native freshwater fishes and invertebrates. Anchialine ponds also are threatened by introduced fishes and shrimps that prey on the native shrimp and alter the habitat structure. Invasive species that are carriers of foreign diseases also are a significant threat. Introduced top minnows have been shown to carry a pathogen that affects the native oʻopu. Recent work has shown that many species of corals have diseases that, in some cases, are on the increase and may be caused by introduced species. Honu (*Chelonia mydas* [green sea turtles]) in most areas suffer from fibropapilloma, which may also be caused by an introduced disease. With little natural resistance to disease, the Hawaiian aquatic fauna is expected to be highly susceptible, and prevention of the establishment of new diseases is a top priority need.

Limited Information and Insufficient Information Management

Accurate population estimates or even population trends for most aquatic wildlife are not available. Large numbers of native invertebrates have not even been described, making assessment of their populations and consideration of the consequences of proposed management actions problematic at best. Huge gaps in knowledge exist for many aquatic species. Population censuses that do occur cannot provide data on basic demographic parameters or determine threats to specific species. Such information is often necessary to direct management, especially for those species persisting at low populations. Data on the effects of different threats to native species also is often lacking, as is information on the effects of different management techniques or actions on natural resources. Management decisions based on inadequate data can result in a misallocation of extremely limited conservation dollars. Resource managers must typically make decisions based on incomplete data and information, but some minimal data standard may be reasonable to expect.

Gaps in information are often magnified by the challenges inherent in sharing information across institutions. Multiple agencies and organizations in Hawaiʻi collect and manage data on a variety of species and habitats. This information is often collected in different formats and for different purposes. There are no comprehensive computerized spreadsheets or databases that list even the names of all known Hawaiian aquatic species. Building on existing efforts to centralize information storage in a spatial database could better identify data gaps, provide a more comprehensive view of the status of a particular species or habitat, and allow management decisions to be made using the most up-to-date and accurate information.

Uneven Compliance With Existing Conservation Laws, Rules, and Regulations

Uneven compliance with existing conservation laws stems from two sources: limited capacity for enforcement and lack of respect and understanding for the value of protecting aquatic wildlife. Limited funding restricts the State's capacity to enforce existing laws, rules, and regulations

protecting native wildlife and habitat. The Department of Land and Natural Resources Division of Conservation and Resource Enforcement is understaffed and underfunded. At the same time, the Division is tasked with additional duties beyond resource conservation (e.g., participation in marijuana eradications and in Homeland Security actions). Consequently, public perception is that the State is not able to effectively respond to or enforce laws relating to the conservation of Hawaii's natural resources, such as regulations prohibiting fishing in a certain area. Moreover, penalties for transgressions are often small. As a result, voluntary compliance with conservation laws and regulations decreases as the public sees few consequences for violations. Poaching of aquatic wildlife and other non-compliance with conservation laws, rules, and regulations is a direct threat to aquatic wildlife and their habitat.

The success of voluntary compliance depends heavily on local community involvement. Peer pressure is one form of this involvement. In addition, community-based education and management give the local community an understanding of the importance and values of native wildlife and their habitat and a sense of pride and ownership or stewardship that encourage voluntary compliance. In many locations, this level of community involvement is absent or not encouraged.

Excessive Extractive Use

Bottomfishes, as defined by the Federal government under the Magnuson Stevens Act to include the ulua (*Caranx* spp.) as well as 'ōpakapaka (*Pristipomoides filamentosus*), onaga (*Etelis coruscans*), and hāpu'u (*Epinephelus quernus*), have been declared in a state of "overfishing," a technical and legal condition in which there is too much fishing effort that will soon lead to a critical drop in the populations of these fishes. As a result, fisheries managers have one year under Federal law to determine how to reduce fishing effort to return these bottomfishes to a healthy state. Other fishes in the State also may be in a state of overfishing, but solid data is lacking to make these technical determinations.

Excessive extractive use constitutes a threat to other aquatic wildlife as well. Certain reef fishes are harvested for sale in the aquarium trade. Many shells are sold locally and in internet shops and auctions. Freshwater and marine fishes and invertebrates are collected for subsistence, recreation, and commercial purposes. These activities are not sustainable on a large scale.

Management Constraints

While more than 31 percent of the land in Hawai'i has been set aside for protection by the State or Federal government or is managed as part of a watershed partnership, these lands are subjected to differing levels of conservation or management effort. Additionally, little active conservation of stream wildlife takes place and may be limited by counter-productive laws and policies. A comprehensive vision for this conservation is lacking. DLNR is limited by infrastructural challenges; for example, the difficulty in filling existing vacant positions on a timely basis and the near impossibility of adding personnel to coordinate new conservation actions is a significant constraint on management. Procurement rules and contracting procedures can delay the State's ability to coordinate and carry out needed conservation actions. Other governmental agencies and non-governmental organizations face similar infrastructural challenges.

Unclear or lengthy regulatory processes constitute another management constraint. Research, response, and control of invasive non-native species (particularly animal species) can be delayed by the existing regulatory process. Current State and Federal regulations require more review and approvals of techniques to control invasive species than are required before introduction of the non-native species into the State. As a result, non-native plants and animals too often gain entry and become established because similar burdens of proof and screening requirements are not placed upon key industries, such as shipping and aquaculture. Other management actions can trigger State permitting and environmental review processes. Many species may qualify for listing as threatened or endangered by the Federal government; however, most are not likely to receive additional regulatory protection in the near future due to understaffing and political considerations.

Inadequate Funding

Limited funding to implement identified priority management actions to protect or restore aquatic wildlife and their habitats on Federal, State, and private lands, to hire staff to coordinate these projects, or to conduct research and monitoring is a significant constraint on effective wildlife conservation in Hawai'i. This is complicated by grant programs that have varying eligibility requirements. Limited State funding can prevent the State from meeting match requirements needed to receive Federal funds that may become available to states for conservation management in the future. These factors contribute to "opportunistic" conservation on a piecemeal basis based on funding availability, rather than addressing needs in order of biological priority.

STATEWIDE CONSERVATION OBJECTIVES

Although Hawaii's aquatic species and habitats face many threats and are in great need of increased conservation, there are several conservation success stories. For example, the threatened green sea turtle (*Chelonia mydas*) population has been increasing since it was put on the ESA threatened list in 1978 due to effective public education and outreach as well as enforcement of regulations against take and fisheries bycatch. A second success story is that of the Fish Replenishment Areas (FRAs) in West Hawai'i. FRAs were established in 2000 to address declining aquarium fish populations due to over collection and to reduce multiple use conflicts. A management council that included community members was established to manage the areas. After five years of FRA closure, the overall densities of seven of the ten most collected aquarium fishes have increased and the yellow tang (*Zebrasoma flavescens*), the most collected aquarium species, increased by 49 percent relative to control areas.

Despite these success stories, however, there are limited conservation dollars and resources for conservation; therefore, the goal of this SAWCS is to guide aquatic conservation efforts across the State to ensure further and adequate protection of Hawaii's Aquatic Species of Greatest Conservation Need and the diverse habitats that support them. Management of habitats to benefit multiple species is the focus of the SAWCS. Hawaii's SAWCS development process sought to identify major threats affecting aquatic wildlife and their habitats throughout the State and then defined major objectives and strategies to respond to these threats and improve aquatic wildlife conditions. The following seven objectives have been identified as elements necessary for the long-term conservation of Hawaii's native wildlife:

- 1) *Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive;*
- 2) *Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication;*
- 3) *Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs;*
- 4) *Strengthen existing and create new partnerships and cooperative efforts;*
- 5) *Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i;*
- 6) *Support policy changes aimed at improving and protecting native species and habitats;*
- 7) *Enhance funding opportunities to implement needed conservation actions.*

Implementation of these seven objectives will allow aquatic resource managers to address the major conservation needs of Hawaii’s aquatic wildlife. The objectives relating to the protection and restoration of habitats and the prevention and control of introduced species address many of the most direct biological threats to native wildlife. The other objectives address somewhat more indirect needs arising from a lack of information, the need for improved coordination of efforts and funding, and management constraints. Because ecological problems are complex, there is overlap among these objectives. For example, much of habitat protection in the State involves invasive species control; more effective invasive species control requires more aggressive policies, cooperation among landowners and regulatory entities, and public support. This overlap underscores the necessity for a multiple-species approach to conservation of Hawaii’s aquatic wildlife. These seven objectives address the overall goal of the SAWCS. Future assessment of their effectiveness as conservation tools is discussed in Chapter 8 (Monitoring, Implementation, and Adaptive Management). In the chapters that follow, specific marine and freshwater strategies that encompass multiple direct conservation actions are outlined for each of the above seven objectives.

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