**Hawai‘i Ocean Health Index**

**Background**

While Hawaiʻi has a wealth of information, research, and management, there is a need for collaboration, communication, and common goals. This model has proven to be successful in Hawaiʻi such as the Promise to Paeʻāina, a collaboration of # agencies and nonprofits to that set targets to achieve to make Hawaiʻi a better place before Hōkūleia returns from its worldwide voyage. These cross-sector collaborations are needed to build resilience between our social, economic, and environmental needs.

Hawaiians have a long history of sustainable management and resource use. They recognized that their wellbeing and health relied on the status or availability of the resource. Today, the same is true; the health of our communities and our environment is intertwined. Healthy communities are more equipped to be stewards of their environment and a health environment supports community wellbeing. Therefore at the core of mālama aina and ocean health is through supporting community wellbeing and health. The strong sense of place or connection to the place that we have in Hawaii drives conservation and sustainability in Hawaiʻi and is a model for the rest of the world. This sense of place and social awareness can be seen in every goal assessed in the Hawaiʻi Ocean Health Index, from the restoration of traditional Hawaiian fishponds as a means to sustainably provide seafood under the Food Provision Goal to the added goal on Sustainable Tourism. Hawaiʻiʻs unique social and cultural practices and values are the foundation for the development of every goal and are also tracked in their own goal, Sense of Place (The Sense of Place Goal accounts for the importance of the relationship between people and aina and relationships among people with regards to the past, present and future).

Goals

This assessment is being done to build a common message and set targets for sustainable ocean use in Hawaiʻi.

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**Learn** Ocean Health Index and its applications 2014-2016

**Plan** the assessment to achieve local objectives and involve stakeholders Jan 2016 – August 2017

Meetings with agencies and goal experts

August 2016 Workshop in Honolulu

December 2016 Workshop in Kailua-Kona

July 2017 Workshop HCC

Ocean perceptions and values survey June 2017 – August 2017

**Conduct** assessment with adapted framework and local data on status, pressures, and resilience. Review draft OHI with stakeholders and managers.

July 2017 – December 2017

**Inform** testing management options, support sustainable actions,

and increase collaboration/communicationDecember 2017 – June

2018.

**Repeat** assessment process incorporating updated science and policies to track progress towards a healthy ocean.

**Scale**

The Hawai‘i OHI+ will use the scientifically robust framework of the Ocean Health Index at the scale of the Hawaiian archipelago. We will focus our development of the Hawaii Ocean Health Index at two scales:

1. The West Hawai‘i region; and
2. Statewide, for coastal waters

The Hawai‘i Statewide assessment will focus on the Main Hawaiian Islands and will be by county. Regions will be Hawai‘i Island, Maui Nui, Oahu, and Kauai & Ni‘ihau. The county scale is being used simplifying incorporation into policy and management for the State of Hawai‘i.

The West Hawai‘i Regional OHI assessment will be at the scale of West Hawai‘i. West Hawai‘i may be divided into two regions North and South West Hawai‘i.

Table 1. Locally defined goals for the Hawaiʻi OHI+ assessment.

|  |  |
| --- | --- |
| Goal | Definition |
| Food Provision | Seafood from fisheries catch and aquaculture (local production of seafood including shrimp ponds and fishponds). This goal contains two subgoals: Fisheries and Mariculture. Fisheries measures the amount of wild-caught seafood from pelagic, bottom fish, and nearshore fisheries that can be sustainably harvested. Mariculture assesses the sustainable production of seafood from aquaculture and the number of active or restored traditional Hawaiian fishponds (loko i‘a). |
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| Artisanal Fishing Opportunities | The opportunity for fishers to supply seafood for themselves, families, and community. It is estimated based on need, the access to the coast from shoreline access points, and the condition of the resource based on fish biomass. |
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| Natural Products | Sustainable harvest of shells, algae, water, and salt. \*Not assessed as data is not available for all regions and the sustainability of many of the natural products is unknown. |
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| Sense of Place | The relationship between people and ‘āina (land/environment) and relationships among people with regards to the past, present and future. This goal is composed of two subgoals: Lasting Special Places and Connection to Place. Lasting special places tracks the protection of marine and coastal areas, and sacred and historical sites. Connection to place is the connection that people have to coastal and marine environments measured through activates that take place in each place. |
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| Sustainable Tourism | Balanced economic growth through tourism with management and preservation of natural resources and Hawaiian culture. This goal is measured as the average of three indicators: visitor generated GDP, environmental protection, and resident sentiment towards tourism. |
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| Clean Waters | The degree to which local waters are polluted by natural and human made causes. \*Moved to pressure layer |
| Biodiversity | The value of coastal and ocean species and habitats. Biodiversity is composed of two subgoals: Habitats and Species. The habitat subgoal measures the extent and condition of reefs, wetlands, soft-bottom habitats, and beaches. The species subgoal measures the population status of Hawai‘i species based on reef fish biomass and the risk of extinction of marine mammals, turtles and birds, and coastal beach and sand dune plants. |
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| Coastal Protection | Extent and condition of habitats (beaches, coral reefs, wetlands) that provide coastal protection from inundation and erosion. |
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| Livelihoods & Economies | Coastal and ocean-dependent jobs and productive coastal economies from the revenue from marine related industries including tourism, fishing, shipbuilding, and transportation. This goal is composed of two subgoals: Livelihoods and Economies. Livelihoods tracks the number of jobs and the quality of wages (wage/livable wage) of marine sectors. Economies tracks the revenue generated from productive coastal economies. |
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**Food Provision**

Measures the sustainably harvested and produced seafood from fisheries catch and aquaculture (local production of seafood including shrimp ponds and fishponds).

**Wild Caught Fisheries**

Stock assessment from pelagic, bottom fish, and reef fish. Stock assessments did not over-lap with the most recent catch data. The most recent stock assessments were 2012-2013 for most species. I used the last ten years of stock assessment data to run a linear regression model to predict stock status to 2016. If stock status was non-linear then the ten year mean stock status was used. The stock indicator for pelagic species was SB/SBmsy. Bottom fish stock assessments were for the aggregated species complex for the Hawaiʻi deep 7 and used B/Bmsy as the stock indicator. Reef fish stock assessment used the spawning potential ratio (SPR) as the stock indicator the reef fish spawning stock was compared to the Northwest Hawaiian Islands and the stock assessment is not reported by year so the stock status was held constant over the 5 assessment years. Used median scores for each group (pelagic, bottom, and reef to gap fill for species that lack formal stock assessments.

Data layers used:

Commercial catch data (2012-2016)

Non-commercial catch data (used as a multiplier for commercial catch data)

**Mariculture**

Mariculture is measures as the local production/harvest of seafood for consumption and the production potential from local fishponds known as loko ia.

Commercial mariculture production is a small fraction of the total seafood production potential of fishponds in Hawaii and thus represents a small percentage of the overall mariculture score. ADD section on importance of fishponds here.

However the value of aquaculture products ($39,970,000 in 2011 USD) natural products and seafood is ranked 4th in the state following seed crops, flowers and nursery products, and cattle (USDA Annual Statistics Bulletin 2011). Revenue from mariculture is incorporated into Livelihoods and Economies.

The species that are produced locally for seafood consumption include:

Abalone (*Haliotus sp)*, oysters (*Crassostrea gigas* and *Crassostrea sikamea*), clams (*Venerupis philippinarum*), kahala (*Seriola dumerili*), Pacific White Shrimp (*Penaeus vannamei*), and limu (Gracilaria sp.). Moi (Pacific Threadfin) is not on the State of Hawaii Department of Agriculture list but it is produced locally for out planting in fishponds. The sustainability of the species produced was assessed as the average of the feed sustainability score (0 protein based, 1 plant based; 0 imported feed, 1 local feed) and the biosecurity risk scored as species status (1 native, 0.75 introduced, or 0 invasive) and the pathogen and virus susceptibility (0 highly susceptible, 0.5 susceptible but preventative measures in place (biosecurity practices such as sterilization and wastewater treatment practices).

The production (lbs of seafood) is reported at the state level to prevent disclosure of sensitive information. To get county level estimates of production the lbs of finfish and shellfish produced at the state level were multiplied by the estimated number of finfish and shellfish operators by county. The number of operators are reported to USDA via census every 5 years (2002, 2007, 2012) ([https://www.nass.usda.gov/Statistics\_by\_State/Hawaii/](https://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/index.php) ). To fill in annual data gaps linear regression models were used.

Reference is maximum harvest across regions.

What would completely sustainable mariculture look like for what we can control – local and sustainable feed production, native species or biosecurity threat. Maximum score when risk is alleviated (risk = 1) and (NELHA as best?)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cultured Species | Species Name | Sustainable Feed (0=imported) | Feed Plant Based (0=protein based) | Susceptibility to Disease (0=highly susceptible) | Native (1), Introduced (0.5), Invasive (0) | Sustainability Score |
| Abalone | *Haliotus refens, Haliotus discus hanai* | 1 | 1 | 1 | 0.5 | 0.88 |
| Broodstock and juvenile shrimp | *Litopenaeus. vanamei, L. monodon, L. stylirostris* | 0 | 0 | 0 | 0.5 | 0.13 |
| Kahala (amberjack) | *Seriola dumerili* | 0 | 0 | 1 | 1 | 0.50 |
| Marine shrimp for food | *Penaeus vannamei* | 0 | 0 | 0 | 0.5 | 0.13 |
| Microalgae | *Spirulina sp, Hematococcus sp* | 1 | 1 | 1 | 1 | 1.00 |
| Seaweed or sea vegetables | *Gracilaria sp* | 1 | 1 | 1 | 0.5 | 0.88 |
| Seed clams | *Mercenaria mercenaria* | 1 | 1 | 1 | 0.5 | 0.88 |
| Seed oysters and clams | *Crassostrea gigas, Venerupis Philippinarum, Crassostrea Sikamea* | 1 | 1 | 1 | 0.5 | 0.88 |
| Tilapia | *Oreochromis* sp | 0 | 0 | 0 | 0 | 0.00 |

**Artisanal Fishing Opportunities**

Three components were identified by stakeholders as key components for measuring artisanal fishing opportunities. These components are access to the resource, the availability of the resource, and number of subsistence/artisanal fishers.

Access was determined as an issue for artisanal fishing opportunities. Access was defined as the number of beach or coastal access points per kilometer of coastline. With development of coastal areas, including hotels, the access and parking for artisanal fishers can be reduced. Beach access is under county jurisdiction. The data for beach access has not been provided by the County of Kauai, we therefore used an average per coastline estimate for the draft of the index for Kauai Island. Shoreline access has been identified as a priority in the State Ocean Resource Management Plan (ORMP). There is an average of 5 shoreline access points that are added statewide per year or an estimated 0.7% increase in statewide shoreline access.

Resource was measured as the current biomass of coastal fish to the pristine biomass of coastal resource fish. The scores come from the NOAA Coral Reef Report Card developed by the Coral Reef Monitoring Program. The reference fish biomass (*Rr*) is the modeled pristine reef fish biomass in the absence of humans (Williams et al 2015).

Ideally need would be assessed based on number of subsistence fishers; however the number of subsistence fishers is unknown. Need was assessed the percent of households that fish. Data comes from the National Atmospheric and Oceanic Administration Hawaiʻi Marine Recreational Fishing Survey (<http://www.fpir.noaa.gov/SFD/SFD_rcf_hmrfs.html>) contracted through the State of Hawaiʻi Department of Land and Natural Resources Division of Aquatic Resources. The percent of households that fish was multiplied by the number of residents per region to obtain an estimate of fishers per region. This number is a proxy for the number of fishers, but it does allow for a comparison of need across regions. The reference need was the combined total fishers in Hawaii (*Nr)*.

The poverty level in Hawaii is 10.6% in 2015 (DEBET <http://dbedt.hawaii.gov/economic/ranks/>). The poverty level was used as the need.

The trend was calculated as the combined change in the resource and coastal access over the past 5 years 2010-2015. The data for the change in shoreline access points comes from the Office of Planning.

|  |  |  |
| --- | --- | --- |
| Region | score | trend |
| Hawai'i | 26.81 | -0.01 |
| Maui Nui | 46.78 | 0.03 |
| Oahu | 48.21 | 0.02 |
| Kauai & Nii'hau | 51.15 | 0.04 |

**Sustainable Tourism**

Sustainable tourism was scored based on the benefit of visitors to economic growth (*economic)* while taking into account thepreservation of social and cultural values of residents *(sentiment)* and the natural environment (*environment).*

*economic = (visitor GDP \* % visitor days per county)\*r*

*r = annual growth rate in visitor generated GDP*

*r ≥2.5% = 1*

*r≤1.5 and r ≥ = -5.0% =0.5*

*r>1.5% and r>2.5% =r*

*sentiment = county sentiment score/(80% HTA target level)*

*environment = % of nearshore waters protected/(30% Sustainable Hawaiʻi Initiative)*

The mean of *economic* (visitor estimated GDP), *sentiment* (preservation of social and cultural values), and *environment* (protection of key habitats) were used to generate regional scores for sustainable tourism.

Data was attained form the State of Hawaiʻi Department of Business, Economic Development, and Tourism (DBEDT) and the Hawaiʻi Tourism Authority (HTA). Data on economic growth was obtained from HTA for the statewide visitor contribution to the economy (HTA 2016 Final Annual Report).

*Economic* was scored based on county estimated visitor contribution to GDP. Visitor contribution to the economy was measured in USD inflation adjusted (real) GDP from. The reference level for visitor contribution to economic growth was set at $13,280 mil by 2020 or 2.5% annual growth rate (HTA 2016 Annual Report). Visitor generated GDP was estimated to county level by weighting GDP by the average daily number of visitors to each county (visitors defined as overnight stays DBEDT 2016 databook).

*Sentiment* scores the preservation of social and cultural values estimated though HTA visitor sentiment surveys. Three questions have been asked consistently and thus have time-series information and were used to score the agreement or sentiment of residents on the benefits and impact of tourism in Hawaiʻi. The three questions were to rate the level of impact and agreement on: 1. Rate the overall impact of tourism on your family, 2. Tourism has brought more benefits than problems, and 3. The island is being run for the tourists at the expense of the local people. The three questions were normalized for a score of 0 to 100 with 100 being positive or agreement on positive impacts of tourism for residence of Hawaii. Questions were averaged and scored to a reference value of 80% as set by the Hawaiʻi Tourism Authority as their target acceptance rate (HTA 2016 Annual Report).

*Environment* scores the protection of the natural environment including ocean areas (Marine Protected Areas, Community Subsistence Fishing Areas, NOAA Sanctuary Areas). Environmental protection data comes from the Aloha+ dashboard on marine managed areas with a reference rate of 30% nearshore areas effectively managed by 2030.

Scores ranged from 59 to 65 by region. Scores are low considering that Hawaiʻi’s economy’s main contributor is the tourism industry. The low scores reflect the need to balance the economic gains with the preservation of Hawaiʻi’s unique cultural and natural environment. Working group participants have identified several areas to improve to increase preservation of social and cultural values and the natural environment. These include increased tourism education programs and increased proportion of the tax revenues generated from the tourism industry allocated to community and environmental preservation.

Table 1. Draft scores for the status of the Sustainable Tourism Goal.

|  |  |  |
| --- | --- | --- |
| Region | Score | Trend |
| Hawaiʻi | 62.5 | -0.29 |
| Maui Nui | 65.2 | -0.28 |
| Oahu | 59.1 | -0.38 |
| Kauai | 62.4 | -0.38 |

**Recreation**

Recreation measures the dominant use areas for recreation activities and the percent of Hawaii residents taking part in recreational activities.

Table # Human use survey on the frequency of ocean uses of Hawaiian residents. Data from Edwards et al. 2014.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Region | Frequency | swimming/wading | snorkeling | diving(scuba or free diving) | camping | beach recreation | boating | wave riding | canoe or kayaking |
| Hawaii | Never | 17 | 39 | 66 | 46 | 19 | 67 | 63 | 69 |
| once a month | 31 | 35 | 19 | 39 | 41 | 22 | 17 | 20 |
| 2-3 times a month | 17 | 8 | 6 | 7 | 17 | 5 | 6 | 4 |
| 4 times a month or more | 35 | 17 | 9 | 8 | 23 | 7 | 14 | 7 |
| Oahu | Never | 22 | 53 | 75 | 54 | 24 | 73 | 59 | 73 |
| once a month | 33 | 28 | 14 | 37 | 40 | 18 | 20 | 17 |
| 2-3 times a month | 13 | 7 | 5 | 4 | 19 | 4 | 8 | 3 |
| 4 times a month or more | 32 | 11 | 7 | 5 | 17 | 6 | 14 | 7 |
| Maui Nui | Never | 18 | 40 | 63 | 49 | 20 | 61 | 53 | 65 |
| once a month | 23 | 31 | 19 | 36 | 34 | 27 | 18 | 21 |
| 2-3 times a month | 13 | 9 | 6 | 8 | 18 | 5 | 8 | 5 |
| 4 times a month or more | 47 | 20 | 13 | 7 | 29 | 7 | 21 | 8 |
| Kauai | Never | 14 | 40 | 62 | 40 | 13 | 61 | 51 | 57 |
| once a month | 23 | 33 | 19 | 42 | 35 | 27 | 21 | 30 |
| 2-3 times a month | 15 | 9 | 5 | 9 | 19 | 4 | 5 | 6 |
| 4 times a month or more | 47 | 18 | 13 | 9 | 34 | 8 | 23 | 7 |

**Livelihoods & Economies**

Oceans jobs and revenue directly provide 18% to the economy of Hawaii. However there are many indirect economy benefits and markets. One could argue that the entire economy of Hawaii is based on the ocean. The attraction of visitors and tourism relies in part on a healthy ocean. In fact tourism and recreation is 90.5% of Hawaiis ocean economy.

Data from ENOW on Employment (jobs), Wages, and Revenue by ocean sector. Sectors include: Marine Construction, Living Resources, Ship and Boat Building, Tourism and Recreation, and Marine Transportation. Self-employed and state employed data sets were aggregated and summarized by county. However, when aggregated to county some of the information was undisclosed therefore this data represents a conservative estimate of Livelihoods and Revenue.

Livelihoods:

Livelihoods was measured as the current number of jobs per marine and ocean sector (*z*) in relation to a reference year (2009) and the sector average wage in relation to median wage calculated as two year rolling average in constant 2013 USD (DBEDT Section 13.2 Hawaii Databook/) or per capita personal income in 2015 $48,288 (DBEDT http://dbedt.hawaii.gov/economic/ranks/). Current year (*c)* is the most recent year with available data (2013). Data on ocean sector employment and wage comes from NOAA (<https://coast.noaa.gov/digitalcoast/tools/enow.html>) and was adjusted by state unemployment rate (DBEDT).

Wage per sector was referenced to estimated Hawaii expenditures, $41,021 (U.S. Bureau of Economic Analysis, Interactive Tables: Personal Income and Employment, Personal Consumption Expenditures, By State: 1997-2014 <http://www.bea.gov/regional/index.htm#data> ). DBEDT Table 13.38

Economies:

Where e is the total adjusted revenue generated from each marine and ocean sector (*z*).

What is gdp inflation adjusted too? What year is the reference usd? 2010?

If total direct and indirect revenue then need economic multipliers:

Industry multipliers: (<http://files.hawaii.gov/dbedt/economic/reports/IO/2007_state_io_study.pdf>)

Aquaculture 1.46

Commercial Fishing 1.42

Water Transportation 1.46

Construction 1.54

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Goal | Subgoal | Region | Score | Trend |
| LE | Liv | 1 | 87.6 | 0.57 |
|  |  | 2 | 87 | 0.58 |
|  |  | 3 | 100 | 0.55 |
|  |  | 4 | 70 | 0.58 |
|  | Eco | 1 | 100 | 1 |
|  |  | 2 | 100 | -1 |
|  |  | 3 | 100 | 1 |
|  |  | 4 | 100 | 1 |

**Sense of Place**

Cultural values are expressed in the development of this goal and several of the other goals and we recognize local and culture values as important to all aspects of ocean health. A working group that includes the Office of Hawaiian Affairs, cultural advisors, and community members are assisting in the definition and development of this goal for Hawai’i. This goal stresses the importance of past, present, and future for the connection of people to places (āina) and relationships or networks of people with each other. Together these define community. Suggested metrics for this goal are the connection of the past, present, and future through knowledge of and representation of Hawaiian place names (ex. ahupuaa boundary signs), network of communities (# of members), acres of community managed areas and/or number of community stewardship programs, and place-based educational opportunities. Hawaiian place names represent knowledge of the past and Hawaiian place names tell a story of the place, what the place was known for or used for. This cultural history is important for present day stewardship and keeping the connection of people to place into the future. Defining shared values and building economic opportunities and support for community programs is a recommended indicator under the Smart Sustainable Communities target under Hawaii Green Growth Aloha+ Challenge.

*Wahi pana*

Table 1. Data from the Hawaii Historic Preservation Plan 2012-2017 (https://historichawaii.org/wp-content/uploads/2014/05/Hawaii-Preservation-Plan-2012-2017.pdf).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| year | region | heiau | archaeological | buildings | total |
| 2011 | Hawaii | 275 | 28713 | 497 | 29485 |
| 2011 | Maui Nui | 278 | 12230 | 140 | 12648 |
| 2011 | Oahu | 145 | 7108 | 143 | 7396 |
| 2011 | Kauai | 135 | 1954 | 77 | 2166 |

The State of Hawaiʻi defines historic preservation as “the research, protection, restoration, rehabilitation, and interpretation of buildings, structures, objects, districts, areas, and sites, including underwater sites and burial sites, significant to the history, architecture, archaeology, or culture of this State, its communities, or the nation.” The definition of historic property means any building, structure, object, district, area, or site, including heiau and underwater site, which is over fifty years old.

**Lasting Special Places**

Clipped NOAA MPA inventory layer to 3nm offshore. MPAs classified by no take, no access, zoned with no take, and zoned with multiple use and zoned with uniform use. All MPAs with no take, no access or zoned with no take were given a weight of 1 and all other MPA classifications were given a weight of 0.5. The score of lasting special places was assessed as the ratio of the total area protected to the total area within 3nm from shore.

Currently – eez not included in calculation

**Connection to Place**

Connection to place is the relationship or connection to places. What we do and how we value coastal and ocean areas can in part define our connection to place. There were many very valuable suggestions on how to measure Connection to Place including the use and knowledge of Hawaiian place names. Hawaiian names often reflect the activities, history, and the environment of the place. Unfortunately there was no consistent way to measure the use of Hawaiian place names. Therefore, connection to Place was assessed as the participation rate in ocean and coastal activities. This information was collected across the state by the NOAA Coral Reef Conservation Program 2014 socioeconomic surveys of human use, knowledge, attitudes, and perceptions in Hawaii (NOAA 2014). Ocean Use Atlas (area of activity)

NOAA (2014) National Coral Reef Monitoring Program: Socioeconomic surveys of human use, knowledge, attitudes, and perceptions in Hawaii from 2014-11-11 to 2014-11-26.

Salt production important story to showcase – loss of production and threats

Climate change mitigation

Place can be defined by what types of activities occur

HCA Conservation Connections http://www.conservationconnections.org/

**Clean Water**

**ICC data used as reference layer in OHI to compensate for marine debris pressure**

Not much we can do to control marine debris at Hawaii scale

Marine debris as pressure layer

Need to stop at production, at the source.

Temporal and Spatial Analysis of Marine Debris

Jordan Toshimasa Muratsuchi

International coastal cleanup was annual event now year round post 2016

Data good from 2008 to 2016

Methods:

Debris per person per mile as reference. Per person cleaning up

Is debris on Hawaii increasing?

Declining slightly since 2008 – how much

References

Jambeck et al 2015

What proportion is Hawaii based vs external sources? Tsunami marine debris?

If Hawaii ends single use plastics what present reduction in marine debris would you expect?

Windward vs leeward affects?

Clean water reference – more pick up = less in environment 30% reduction in marine debris – fit with 30 by 30 target 30% reference

Marine Debris

**Coastal Protection**

C is the condition at current (c) and reference (r) extent or condition of the habitat. Habitats were not weighted by extent as areas and lengths are used and the protective ability of each habitat for coastal protection is not fully known. Habitats include coral reefs, beaches, and wetlands.

*Coral reefs*

Coral reef extent from cumulative impact mapping layers that combine hard bottom and coral reef habitats to a depth of 100 meters (Lecky 2016).

Coral reef condition indicators come from the Hawaii Monitoring and Research Collaborative and combined coral reef monitoring database used to develop measurements of reef status and trends to support reef management decisions statewide, and; measure our progress toward the Sustainable Hawaii Initiative goal to effectively manage 30% of our nearshore ocean waters by 2030.

Coral reef condition is assessed as the coral reef index, a measure of coral reef health from combined indicators for % coral cover, %macroalgae, % coralline algae, and the ratio of calcifiers to non calcifiers, all fish biomass, resource fish biomass, parrotfish biomass, total fish biomass no sharks and jacks. The coral reef index scores are a rank assessment among the 42 Mokus (traditional land management areas).

Coral Reef trend – to be determined at later date, from HIMARC but for now used data from CREP 2016 Report on change in % coral cover from 2011-2012 to 2016 surveys from the Main Hawaiian Islands.

*Beaches*

Beach condition and trend data comes from Fletcher et al. 2012. Beach erosion is expected to increase with sea level rise and sea level rise acts as a large pressure on this goal. Beach extent is calculated as the total length of classifications3, 4, and 5 from the National Oceanic and Atmospheric Administration Office of Response and Restoration Environmental Sensitivity Index. Beach condition is the percent of beaches remaining stable (not eroding). The beach trend is the long term erosion rate (past century) calculated from Fletcher et al. 2012. This data may be updated as USGS plans to assess the beach erosional rate every 5-10 years (Fletcher et al. 2012).

*Wetlands*

Wetlands are classified based on soil saturation, percent of herbaceous vegetation, trees and shrubs, locality (riverine), and salinity ([National Oceanic and Atmospheric Administration](file:///D:\Documents%20and%20Settings\eschemmel\AppData\Local\Temp\Temp1_Re%253a_expense_sharing.zip\11_Costofwetlandschange%202013%20update%2011_DEC_2013.docx#_ENREF_15), USGS NRC). Along with providing coastal protection, wetlands are important habitats which are crtitical habitats for many endemic and endangered plants and animals. Pressures to wetlands include invasive species (including mangroves), land development, and land-based sources of pollution.

Wetland extent was assessed from National Oceanic and Atmospheric Administration Coastal Change Analysis Program (NOAA C-CAP) data clipped to within 1 km inland from the coast to capture coastal wetlands extent. All estuary categories were included in this assessment that were within 1km of the coastline as these habitats within 1km of the shoreline will mitigate against flooding and wave inundation. Spatial resolution to 2.4m2. Surveys are repeated every 5 years to measure changes in land cover. Wetland condition information from Van Rees and Reed (2014) and was modeled as the from the percent loss of historical coastal wetlands to an elevation of 304 meters. Trend in coastal wetlands was assessed as the difference in area from 2010/2011 to 1992 NOAA CCAP wetlands extent within 1 km of the coastline. Spatial resolution changed from 30 meter to 3 meters from 1992 to 2010.

*Mangroves*

While mangroves are considered unique and integral ecosystem species in their native range they can be a huge threat to areas where they are introduced and invasive. Mangroves are an introduced and invasive species in Hawaii. While they do offer coastal protection, we did not include them in this assessment as they are considered to do more harm than good. Mangroves have especially large impacts to native biodiversity and traditional Hawaiian fishponds (loko iʻa) (references). Removal efforts are underway to remove and clear mangroves and restore native estuaries and fishponds (LINK to work).

*Data Gaps and Priorities*

* Need infromation on fishpond extent and conidtion to incorperate them into the assessment of coastal protection
* Looking into incorporating dune data as well as beach data
* Looking at estimates of shoreline protective ability based on slope or shoreline relief/aspect ratios
* Information on the protective ability or importance of each habitat for coastal protection in Hawaii.
* Updated inventory on coastal wetlands and estuaries is currently being developed by the Hawaii Department of Land and Natural Resources Division of Aquatic Resources.

**Biodiversity**

*Opihi data important – rest areas*

*Intertidal – Chris Bird – definition - rocky intertidal – length – shorelines rocky from ESI data layers – just extent*

*Coral reefs*

Coral reef extent from cumulative impact mapping layers that combine hard bottom and coral reef habitats to a depth of 100 meters (Lecky 2016).

Coral reef condition indicators come from the Hawaii Monitoring and Research Collaborative and combined coral reef monitoring database used to develop measurements of reef status and trends to support reef management decisions statewide, and; measure our progress toward the Sustainable Hawaii Initiative goal to effectively manage 30% of our nearshore ocean waters by 2030.

Coral reef condition is assessed as the coral reef index, a measure of coral reef health from combined indicators for % coral cover, %macroalgae, % coralline algae, and the ratio of calcifiers to non calcifiers, all fish biomass, resource fish biomass, parrotfish biomass, total fish biomass no sharks and jacks. The coral reef index scores are a rank assessment among the 42 Mokus (traditional land management areas).

Coral Reef trend – to be determined at later date, from HIMARC but for now used data from CREP 2016 Report on change in % coral cover from 2011-2012 to 2016 surveys from the Main Hawaiian Islands.

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Beach condition and trend data comes from Fletcher et al. 2012. Beach erosion is expected to increase with sea level rise and sea level rise acts as a large pressure on this goal. Beach extent is calculated as the total length of classifications 3, 4, and 5 from the National Oceanic and Atmospheric Administration Office of Response and Restoration Environmental Sensitivity Index. Beach condition is the percent of beaches remaining stable (not eroding). The beach trend is the long term erosion rate (past century) calculated from Fletcher et al. 2012. This data may be updated as USGS plans to assess the beach erosional rate every 5-10 years (Fletcher et al. 2012).

*Soft Bottom*

Near shore soft bottom habitat extent was mapped to a depth of 100 meters (Ocean Tipping Points). The condition was measured as the proportion of soft bottom habitat that was not dredged. Dredging was defined as activity involving physically removing substrate with machinery typically to allow for safe passage of vessels Ocean Tipping Points (http://www.pacioos.hawaii.edu/projects/oceantippingpoints/#data).

*Saltmarshes/Wetlands*

Refer to Coastal Protection Goal

National Oceanic and Atmospheric Administration Coastal Change Analysis Program (NOAA C-CAP)

*Estuaries*

Estuaries are defined as the transition zone where fresh water from land meets and mixes with seawater creating some of the most productive ecosystems in the world (REF) There are many challenges to mapping and defining estuary types. Currently, there is not a complete database for estuaries in Hawaii. However, this database is currently being developed by the Hawaii Department of Land and Natural Resources Division of Aquatic Resources. For this assessment we used the National Wetlands Inventory with the deeper water estuaries excluded as these were previously mapped out to the full near shore extent (3nm) and did not fit our classification of estuary habitats.

*Mangroves*

Mangroves are invasive in Hawaii and pose several negative ecological impacts (Allen 1998), therefore they are not included in the goal models but they are included as a pressure that is applied to Biodiversity, Artisanal Fishing, Recreation, Sense of Place, and Food Provision.

*Species*

Hawaiʻi has a high rate of endemic species. The latest assessment lists 501 Endangered species (77 animal) (Environmental Conservation Online System 02/13/2015). The Endangered Species Act (ESA) was established in 1973 provides for the conservation of species that are endangered or threatened (likely to become endangered in the near future without protection) throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. To assess species status we combined information on local reef fish species status indicators (NOAA report card/ HMARC), and ESA status of marine mammals (cetacean table), turtles, and coastal plants. We incorporated reef fish indicators even though many of Hawaiʻiʻs reef fish are not considered threatened or endangered. Local indicators of reef fish populations and status are important for understanding the health of coral reefs and biodiversity and therefore were included along with reef fish species richness.

*Fish – biomass of reef fish ranked by spatial reference (by Moku). Fish species richness…*

Fish species richness and reef fish indicator scores were averaged per region.

Reef fish indicators are made up of 3 components (Reef Fish Biomass, Reef Fish Sustainability, and Reef Fish Predators). Reef Fish Biomass: mean biomass of all reef fishes other than sharks and jacks derived from underwater visual surveys of <30m hardbottom habitats. Survey biomass per location is compared against a meaningful local baseline (to account for inherent environmental and habitat differences among locations. High scores therefore represent populations that are close to their natural carrying capacity. Reef Fish Sustainability represents an index of mean size of a range of targeted reef fish species relative to their size at first maturity. High scores therefore represent assemblages where there are still many of large individuals of targets species, those large fishes being particularly important components of the breeding stock.Reef Fish Predators. This indicator is made up of 2 components: ‘reef sharks’ and ‘other reef piscivores’ with data taken respectively from towed-diver and point-count surveys by divers. High scores represent locations where upper trophic level fishes are still a conspicuous and ecologically important component of the reef ecosystem.

*Marine Mammals & Turtles*

Data from the Main Hawaiian Islands Biogeographic Assessment (2016) was used to create a marine mammal species distribution map. Species with modeled relative abundances were combined into one mosaic dataset to count the number of overlapping marine mammals per cell.

*n =* number of species per grid cell *c*

*M =* number of grid cells in the assessment region

*Ac*  = total area of grid cell

*AT* = total area of the assessment region

|  |  |  |
| --- | --- | --- |
| Common name | Species name | ESA Status |
| Blainville’s beaked whale | Mesoplodon densirostris | NC |
| Blue whale | Balaenoptera musculus musculus | E |
| Bryde’s whale | Balaenoptera edeni | NC |
| Common bottlenose dolphin | Tursiops truncatus truncatus | NC |
| Cuvier’s beaked whale | Ziphius cavirostris | NC |
| Dwarf sperm whale | Kogia sima | NC |
| False killer whale | Pseudorca crassidens | E |
| Fin whale | Balaenoptera physalus physalus | E |
| Fraser’s dolphin | Lagenodelphis hosei | NC |
| Green | Chelonia mydas | T |
| Hawaiian monk seal | Neomonachus schauinslandi | E |
| Hawksbill | Ertmochelys imbricata | E |
| Humpback whale | Megaptera novaeangliae | E |
| Killer whale | Orcinus orca | NC |
| Leatherback | Dermochelys cariacea | E |
| Loggerhead | Caretta caretta | E |
| Longman’s beaked whale | Indopacetus pacificus | NC |
| Melon-headed whale | Peponocephala electra | NC |
| Minke whale | Balaenoptera acutorostrata scammoni | NC |
| North Pacific right | Lissodelphis borealis | NC |
| Olive Ridley | Lepidochelys olivacea | T |
| Pantropical spotted dolphin | Stenella attenuata attenuata | NC |
| Pygmy killer whale | Feresa attenuata | NC |
| Pygmy sperm whale | Kogia breviceps | NC |
| Risso’s dolphin | Grampus griseus | NC |
| Rough-toothed dolphin | Steno bredanensis | NC |
| Sei whale | Balaenoptera borealis borealis | E |
| Short-finned pilot whale | Globicephala macrorhynchus | NC |
| Sperm whale | Physeter macrocephalus | E |
| Spinner dolphin | Stenella longirostris longirostris) | NC |
| Striped dolphin | Stenella coeruleoalba | NC |

**Carbon Storage**

Carbon storage was calculated as the condition and area of coastal wetland habitat weighted by the estimated carbon storage capacity of wetlands.(NOAA\_CCAP 2011; REF).

Seagrasses are also considered habitats for carbon storage however they are not included in this assessment as seagrass area has been estimated to be less than 0.02% of the Hawaiian Island benthic cover (NOAA Coral Reef Habitat Assessment 2009) and is not well mapped.

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