OHI documentation

**Wild Caught Fisheries**

Data layers used

Commercial catch data (2012-2016)

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

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 assessment was 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.

**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 temporal maximum harvest?

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 ornamentals fish and plants | *Various species* | 0.5 | 0.5 | 1 | 0.5 | 0.63 |
| Marine shrimp for food | *Penaeus vannamei* | 0 | 0 | 0 | 0.5 | 0.13 |
| Microalgae | *Spirulina sp, Hematococcus sp* | 1 | 1 | 1 | 1 | 1.00 |
| Seahorses (various species) | *Hippocampus sp* | 0.5 | 0 | 1 | 1 | 0.63 |
| 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 or artisanal fishers.

Access was determined as an issue for artisanal fishing opportunities. Access was defined as the number of beach or coastal access points from the workshops. 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 was not available therefore access was assessed by….

Resource was measured as the current biomass of coastal resource fish (fish that are commonly harvested) to the reference biomass of coastal resource fish.

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 likely an overestimate given that not all household members will be fishers but it does allow for a comparison of need across regions.

**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<5.0% and r>25% =0.25*

The mean of *sentiment* (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 Hawaii 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) and watersheds (state of Hawaiʻi priority watersheds). Environmental protection data comes from the Aloha+ dashboard on marine managed areas with a reference rate of 30% nearshore areas effectively managed by 2030.

RESULTS

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 a proportion of the tax revenues generated from the tourism industry allocated to community and environmental preservation.

|  |  |  |
| --- | --- | --- |
| Region | Score | Trend |
| 1 | 62.5 | -0.29 |
| 2 | 65.2 | -0.28 |
| 3 | 59.1 | -0.38 |
| 4 | 62.4 | -0.38 |

**Livelihoods & Economies**

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).

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.

**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

**Biodiversity**

*Opihi data important – rest areas*

*TNC ecoregional assessment -Joey got from NOAA – Joey steward of the database - wetlands layer –*

*Wetlands layer from TNC Reference – where got data from -Merp –*

*Run marxsan analysis for priority areas to work in conservation*

*Targets – conservation targets*

*Original – more information in attribute tables*

*Targets-marxan*

*Conservation areas is the output of the marxan*

**Cummulative impact – mesophotic -**

**Nearshore all habmerged – NOAA 2007 habitat data**

**Nearshore habs final compare to maps in thesis to figure out wat categories relate to which habitat**

**3**

**2**

**1**

Habitats

*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).

What do the number units represent – biomass calculated as ?

Notes on coral reef health number form HMRC

Niʻihau combined with Kauai

Koalawae combined with Maui Nui

**Coral Reef trend – to be determined at later date**

*Beaches*

Beach extent, condition, and trend data comes from Romine and Fletcher 2013). Beach erosion is expected to increase with sea level rise. This is a large pressure on this goal. Extent is average beach length- ask Romine. Beach condition is the percent of beaches remaining stable (not eroding). The condition is the rate of change

is the long term erosion rate (past century) calculated from Romine and Fletcher 2013.

USGS plans to assess the beach erosional rate every 5-10 years.

*Wetlands & Estuaries*

*Wetlands*

The extent of wetlands were assessed from NOAA ccap data clipped to within 1 km inland from the coast to capture coastal wetlands extent. Estuary categories included in this assessment are estuarine emergent wetland, estuarine forested wetland, estuarine scrub shrub wetland (<https://coast.noaa.gov/data/digitalcoast/pdf/ccap-class-scheme-regional.pdf>). Spatial resolution to 2.4m2. Surveys are repeated every 5 years to measure changes in land cover.

The reference condition used for the assessment is wetland area in 1989 at the time of the no net loss act (what is this policy reference). The predevelopment (1780) extent of wetlands in Hawaii has been estimated to be 58,800 acres or 238 square kms and estimates in 1980s are 51,800 acres.

The trend of wetlands was assessed as the percent loss from 2005 to 2010/2011.

*Estuaries*

There is not a complete database for estuaries in Hawaii. The database form TNC ERA has estuaries however it needs to be updated and estuary classifications assigned.

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

*Species*

The subgoal species was assessed as the mean of the fish species and marine mammals and turtles scores.

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

Fish species richness and biomass scores were averaged per region.

*Marine Mammals & Turtles*

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

*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 |

References

Romine, B.M. and Fletcher, C.H., 2013. A summary of historical shoreline changes on beaches of Kauai, Oahu, and Maui;

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