Cetacean Stock Assessment by the PIFSC CRP

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2015 External Review: Protected Species
Pacific Island Cetaceans

- 25 species
  - Hawaii: 24
  - Guam/CNMI: 22
  - Palmyra/Kingman: 18
  - Johnston: 15
  - American Samoa: 12
  - Wake: 8
  - Howland/Baker: 6
  - Jarvis: 1

- 121 stocks

Stock Assessment Reports (SARs) mandated by MMPA
Staff & Collaborators

- Currently 3 full-time staff and 2 part-time contractors contributing to stock assessment analyses

- Major collaborators:
  - Cascadia Research Collective
  - Southwest Fisheries Science Center
  - PIRO Observer Program
  - Hawaiian Islands Humpback Whale National Marine Sanctuary
  - PIR Marine Mammal Response Network
Presentation Overview

Objective: Describe how the CRP uses standard approaches to assess cetaceans

- Main SAR components:
  1. Occurrence
  2. Stock structure
  3. Abundance
  4. Human-caused mortality

- Component coverage:
  - Datasets, analytical methods, important findings, common challenges, and innovations
1. Stock Occurrence

- Basic assessment component
- Presence of species in outlying areas still being determined
- From simple presence to when and where a species/stock occurs
- Useful to consider to what degree regions have been surveyed

J. Cotton, SWFSC
Establishing Occurrence

- Full EEZ ship survey
- Partial EEZ ship survey
- Unsurveyed

*Also multi-year island-associated small-boat surveys*
Occurrence in Surveyed Areas

- Ship surveys give temporal snapshot of occurrence, but of coarse resolution

<table>
<thead>
<tr>
<th>Region</th>
<th>Years fully surveyed</th>
<th>Years partially surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmyra/Kingman</td>
<td>2005, 2011-12</td>
<td></td>
</tr>
<tr>
<td>Johnston</td>
<td>2005</td>
<td>2006</td>
</tr>
<tr>
<td>Guam/CNMI</td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>American Samoa</td>
<td></td>
<td>2006, 2012</td>
</tr>
<tr>
<td>Wake</td>
<td></td>
<td>2010</td>
</tr>
</tbody>
</table>
Small boat surveys can increase coverage for island-associated species, but constrained by weather conditions. 

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Baird et al. 2013
Satellite Telemetry

- Powerful tool in PIR for assessing full seasonality and range
- Extensive tagging of odontocetes by CRC (HI) and increasing tagging by CRP (Guam/CNMI, HI)
- CRC actively pursuing quantitative analyses of spatial and habitat use
- CRP beginning, although sample sizes low

Baird et al. 2012
Problem Solved?

- Tags are costly, require ideal conditions, and have varying durations
- Current tagging program not appropriate for smallest odontocetes or baleen whales
- Limited capacity within CRP for geospatial analyses
Occurrence in Unsurveyed Areas

- Data from verified reports from a variety of sources (and CRP acoustic recorders)
- Would require 105 sea days to survey Howland/Baker and Jarvis
- Likelihood of adding species is high, but at a cost to advancing assessments of high priority species in other regions
Main SAR components:
1. Occurrence
2. Stock structure
3. Abundance
4. Human-caused mortality
2. Stock Structure

- 98 of 121 (81%) of PIR stocks are recognized as an EEZ-wide stock

- According to GAMMS, EEZ is sufficient basis for defining a stock, although basis under evaluation

- Island ecosystems are known to isolate island-associated (odontocete) populations
  - When data are available to test for structure, it is usually found
  - All stocks with finer levels of stock structure are island-associated
  - “Pelagic” stock designated by default to account for offshore individuals
Genetic Stock Delineation

- Genetic analyses (of mt/nuDNA) are the “gold standard” for evaluating stock structure
- Biopsy samples routinely collected by CRP and collaborators
  - CRP does not have capacity for genetic analyses
- Genetic analyses have successfully revealed island-associated populations

Andrews et al. 2010
Hill et al. 2011
All that Glitters...

- For some species, biopsy samples are difficult to obtain or slow to accrue
  - Stocks of rare or cryptic species vulnerable to human-caused mortality would never be delineated based on genetics alone

- Other information (photo-ID, movements) may strongly indicate stock structure
  - Stock delineation not generally based on such information

NMFS established the Stock Delineation Guidelines Initiative to develop a consistent national approach for defining stocks from multiple lines of evidence
Melon-headed Whales

- Photo-ID and social network analyses suggested 2 HI populations
- Supported by movements and preliminary genetic analyses

Recognized as 2 stocks in 2013

Aschettino et al. 2012
Presentation Update

- Main SAR components:
  1. Occurrence
  2. Stock structure
  3. Abundance
  4. Human-caused mortality
3. Stock Abundance

- Estimates used to evaluate trends and to calculate sustainable levels of bycatch in SARs
- Estimates used in SARs considered outdated after 8 years
- Generally difficult to obtain precise abundance estimates
- Commonly obtained using line-transect or mark-recapture methods
Estimating Abundance in the PIR

A. Line-transect abundance estimates using ship-based visual survey data

B. Habitat-based density estimates using ship-based visual survey data

C. Mark-recapture abundance estimates of island-associated species using small-boat survey data
Hawaiian Islands Cetacean Ecosystem Assessment Survey (HICEAS)

- In 2002, SWFSC conducted the first HICEAS

- Ship-based, visual line-transect survey to estimate cetacean abundance in the Hawaiian EEZ

- 23 species encountered and abundance estimated for 19

- First abundance estimates for most Hawaiian stocks

- Second HICEAS carried out in 2010 by SWFSC and PIFSC
HICEAS 2010 Data Collection

- Conducted during summer and fall using 2 vessels
- Parallel lines formed a grid that comprehensively covered the study area
- Used well-established visual observation methods
- 6 observers rotated through 3 positions
- Ship diverted to sightings within 5.6 km of trackline
- Various data collected including bearing and radial distance
HICEAS 2010 Overview

- 16,145 km systematic transect effort in Beaufort 0-6 (95% in 3-6)
- 198 systematic-effort sightings = 211 sightings of 20 species (15 odontocetes, 5 mysticetes)
  - Spinner dolphins and dwarf sperm whales not seen on systematic effort
  - Humpback whales were, but not properly sampled
  - Pygmy sperm whales not seen

Bradford et al. in review
## Sighting Summary

<table>
<thead>
<tr>
<th>Species</th>
<th>No. Sightings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spotted</td>
<td>10</td>
</tr>
<tr>
<td>Striped</td>
<td>18</td>
</tr>
<tr>
<td>Rough-toothed</td>
<td>8</td>
</tr>
<tr>
<td>Bottlenose</td>
<td>6</td>
</tr>
<tr>
<td>Risso’s</td>
<td>9</td>
</tr>
<tr>
<td>Fraser’s</td>
<td>3</td>
</tr>
<tr>
<td>Melon-headed</td>
<td>1</td>
</tr>
<tr>
<td>Pygmy killer</td>
<td>4</td>
</tr>
<tr>
<td>Short-finned pilot</td>
<td>11</td>
</tr>
<tr>
<td>Killer</td>
<td>1</td>
</tr>
<tr>
<td>Sperm</td>
<td>23</td>
</tr>
<tr>
<td>Blainville’s</td>
<td>1</td>
</tr>
<tr>
<td>Cuvier’s</td>
<td>2</td>
</tr>
<tr>
<td>Longman’s</td>
<td>3</td>
</tr>
<tr>
<td>Bryde’s</td>
<td>19</td>
</tr>
<tr>
<td>Sei</td>
<td>2</td>
</tr>
<tr>
<td>Fin</td>
<td>1</td>
</tr>
<tr>
<td>Blue</td>
<td>1</td>
</tr>
</tbody>
</table>

No. of sightings range: 1-23
Estimation Approach

**Encounter rate \(\frac{n}{L}\)**
- Low \(n\) leads to high variance in encounter rate that dominates CV

\[
D = \frac{1}{2 \cdot L \cdot g(0)} \sum_{j=1}^{n} f(0, c_j) \cdot S_j
\]

**Trackline detection probability**
- Barlow (2015) estimated relative values of \(g(0)\) in different survey conditions by comparing Beaufort-specific density estimates
- Fit GAMs to survey data from 1986-2010, including HICEAS 2010 data

**Group size**
- Geomean of calibrated “best” estimates from each observer

**Detection function**
- Sightings pooled with sightings from previous surveys of the central Pacific
- Species with similar detection characteristics also pooled
- Modeled as a function of factors affecting detectability
Barlow (2015) g(0) Estimates

Relative $g(0)$ values decrease with increasing Beaufort state and indicate $g(0)$ has previously been underestimated

- New $g(0)$ values used in HICEAS 2010 estimation
- Assumed to be absolute values
- Weighted average of Beaufort-specific $g(0)$ values

<table>
<thead>
<tr>
<th>Dolphin Species</th>
<th>Old $g(0)$</th>
<th>New $g(0)$</th>
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<tbody>
<tr>
<td>Spotted</td>
<td>0.76</td>
<td>0.28</td>
</tr>
<tr>
<td>Striped</td>
<td>0.76</td>
<td>0.33</td>
</tr>
<tr>
<td>Rough-toothed</td>
<td>0.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Bottlenose</td>
<td>0.76</td>
<td>0.27</td>
</tr>
<tr>
<td>Risso’s</td>
<td>0.76</td>
<td>0.58</td>
</tr>
<tr>
<td>Short-finned pilot</td>
<td>0.76</td>
<td>0.60</td>
</tr>
<tr>
<td>Killer</td>
<td>0.90</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Abundance Summary

<table>
<thead>
<tr>
<th>Species</th>
<th>N</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough-toothed</td>
<td>72,528</td>
<td>0.39</td>
</tr>
<tr>
<td>Striped</td>
<td>61,201</td>
<td>0.38</td>
</tr>
<tr>
<td>Spotted</td>
<td>55,795</td>
<td>0.40</td>
</tr>
<tr>
<td>Fraser’s</td>
<td>51,491</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Bottlenose, short-finned pilot, Risso’s, pygmy killer (>10,000)
Melon-headed, Longman’s, sperm, Blainville’s, Bryde’s (<10,000)
Cuvier’s, Sei (<1,000)

CV range: 0.29 (Bryde’s) to 1.13 (Blainville’s)

Low density: 145 individuals 1000 km⁻²
Estimating Abundance in the PIR

A. Line-transect abundance estimates using ship-based visual survey data

B. Habitat-based density estimates using ship-based visual survey data

C. Mark-recapture abundance estimates of island-associated species using small-boat survey data
Palmyra CEAS

- SWFSC conducted a ship-based, visual line-transect survey of the Palmyra EEZ in 2005
- Aside from false killer whales, no abundance estimates produced
- PIFSC surveyed Palmyra EEZ fall 2011 and spring 2012 (35 DAS in study area, 18 DAS transit)
Palmyra Survey Evaluation

- 22 systematic effort sightings of 7 species (all odontocetes)
  - 18 species known to occur
  - 13 sightings unidentified to species
- 63 other sightings: non-systematic (circumnav, transit), off-effort, and small boat
  - Include 6 additional species
- 193 acoustic detections, 22 biopsy samples, and over 6,000 photos collected
- Survey did not readily lend itself to intended purpose
Habitat-based Density Estimation

- Forney et al. (2015) used ship-based visual sightings in the CNP from 1997-2012 to make grid-based spatial predictions of cetacean density for 9 species.

- Used GAMs to model group density and size as a function of habitat predictors.

- Species-specific density estimated by incorporating group density and size models into standard line-transect equation.
Model Validation: HICEAS Surveys

- **Qualitative:**
  - Compare predicted densities and actual sightings

- **Quantitative:**
  - Calculate ratios of observed-to-predicted density
  - Compare with line-transect abundance estimates

- Model validation a challenge in areas of little to no coverage

Sightings from these areas are of value for building and validating habitat models
Estimating Abundance in the PIR

A. Line-transect abundance estimates using ship-based visual survey data

B. Habitat-based density estimates using ship-based visual survey data

C. Mark-recapture abundance estimates of island-associated species using small-boat survey data
Mark-recapture Data Collection

- Small-boat surveys designed to maximize encounter rate and directed sampling opportunities
  - While covering a range of habitats and minimizing overlap of survey tracklines

- When groups encountered, various data collected and photo-ID images taken

- Photo processing involves:
  - Assigning distinctiveness and quality ratings
  - Matching individuals within and between sightings
  - Evaluating proportion of marked individuals
Mark-recapture Abundance Estimation

- Encounter histories can be used for mark-recapture abundance estimation when robust in size and if analysis assumptions can be addressed.

- In Hawaii, such estimates primarily pursued by CRC
  - Bottlenose and rough-toothed dolphins, melon-headed and false killer whales, and Cuvier’s and Blainville’s beaked whales.

- CRP has conducted small-boat surveys in Guam/CNMI, Palmyra, and American Samoa
  - Pursuing estimates for some species off Guam/CNMI and Palmyra.

<table>
<thead>
<tr>
<th>Region</th>
<th>Species</th>
<th>Catalog Size</th>
<th>No. Sightings</th>
<th>No. Resights</th>
<th>% Resighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guam/CNMI</td>
<td>Short-finned pilot whale</td>
<td>178</td>
<td>305</td>
<td>112</td>
<td>63%</td>
</tr>
<tr>
<td>Guam/CNMI</td>
<td>Spinner dolphin</td>
<td>307</td>
<td>712</td>
<td>175</td>
<td>57%</td>
</tr>
<tr>
<td>Palmyra</td>
<td>Melon-headed whale</td>
<td>158</td>
<td>298</td>
<td>56</td>
<td>35%</td>
</tr>
</tbody>
</table>
Mark-recapture Sampling

**Benefits:**
- Data collected from small boats (cheaper)
- No need to representatively sample habitat
- Generally obtain more precise estimates
- Establishes framework for demographic inference

**Limitations:**
- Can require multiple years to achieve sample sizes
- Generally not practical for pelagic stocks
- Photo processing extremely labor intensive
- May have to invest in feasibility assessment
  - Spotted dolphins in Guam/CNMI (PYSO Intern project)
Presentation Update

- Main SAR components:
  1. Occurrence
  2. Stock structure
  3. Abundance
  4. Human-caused mortality
4. Human-caused Mortality

- Encompasses serious injuries, recently clarified as an injury more likely than not to result in mortality
- M&SI (minimum or quantitative estimates) by source are compiled and averaged over a 5-year period in SAR
- MMPA (and SARs) focus on fisheries M&SI, though other sources are relevant
- Known M&SI sources for PIR:
  - HI and AS longline fisheries
  - Nearshore fisheries
  - High seas fisheries
  - Vessel collisions
Injury Determination

- Cetaceans rarely found dead in the PIR where cause of death can unequivocally be attributed to human causes
- More often observed alive interacting with source, so the severity of the injury must be determined
- In 2012, NMFS published a revised process for injury determination
  - Make process more consistent and transparent
  - Provide additional guidance for cases that previously would have been classified as “cannot be determined.”
M&SI – Pelagic Longline Fisheries

- Deep-set targeting tuna (HI and American Samoa) and shallow-set targeting swordfish (HI)
  - Observer coverage: deep-set at least 20%, shallow-set 100%

- Observer data used to determine number of cetacean deaths and serious/non-serious injuries by fishery, species, and area
  - Basis of bycatch estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Dead</th>
<th>SI</th>
<th>NSI</th>
<th>CBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
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<tr>
<td>2011</td>
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<tr>
<td>2012</td>
<td></td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>2013</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
M&SI – Nearshore Fisheries

- Hawai‘i State fisheries encompass a variety of methods that can be practiced interchangeably.
- Commercial Fish Catch Reports indicate cetacean depredation, but fisheries not observed.
- Indirect evidence suggests impacts worth evaluating for some stocks.
- Potentially an issue in other areas, but also of unknown magnitude.

Baird et al. 2014

S. Yin, HDR
Response Network Reports

- Reports of injured cetacean in Hawaiian waters made each year to the PIR-MMRN and the HIERN
- Largely involve humpback whales entangled in fishing gear or marine debris or struck by a vessel
- Previously unaccounted for in SAR M&SI estimates

For CNP humpbacks, minimum estimates of entanglement and vessel collision from HI are higher than from AK
- Mean annual M&SI 2008-2012 was 7.18 or 9% of PBR

N. Davis, HIERN
HCM Estimation Challenges

- **Observer data:**
  - Uncertainty in species ID or nature of interaction
  - Long processing times by Observer Program

- **Response network data:**
  - Reduced emphasis on non-humpback cetaceans
  - Variable maintenance of database by PIR-MMRN
  - Off-site HIERN collaborator

- **Bycatch estimation:**
  - Bycatch proration to species and stock strains framework

How do we account for unobserved fisheries and other sources of HCM?
Assessment Summary

For the 121 known stocks in 8 PIR areas, only 47 (39%) are accounted for in SARs

- **Major successes:**
  - Delineated and assessed 38 stocks of 23 species in HI
  - Using robust quantitative approaches for overcoming sample size limitations in abundance estimation
  - Processing previously unaccounted for information on HCM and incorporating it in SARs

- **Major challenges:**
  - Assessment approaches strained in PIR given size, high cetacean diversity, and low cetacean density
  - Balancing needs for assessing poorly-known stocks with updating assessments of high priority stocks
Acknowledgements

- Cascadia Research Collective: Robin Baird
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- PIRO: Nancy Young
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- PIR Marine Mammal Response Network: Aliza Milette-Winfree
- Additional funding: U.S. Navy Pacific Fleet
Questions?