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Island-associated stocks of odontocetes in the main Hawaiian Islands: A synthesis of available information to facilitate evaluation of stock structure

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Executive Summary

Populations of several species of odontocete have recently been split by NMFS into one or more island-associated stocks near Hawaii, including false killer whales (*Pseudorca crassidens*), common bottlenose dolphins (*Tursiops truncatus*), and spinner dolphins (*Stenella longirostris*). The unique oceanographic environment of the Hawaiian Archipelago, including relatively high near-shore productivity, together with significant isolation from other island ecosystems, may over evolutionary time-scales encourage separation of populations into wide-ranging pelagic stocks and island-associated stocks that are better suited to exploit near shore resources. In the case of spinner and bottlenose dolphins, variation between stocks exists at individual and multiple island-scales, both in genetic characteristics and group behavior, resulting in several island-associated stocks within Hawaii.

As part of an overall review of odontocete stock structure near Hawaii, we evaluated data on the occurrence, abundance, population structure, movements and behavior of odontocete species found near-shore in the main Hawaiian Islands. Our review indicates that there may be additional species that could be split into one or more island-associated stocks. It is also apparent that the pace of data collection varies by species due to detectability, behavior, or density, , and that pace may provide some guidance on the level of data required for providing information to information splitting stocks. Where significant new data continues to inform questions about stock structure, it may be best to hold decisions about specific stock boundaries as incoming datasets may reveal that those boundaries should be defined differently or that some stocks were created with incomplete data and now should be combined or further subdivided. Where the pace of data collection is very slow, the conservative approach would be to propose new island-associated stocks now based on what evidence is available, acknowledging that boundaries or stock designations may change should new data become available.

At least 23 species of cetacean occur in Hawaiian waters. Many of these are considered broadly oceanic with population distribution and movements not clearly influenced by island processes. Although these species are occasionally seen during nearshore surveys, there is no indication that species such as Risso's (*Grampus griseus*), striped (*S. coeruleoalba*), and Fraser's dolphin (*Lagenodelphis hosei*), sperm (*Physeter macrocephalus*) and pygmy sperm whale (*Kogia breviceps*), or Longman's beaked whale (*Indopacetus pacificus*) associate strongly with the island ecosystem. Most baleen whales are migratory from productive North Pacific waters, residing in Hawaiian waters only during the fall and winter. One exception is Bryde's whales (*Balaenoptera edeni*), a species for which preliminary genetics evidence suggests there may be multiple populations throughout the Pacific but which is rarely seen during nearshore surveys, such that it is currently not possible to evaluate island association. Here we review data from the main Hawaiian Islands on eight species of odontocetes - melon-headed whale (*Peponocephala electra*), short-finned pilot whale (*Globicephala macrohynchus*), rough-toothed dolphin (*Steno bredanensis*), pantropical spotted dolphin (*Stenella attenuata*), Blainville's (*Mesoplodon densirostris*) and Cuvier's (*Ziphius cavirostris*) beaked whales, pygmy killer whale (*Feresa attenuata*) and dwarf sperm whales (*Kogia sima*) - species for which there is some evidence for separation of at least one island-associated stock from the broader pelagic population in the central Pacific around Hawaii. To these reviews we applied three criteria for choosing whether to propose new stocks and their boundaries, criteria based upon the quality of data available now, the likelihood of obtaining new information that may significantly refine our knowledge of stock structure in the near-term, and the overall pace of data collection for each individual species. From this we have developed three categories:

1. Data Rich Stocks: Stocks for which ample data are currently available to support or reject the recognition of new stocks and the placement of new stock boundaries. Although we attempt to base this judgment primarily on peer-reviewed published science, high-quality, well-documented datasets that have been partially reviewed are also considered.
2. Data Poor Stocks: Stocks for which there is some evidence for the existence of an island-associated stock, but for which data will not be available to specifically define the range and boundaries of that stock in the foreseeable future.
3. Stocks with Increasing Data: Stocks for which the pace of data collection is high, such that there may be significant additional information within the next few years with which to better define stock structure. Although some peer-reviewed data may be available which supports formation of new stocks, the range and boundary of those stocks may be much better informed by on-going genetic, sighting history, or ecological analysis, such that postponing designation of new stocks for a few years will result in better defined structure with fewer adjustments to stock assessments over time.

Each of the eight species reviewed have been placed into one of these categories for subsequent action for either 1) officially recognizing new island-associated stocks (Data Rich Stocks), 2) proposing designation of Prospective Stocks (Data Poor Stocks), or 3) withholding designation of any new stocks until on-going analyses are complete (Stocks with Increasing Data). Melon-headed whales and pantropical spotted dolphins are considered data rich stocks, Blainville's and Cuvier's beaked whale, dwarf sperm whales, and pygmy killer whale are considered data poor stocks, and rough-toothed dolphins and short-finned pilot whales are a species for which new data and analyses are expected within the next few years that will refine any designation of new stocks in the Hawaiian Archipelago. Available data by species are reviewed here, providing the rationale for designation of new stocks, prospective stocks, or no new stocks at this time. Species for which island-associated stocks have already been designated and those for which the available data does not suggest island-association are not discussed as part of this review.

Stock Structure under MMPA

The MMPA defines a stock as a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature. Under the 1994 amendments to the MMPA the PBR system was implemented to assure the goal of the MMPA that "population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." Estimates of minimum abundance are central to successful implementation of the PBR system, such that PBR can be over- estimated if stocks are not correctly identified (e.g., are inappropriately pooled into one large stock). Further, stocks may be at risk when underlying structure is not identified, and takes do not occur evenly across the stocks' area.

The original guidelines for marine mammal stock assessments under the MMPA (Barlow et al. 1995) cited the "population stock" as the fundamental unit of legally-mandated conservation efforts. Citing both biological and ecological guidance for making such determinations within the MMPA, the original guidelines outlined the definition of stock structure based on a risk-averse strategy requiring stock definitions to be based on small groupings that are only "lumped" when there is compelling evidence to do so. The revised guidelines (Wade and Angliss 1997) revised this definition to recognize stocks as being a management unit that identifies a "demographically isolated biological population." The revised guidelines acknowledged that "many types of information can be used to identify stocks of a species: distribution and movements, population trends, morphological differences, genetic differences, contaminants and natural isotope loads, parasite differences, and oceanographic habitat differences."

Further, the guidelines suggested that evidence of reproductive isolation, such as morphological or genetic differences, is "proof of demographic isolation, and thus separate management is appropriate when such differences are found." Although there was no intent to define stocks at such small scales that they could represent less than demographically isolated populations, there was recognition that "for some species genetic and other biological information has confirmed the likely existence of stocks of relatively small spatial scale, such as within Puget Sound, WA, the Gulf of Maine, or Cook Inlet, AK."

The current Guidelines for Assessing Marine Mammal Stocks (GAMMS) (NMFS, 2005) have clarified the definition of demographic isolation. "Demographic isolation means that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics). Thus, the exchange of individuals between population stocks is not great enough to prevent the depletion of one of the populations as a result of increased mortality or lower birth rates."

The GAMMS II revisions also added the category of "Prospective Stocks," where available information "appears to justify a different stock structure or stock boundaries." The descriptions of prospective stocks would appear within the existing Stock Assessment Report for the more broadly-defined stock and would include a description of the evidence for the new stocks, calculations of the prospective PBR for each new stock, and estimates of human-caused mortality and serious injury, by source. The notice of availability of draft reports with prospective stocks would include a request for public comment and additional scientific information specifically addressing the prospective stock structure. Prospective stocks would be designated as separate stocks unless additional evidence was produced to contradict the prospective stock structure.

Within this review we propose designation of prospective stocks for those data poor species with evidence of island-association. In these data poor cases, the weight of the evidence for island-association and separation into insular and pelagic stocks is not as strong as for the data rich stocks and considerable uncertainty remains on population size, range, and stock boundaries. The pace of data collection for data poor stocks is very slow, such that it may take decades to collect enough genetic samples or encounters with identification photos to rigorously assess stock structure, while threats to these potentially very small resident stocks persist. In considering whether to make a prospective stock designation, a primary concern is whether an EEZ-wide PBR is inadequately protective of a small resident stock, and whether a potentially lengthy delay in designating a new stock, while awaiting more complete data, will put the resident populations at risk from known human impacts. Input from the Scientific Review Group, other researchers, management agencies, and the public should help us assess whether the separation of an island-associated stock is appropriate at this time, and if so, how outstanding questions on abundance, range, and boundaries should be handled.

Data Rich Stocks

Melon-headed whales

Melon-headed whales are typically found in tropical and subtropical waters worldwide. They are typically oceanic, though they are commonly seen around tropical islands, such as around Dominica in the western Atlantic (Watkins et al. 1997) off Mayotte, in the western Indian Ocean (Kiszka et al.2007), the Marquesas Islands (Nuku Hiva) in the South Pacific, Palmyra Atoll (Brownell et al. 2009), and near the Hawaiian Islands (Aschettino et al. 2012), where they are relatively well-studied in contrast to other portions of their range.

Surveys, Photo-ID, and Movements

Intensive photo-identification work by Cascadia Research in the main Hawaiian Islands has resulted in 57 encounters with melon-headed whale groups where identification photographs were collected (Kauai/Niihau = 4, Oahu = 2, Lanai = 1, Hawaii = 50) between 2002 and 2012. These photos form the basis of a photo identification catalog including individual sighting histories for those animals seen on more than one occasion. An additional eleven encounters with identification photos by other researchers (Oahu = 4, Hawaii = 7) collected between 2005 and 2009 have also been examined for presence in the catalog. Aschettino et al (2012) processed photographs from a subset of these encounters resulting in the identification of 1,046 distinctive or very distinctive individuals with good or excellent photo quality. A large portion of these individuals (716) were seen only once, while 330 individuals were seen on more than one occasion, with an overall re-sighting rate of 23.9%. The maximum number of times an individual was seen was 8.

Re-sighting and social network analyses (Fig. 1) of the Hawaii melon-headed whale photo-ID catalog indicates that most (820/1046) individuals are linked by association to a single social cluster (defined in Whitehead 2008). A smaller, though still sizable second social cluster consists of 180 individuals. The remaining 46 individuals made up three small clusters without association to either of the larger clusters. Aschettino et al (2012) further evaluated the two primary social clusters for variation in sighting depth, frequency, and location. The largest cluster had a median sighting depth of 1662m (range 968-4104m), with several of those individuals seen at both Hawaii Island and near Kauai only 2 months apart. The percentage of animals from the largest cluster that have been re-sighted off Hawaii Island is 16.9%. The smaller social cluster had a median sighting depth of 381m (range 285-905m), with the greatest distance between re-sightings of individuals of 36.1km.

The percentage of animals within the smaller cluster that have been re-sighted off Hawaii Island is 35.6%.

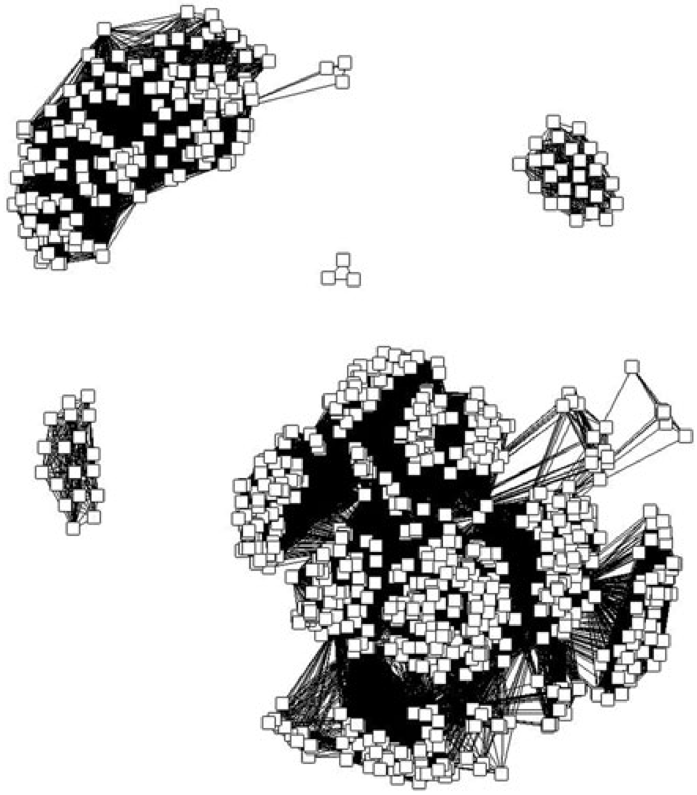
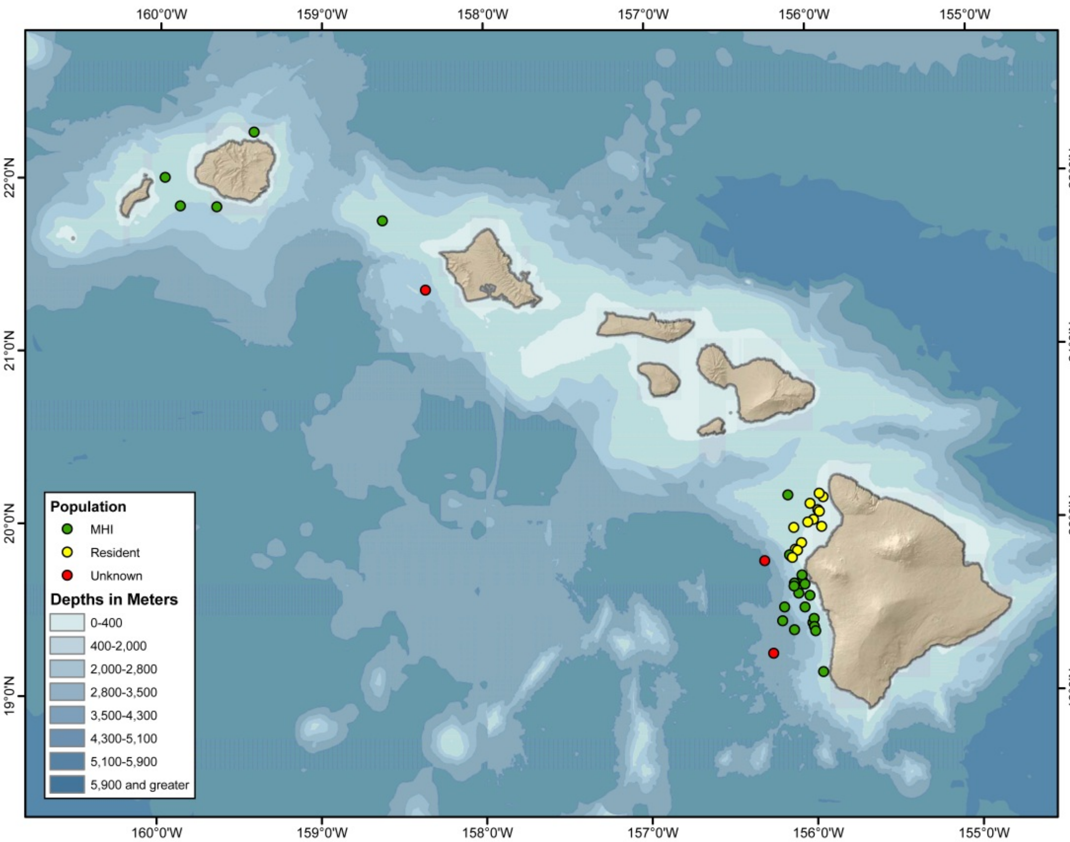


Figure 1. (from Aschettino et al. 2012). Social network diagram showing associations of all well-photographed distinctive individual melon-headed whales. Nodes correspond to individual melon-headed whales, and lines between nodes represent presence within the same group. The majority of individuals (820, 78.4%) are linked to the main cluster and includes individuals seen throughout the main Hawaiian Islands, 180 (17.2%) are part of a second large cluster seen off Hawaii Island, and the remaining 46 (4.4%) are part of three small clusters not linked to either of the main clusters (a cluster of three seen off Hawaiʻi, a cluster of 18 seen off Oʻahu, and a cluster of 25 seen off Hawaiʻi).

Based on the photo-ID and social network results, Aschettino et al (2012) suggests two separate stocks of melon-headed whales exist within the Hawaiian Archipelago: a small resident stock consisting of the smaller social cluster found off of the west and northwest shores of Hawaii

Island and a larger stock consisting of the larger social cluster seen throughout the main Hawaiian Islands. Aschettino et al. (2012) referred to these populations as the Hawaii Island Resident population and the Main Hawaiian Islands population, respectively. Individuals from both of these social clusters have been seen throughout the year and some have sighting histories dating back more than a decade (22 yrs for one Hawaii Islands resident individual), suggesting high site-fidelity for both groups. Bayesian dispersal analysis conducted on the sighting histories also supports separation of these groups based on a median dispersal rate



between these groups of 0.0009/yr (Aschettino et al. 2012).

Figure 2. (updated from Aschettino et al. 2012). Map of melon-headed whale sightings from dedicated surveys between 2002 and 2009. Yellow symbols show encounter locations with the Hawaiʻi Island resident population, green symbols show encounter locations with the main Hawaiian Islands population, and red symbols represent encounter locations with the group that did not link to either population.

Photographs from the Hawaii melon-headed whale catalog have also been compared to ID photographs collected off of Palmyra Atoll between 2006 and 2009 (Baird et al 2010). While the number of good and excellent quality photos with distinctive or very distinctive fins was small relative to expected population size near Palmyra, no matches were found between any animal seen near Hawaii and those seen near Palmyra, suggesting separation of both Hawaii clusters from individuals near Palmyra.

As of February 2013, 19 satellite tags have been deployed on melon-headed whales in the Hawaiian Islands, 13 on individuals from the main Hawaiian Islands cluster and 6 on individuals from the Hawaii Island resident cluster. Movements of ten individuals from the main Hawaiian Islands cluster were analyzed to assess their association with offshore eddies near the main Hawaiian Islands (Woodworth et al 2012). Tracks ranged from 7 to 24 days and from 172 to 1140 km in total length. Five tracks contained offshore components, while the remaining 5 were entirely nearshore. Offshore tracks extended to 160-819km from shore with 33-80% of track duration spent offshore (i.e. in depths greater than 3000m). Three individuals used the edges of cold core cycloninc eddies and the centers of warm core anticycloninc eddies for extended periods.

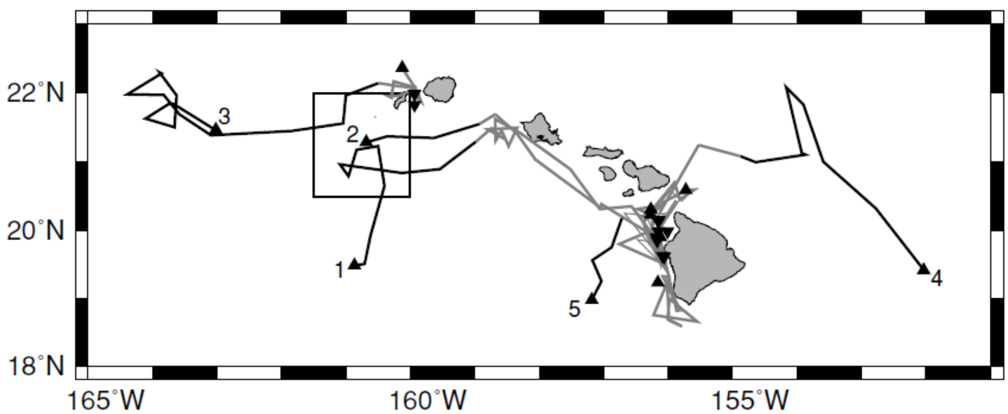


Figure 3. (from Woodworth et al. (2012)). Tracks of all 10 melon-headed whales from the main Hawaiian Islands population with nearshore portions in gray and offshore portions in black. Downward-pointing triangles represent tag deployment positions while upward-pointing triangles represent final recorded track positions. The five offshore tracks are numbered near their final recorded track positions.

Six tags have been deployed on individuals from the Hawaii Island resident population, in four different years (2008, 2009, 2011, 2012), and all six have remained associated with the northwest portion Hawaii Island (Schorr et al. in prep) (Figure 5). The farthest offshore location from the satellite tag data was 49 km, with over 95% of locations within 25 km of shore. Restricting analyses only to high-quality location estimates (LC3, LC2, LC1), the farthest offshore location was 30 km (Schorr et al. in prep.).

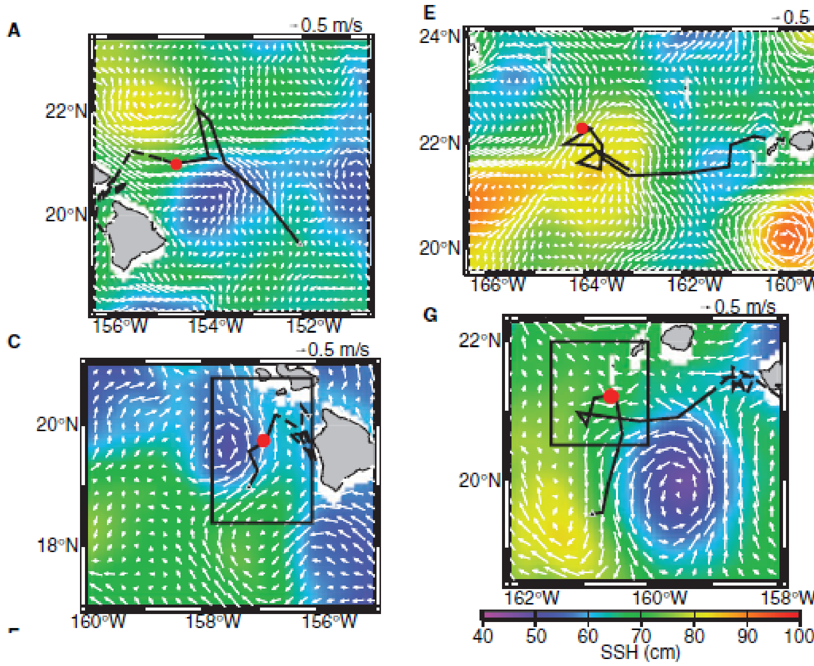


Figure 4. (from Woodworth et al 2012). Melon-headed whale tracks 4 (a), 5 (c), 3 (e), and 1 (g) and HYCOM SSH (color) and surface currents (vectors) for 13 July 2008, 21 December 2008, 8 July, 2008, and 9 May 2008, respectively. The nearshore segment of the track is represented by a dotted line, offshore by solid. The red circle designates the position of the melon-headed whale on the day coinciding with the HYCOM output extended to 160-819km from shore with 33-80% of track duration spent offshore (i.e. in depths greater than 3000m). Three individuals used the edges of cold core cyclonic eddies and the centers of warm core anticyclonic eddies for extended periods.

Genetics

The genetics of Hawaiian melon-headed whales are currently being assessed, as part of a global study of melon-headed whale population structure. To date, mtDNA results indicate significant differentiation between the main Hawaiian Islands cluster and the Hawaii Island resident cluster (K. Martien, unpublished data), though mtDNA differentiation alone may not be adequate to assess population structure given the complex social structure of many odontocete species. Both clusters are also significantly differentiated from individuals sampled at Palmyra and Johnston Atolls. All samples have been genotyped for 7 microsatellite loci. Genotyping for 8 additional microsatellite loci is nearly complete. Preliminary analyses of the microsatellite dataset will be presented at the SRG meeting.

Table 1. Comparison of Hawaii Island (Kohala) Resident and Hawaiian Islands melon-headed whale distance from shore and depth use based on satellite tag deployments since 2008. Values are medians across all deployments, with overall maximum distance from deployment location and maximum distance from shore given in parentheses. (Schorr et al in prep). The name given by Aschettino et al 2012 is followed by the stock name in parentheses, as described below.

Population	Median (Maximum) distance from deployment location [km]	Median (Maximum) distance from shore [km]	Depth [m]
Hawaii Island (Kohala) Residents	34.3 (49.4)	29.6 (39.4)	665.5
Main Hawaiian islands (Hawaiian Islands)	191.4 (557.1)	77.5 (342)	2748.0

Abundance

Using the photo-ID catalog of individuals encountered between 2002 and 2009, consisting of 40,000 photos of 1,640 individuals, of which 1,046 are well-photographed and distinctive, Aschettino (2010) conducted a mark-recapture analysis to estimate population size for each of the two largest social clusters. Using a POPAN open-population model within the mark-recapture software, program MARK, the Hawaii Island resident cluster was estimated to number 447 (CV=0.12) individuals and the main Hawaiian Islands cluster to number 5,794 (CV=0.20) individuals.

Conclusions

Photo-ID and social network analyses (Aschettino et al 2012), movement data (Woodworth et al 2012, Schorr et al. in prep.), and preliminary genetics findings all support separation of melon-headed whales in Hawaiian waters into two stocks: the Kohala resident stock and the Hawaiian Islands stock. The Kohala stock, a small resident stock, occurs primarily along the northwest end of Hawaii Island and is clearly island-associated based on the distribution of sightings and satellite tag data. Based on the distribution of satellite-telemetry locations and sightings of the Kohala resident stock, we assess the stock boundary to be the 2500 m isobath around the west and northwest sides of Hawaii Island, extending south to 19^0 15'N and east to 155^0 45'W. The more broadly distributed stock, the Hawaiian Islands stock, also occurs nearshore, but is known to use offshore waters and pelagic features as well. This stock also overlaps geographically with the Kohala resident stock, such that absolute assignment of individuals seen in that region to either stock would require either identification photographs or genetic analysis of tissue samples. However, encounter rates of each stock indicate that 81% of melon-headed whale encounters (17 of 21) north of Keahole Point are residents, while only 12.5% of melon-headed whale encounters (2 of 16) south of Keahole Point are residents.

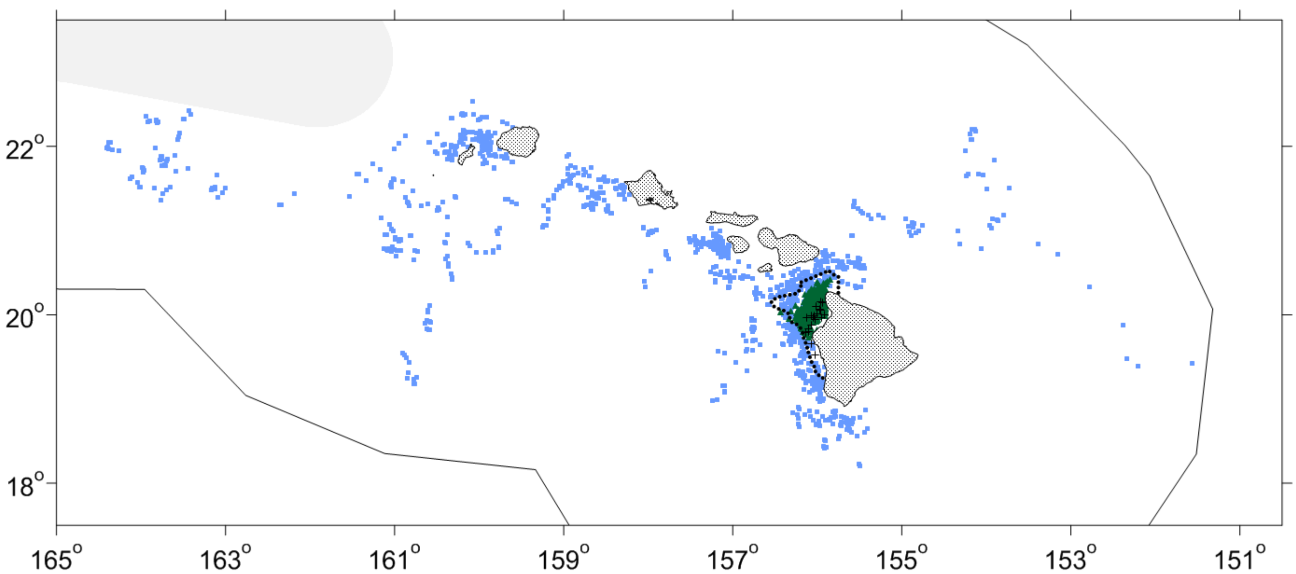


Figure 5. Melon-headed whale stock boundaries. The Hawaii Island Kohala resident stock boundary is delineated by the black dotted line, with supporting sighting (crosses) and telemetry locations (green dots). The Hawaiian Islands stock telemetry locations are shown as blue dots, some within the Kohala stock range.

Although the Hawaiian Islands stock has been previously referred to as the main Hawaiian Islands population, in part because the bulk of information about this stock comes from sighting surveys near the main Hawaiian Islands, it is clear based on the extensive offshore movements of these whales that this stock is not confined in its range to the near shore waters of the main Hawaiian Islands.

No photographs or biopsy samples are available from a single sighting of melon-headed whales during the NMFS 2010 Hawaiian Islands Cetacean Ecosystem Assessment Survey (HICEAS) with which to assess population membership. However, based on the location at the edge of the

Hawaiian EEZ, southwest of French Frigate Shoals, the group seen during HICEAS 2010 is assumed to be part of the Hawaiian islands stock.

Pantropical spotted dolphins

Surveys, Photo-ID, and Movements

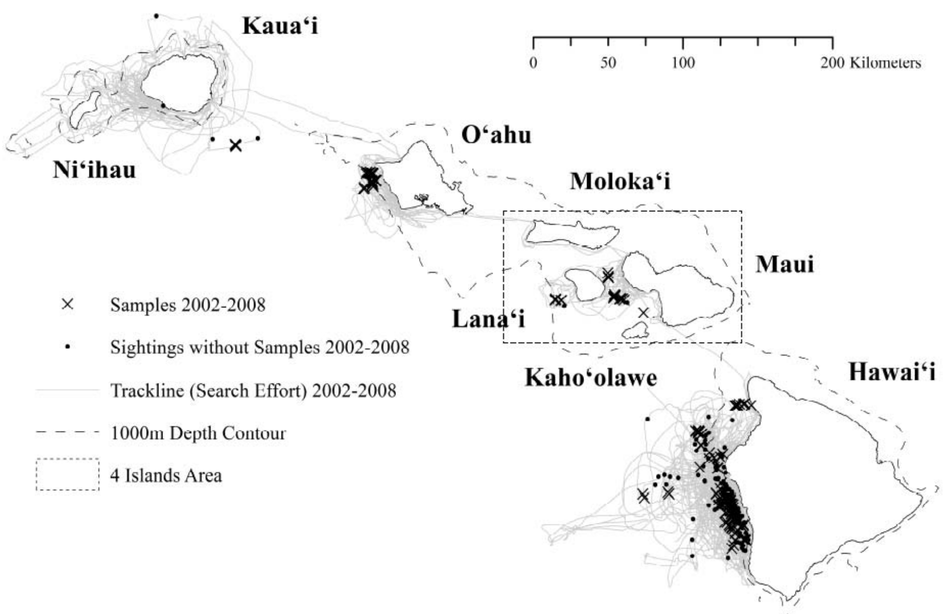


Figure 6. (from Courbis 2011). Locations of samples, sightings without samples, and search effort for pantropical spotted dolphins near the main Hawaiian Islands for 2002 through 2008.

Pantropical spotted dolphins are widespread throughout the tropical Pacific and have been well-studied in the eastern tropical Pacific due to interactions there with the U.S. and international tuna purse-seine fisheries. The have also been commonly taken in direct harvest or as incidental takes in China, Taiwan, and Japan. Although not the focus of most studies near Hawaii, spotted dolphins are the second-most frequently encountered species during Cascadia Research surveys near the main Hawaiian Islands and appear to have the highest relative abundance of any species (Baird et al. 2013a). This species has been recorded in all months of the year around the main Hawaiian Islands, and in areas ranging from shallow near-shore water to depths of 5,000 m, although they peak in sighting rates in depths from 1,500 to 3,500 m (Baird et al. 2013a). Although they represent from 22.9 to 26.5% of the odontocete sightings from Oahu, the 4-islands region (Molokai, Maui, Lanai, and Kahoolawe), and Hawaii Island, they are largely absent from the nearshore waters around Kauai and Niihau, representing only 3.9% of sightings in that area (Baird et al. 2013a). Furthermore, Baird et al. (2013a) note that four of the nine sightings of this species off Kauai and Niihau in their study were all of the same lone individual, seen with a group of spinner dolphins.

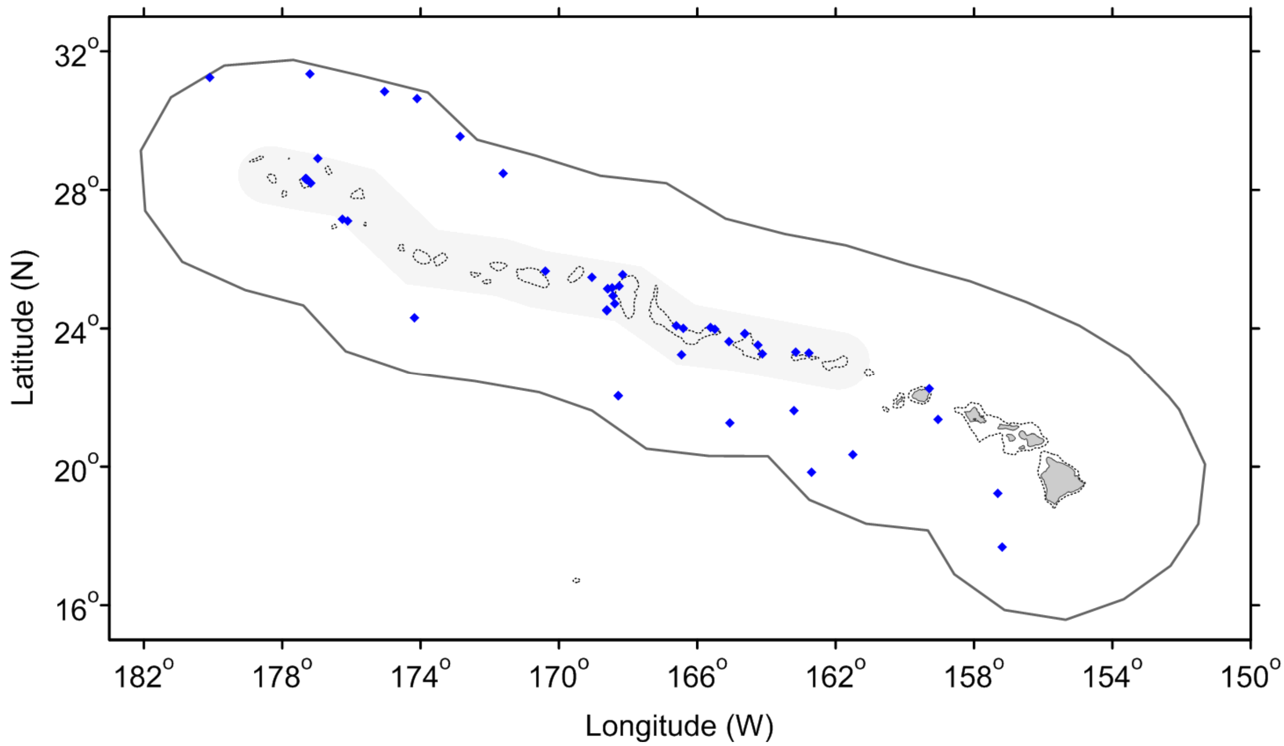


Figure 7. Pantropical spotted dolphin sightings during the hICEAS 2010 survey of the Hawaiian Islands EEZ. The solid line represents the EEZ boundary, gray shading the Papahanaumokuakea Marine National Monument area, and the dotted line h 1000m isobath.

Genetics

Genetic analyses have been undertaken using 176 unique samples of pantropical spotted dolphins collected during near-shore surveys off each of the main Hawaiian Islands from 2002 to 2003, and near Hawaii Island in 2005 through 2008 (Courbis 2011). Haplotypes were identified from all 176 samples. Microsatellite (nuDNA) results are available from those samples collected throughout the islands from 2002 and 2003, including Hawaii (37), the 4-Islands region (26) and Oahu (26). The results of the Courbis (2011) study indicate that pantropical spotted dolphins have low haplotypic diversity and haplotypes unique to each of the island regions. There were only 10 haplotypes found with one being common, two moderately common, and 7 unique (found only once) (Figure 8). Three haplotypes were only found near Hawaii Island.

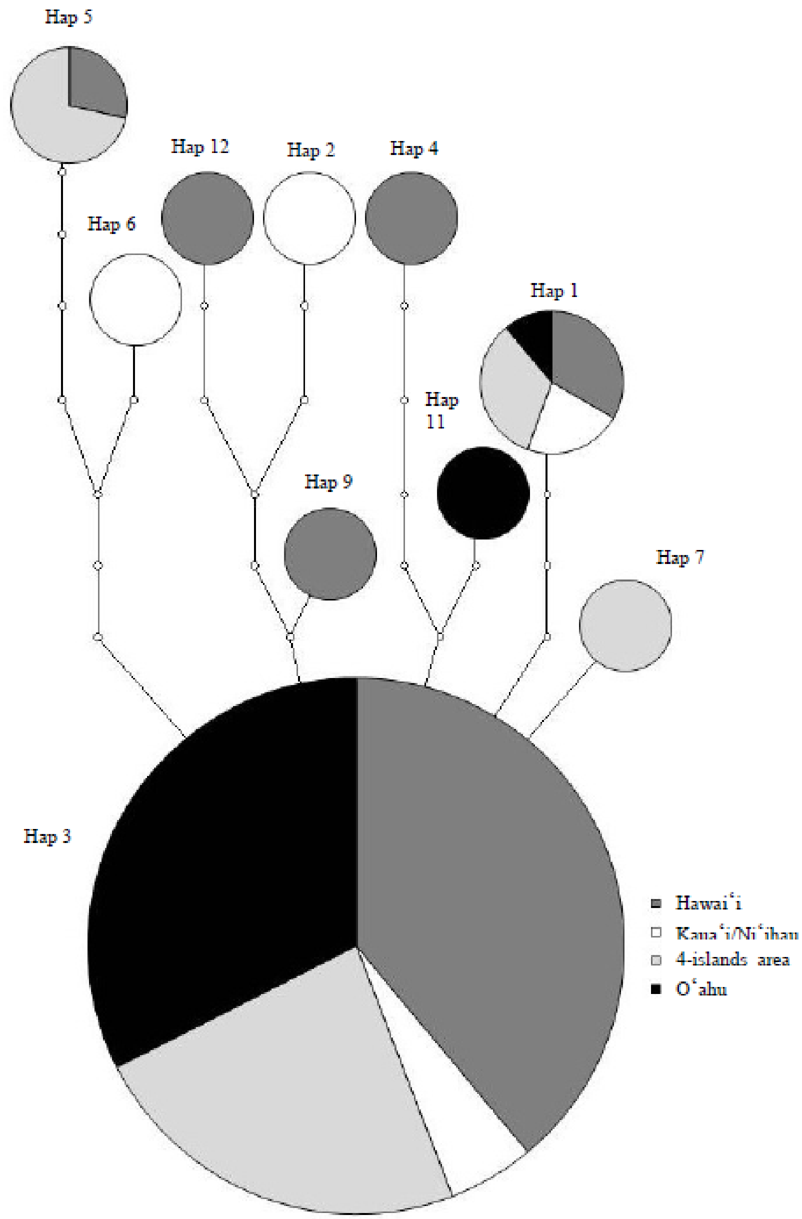


Figure 8 (from Courbis 2011). Haplotype network for main Hawaiian Islands pantropical spotted dolphins. Size of the oval represents the number of individuals with the haplotype. Pie charts indicate relative numbers of individuals with each haplotype from each island area.

Courbis (2011) conducted extensive tests on the relatedness of individuals among islands using the microsatellite dataset. Most significantly, F_{ST} comparisons among all islands were significantly different from zero (p=0.001) (Table 2), suggesting differentiation among islands. This suggestion is supported by the results of assignment tests, which indicate support for 3 island-associated populations: Hawaii Island, the 4-Islands region, and Oahu (Figure 9, Table 3). Samples from Kauai and Niihau did not cluster together, but instead were spread among the Hawaii and Oahu clusters. Analysis of migration rate (Table 4) further supports the separation of pantropical spotted dolphins into three island-associated stocks, with migration between regions on the order of a few individuals per generation, much lower than the standard 1-2% migration rates typically used to define stocks under the MMPA.

Table 2. (from Courbis (2011)). Top: F_{ST} (below the diagonal) and R_{ST} (above the diagonal) values for the pantropical spotted dolphin microsatellite dataset. 95% CL for values, calculated form 20,000 bootstrap resamples, are shown in brackets. Numbers in bold are significantly different from zero, and *p*-values are in parentheses. Middle: F_{ST} (below the diagonal) and Φ_{ST} (above the diagonal) for mtDNA sequences. Numbers in bold are significantly different from zero, and *p*-values are shown in parentheses. Bottom: MtDNA F'_{ST} (above the diagonal) and microsatellite F'_{ST} (below the diagonal).

F_{ST} and R_{ST}

	Hawai‘i	4-islands area	O‘ahu	Kaua‘i/Ni‘ihau
Hawai‘i (*n*=37)		**0.044 [0.019-0.079] (0.004)**	**0.055 [-0.007-0.132] (0.001)**	-0.014 [-0.036-0.003] (0.769)
4-islands area (*n*=26)	**0.028 [0.013-0.045] (<0.001)**		0.018 [-0.002-0.042] (0.061)	**0.047 [-0.005-0.091] (0.048)**
O‘ahu (*n*=26)	**0.038 [0.023-0.053] (<0.001)**	**0.037 [0.020-0.056] (<0.001)**		0.039 [-0.032-0.087] (0.065)
Kaua‘i/Ni‘ihau (*n*=8)	0.016 [-0.002-0.026] (0.057)	**0.045 [0.023-0.064] (<0.001)**	**0.029 [0.009-0.048] (0.003)**	

F_{ST} overall = **0.033 [0.024-0.042] (<0.001)**; R_{ST} overall = **0.036 [0.005-0.074] (0.001)**

F_{ST} and Φ_{ST}

	Hawai‘i	4-islands area	O‘ahu	Kaua‘i/Ni‘ihau
Hawai‘i (*n*=38)		0.017 (0.212)	0.005 (0.336)	0.028 (0.155)
4-islands area (*n*=27)	0.011 (0.229)		**0.105 (0.032)**	0.005 (0.387)
O‘ahu (*n*=27)	0.016 (0.180)	**0.112 (0.010)**		**0.191 (0.012)**
Kaua‘i/Ni‘ihau (*n*=8)	0.087 (0.064)	0.018 (0.315)	**0.282 (0.013)**	

F_{ST}=0.055 (0.023); Φ_{ST} overall = 0.039 (0.044)

F'_{ST}

F'_{ST}	Hawai‘i	4-islands area	O‘ahu	Kaua‘i/Ni‘ihau
Hawai‘i		0.019	0.021	0.171
4-islands area	0.165		0.169	0.046
O‘ahu	0.205	0.195		0.415
Kaua‘i/Ni‘ihau	0.098	0.262	0.156	

F'_{ST} overall for microsatellites = 0.186; F'_{ST} overall for mtDNA = 0.089

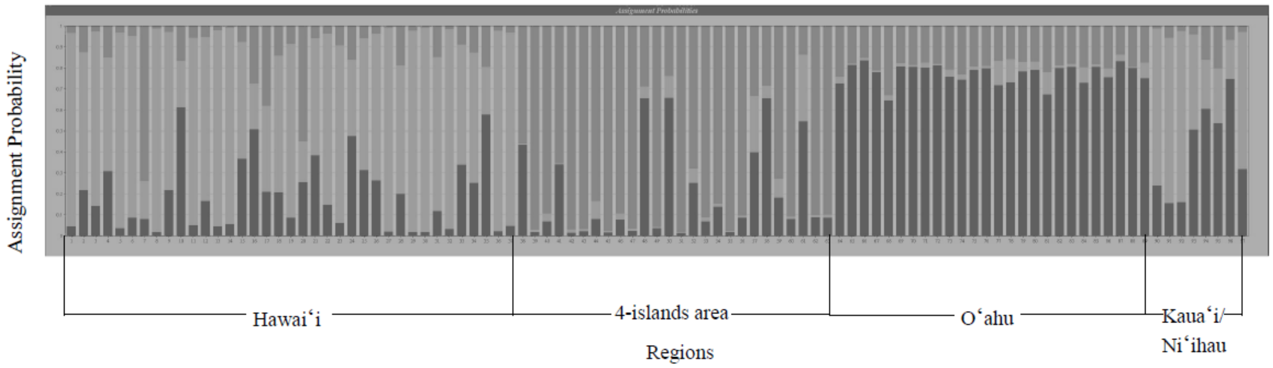


Figure 9. (from Courbis (2011)). Example of assignment probability bar plot for K=3 from the TESS analysis. The three shades of gray indicate the assignment probability for each of the 97 individuals in the pantropical spotted dolphin microsatellite data set to each of the three clusters.

Table 3. (modified from Courbis (2011)). Assignment probability for each of three clusters is from the TESS analysis of the pantropical spotted dolphin microsatellite data set. One hundred iterations were performed at K=3 and the ten with the lowest DIC values were used. Means, standard errors, and significant differences among means based on ANOVA analyses are shown here. Bold values are the largest assignment probabilities for each region. Tukey tests (Zar 1999) indicate that there were significant differences for all pairs of clusters for each region except Kauai/Niihau Cluster 1 and Cluster 2. n = total number of samples from each region, N = number of groups sampled.

Region	Cluster 1	Cluster 2	Cluster 3	*F*-value	*p*-value
Hawai'i (*n*=37, N=11)	0.27 (SE±0.02)	**0.63 (SE±0.04)**	0.10 (SE±0.02)	98.17	<0.001
4-islands Area (*n*=26, N=8)	0.24 (SE±0.04)	0.06 (SE±0.02)	**0.70 (SE±0.05)**	77.00	<0.001
O'ahu (*n*=26, N=8)	**0.72 (SE±0.01)**	0.11 (SE±0.01)	0.17 (SE±0.01)	2725.77	<0.001
Kaua'i/Ni'ihau (*n*=8, N=1)	**0.43 (SE±0.06)**	**0.50 (SE±0.07)**	0.07 (SE±0.02)	16.97	<0.001

Table 4. (from Courbis (2011)) Migration rate (N*m*) of pantropical spotted dolphins between pairs of regions in the main Hawaiian Islands, based on method of Barton & Slatkin (1986). This method assumes no admixture and populations in equilibrium, so values likely do not reflect exact migration rates but do suggest that migration is relatively low.

Pairwise Regions	Mean Frequency of Private Alleles across Both Regions	N*m*
Hawaiʻi-4-islands area	0.03	3.45
Hawaiʻi-Oʻahu	0.04	2.90
Hawaiʻi-Kauaʻi/Niʻihau	0.05	2.63
4-islands area-Oʻahu	0.04	2.51
4-islands area-Kauaʻi/Niʻihau	0.07	1.49
Oʻahu-Kauaʻi/Niʻihau	0.07	1.69

Conclusions

The genetics analysis of Courbis (2011) strongly support the designation of three new island-associated stocks of pantropical spotted dolphins in the main Hawaiian Islands, one each at Hawaii Island, the 4-Islands region, and at Oahu. Significant uncertainty about the relationship of individuals at Kauai and Niihau remains and suggests that we do not yet have enough information to assess the membership of these animals to any particular stock. A fourth broadly distributed spotted dolphin stock is also recognized given the frequency of sightings in Hawaii pelagic waters. Abundance estimates for each of the island-associated stocks are not yet available, though identification photos from several hundred sightings are available for sorting into a catalog and for eventual mark-recapture estimation of population size at each island region. We propose establishing the boundary of each new island-associated stock by applying the greatest distance from shore of sampled spotted dolphins used in the Courbis (2011) study, such that the Oahu and 4-Islands stocks each extend to 20km from shore and the Hawaii Island stock extends to 65km from shore. The depth distribution of spotted dolphin sightings (Baird et al 2013a) suggests these stocks could extend much farther from shore; however, without confirmation of the stock identity of sighted groups, we restricted the offshore boundary at this time to avoid incorporating pelagic spotted dolphins within the stock range. It is likely that the offshore extent of the stock boundary for each island-associated spotted dolphin stock will change once photographic data are fully processed and analyzed or if satellite tags are deployed to assess movements.

Data Poor Stocks

We define data poor stocks as those for which there is evidence for the existence of an island-associated stock, but for which data is not available to specifically define the range and boundaries of that stock and will not be in the foreseeable future. In the specific cases detailed below, we propose designation of "prospective stocks" for each of these data poor stocks given the evidence that is available, the slow pace of data collection, and the potential threats to small island-associated populations that may not be adequately recognized within an EEZ-wide stock designation.

Barring significant reasons against the new stock designation, these prospective stocks will become new stocks at the next revision the Stock Assessment Reports. Because of the paucity of data, many questions remain regarding population size, population range, and appropriate stock boundaries for each prospective stock. We request input from the Pacific Scientific Review Group, other researchers, management agencies and the public to guide appropriate assessment of these stocks. The following questions merit PSRG discussion and apply to all the data poor stocks addressed in this report:

1. How should abundance be estimated and a minimum population estimate be derived when survey data are available from only a small portion of the population range? In some cases photographic catalog size may be used, but this would likely be an underestimate of minimum population size.
2. Given the lack of survey data from nearshore waters around the Northwestern Hawaiian Islands, the extension of island-associated stocks into those waters cannot be robustly assessed. Should continuity of suitable habitat be considered when designating new stock boundaries?
3. Conversely, should localized impacts within the main Hawaiian Islands drive stock boundary decisions until, and if additional information becomes available to justify expanding stock boundaries to the Northwestern Hawaiian Islands?

Blainville's beaked whale

The twenty-one species of beaked whales from various parts of the world's oceans are poorly known. They are best known in the waters of various oceanic islands where it has been possible to conduct photo-identification and tagging studies, such as in Hawaii (e.g. Schorr et al., 2009), the Bahamas Islands (e.g. Claridge 2006), and the Canary Islands (e.g. Johnson et al. 2007). Three species of beaked whales have been documented in Hawaiian waters - Blainville's beaked whale (*Mesoplodon densirostris),* Cuvier's beaked whale *(Ziphius cavirostris*), and Longman's beaked whale (*Indopacetus pacificus*). While Longman's beaked whales have only been documented in a small number of sightings, Blainville's and Cuvier's beaked whales have both been subjected to dedicated studies over the last 10 years off Hawaii Island.

Photographic identifications of individual Blainville's beaked whales are available from the Hawaii Island from 1986 through 2012 (McSweeney et al. 2007; Baird et al. 2013b). Two individuals have been seen over a 17-year span in this area (Baird et al. 2011a). Social network and re-sighting analyses over the period 2002-2012 indicate that 75% of 76 individuals documented link by association into a single social network (Baird et al. 2013b). Encounters farthest offshore (>35 km) and in very deep water (>2100 m), representing 5 of 29 encounters, involved individuals that had only been seen on a single occasion, suggesting they may be from an offshore population (Baird et al. 2011a).

Thirteen Blainville's beaked whales were satellite tagged off Hawaii Island between 2006 and 2012, with data on their subsequent whereabouts spanning intervals of 15 to 159 days (Schorr et al. 2009; Baird et al. 2011a, 2013b). One individual tagged in a group seen 32km from shore had not been previously identified off the island. Over a span of 40 days, this individual ranged from 17.6 to 573.0km from land, moving over 900km from the tagging location in 20 days (Figure 10; Baird et al 2011a). Of the remaining 12 individuals, 11 linked by association in a single social network (Baird et al. 2013b), and all 12 remained associated with the main Hawaiian Islands (Figure 11). Although one individual dispersed as far as east of Oahu, and one made an offshore excursion to 192 km from shore (before returning to the island), these individuals remained an average distance from shore of 21.6 km and an average distance from the tagging location of 54.5 km (Baird et al. 2013b).

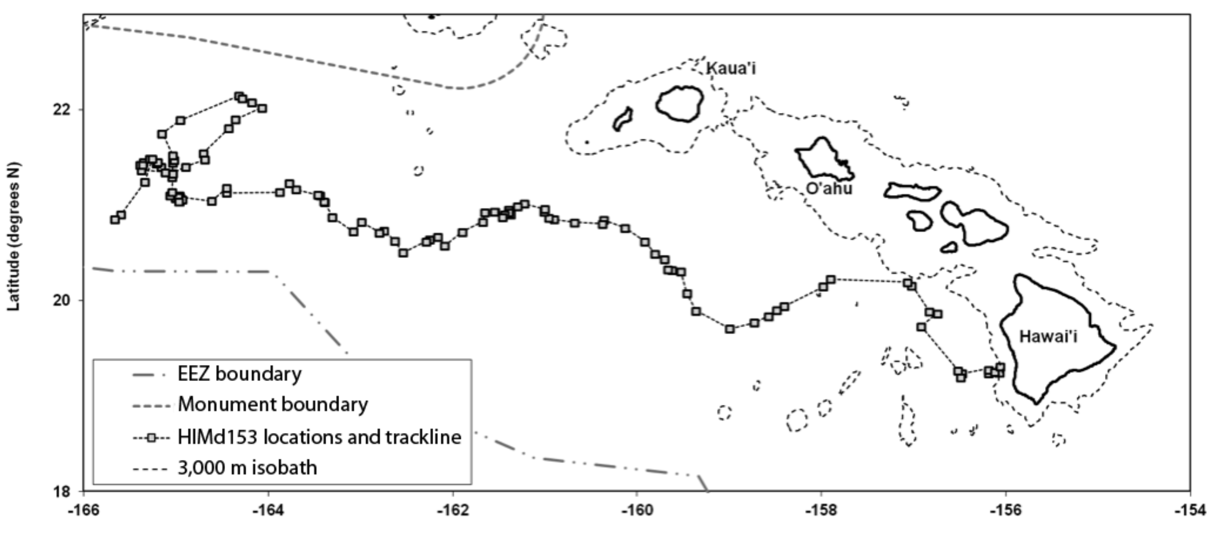


Figure 10. (from Baird et al. 2011a). Movements of HIMd153, initially tagged 32km from shore, over the 40 d of signals from the tag.

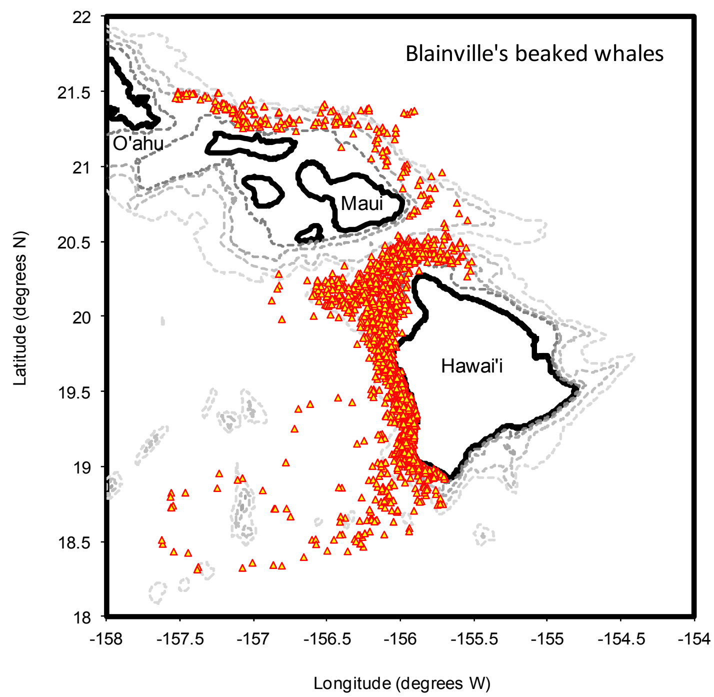


Figure 11. (from Baird et al. 2013b). Satellite-derived locations of 10 Blainville's beaked whales tagged in 2006, 2008, 2009, 2011, and 2012. The 500 m, 1000 m, 2000 m and 3000 m depth contours are shown.

Re-sightings and movements of tagged individuals suggest an island-associated population of this species exists in the Hawaiian Islands. A preliminary abundance estimate based on mark-recapture analyses of photo-identification data off Hawaii island indicated approximately 140 individuals used the study area between 2003 and 2006, although that estimate likely included individuals from both the island-associated and offshore populations (Baird et al. 2009). At this time there is insufficient information to evaluate population range and boundaries or abundance. Genetics cannot currently be used to assess population structure of this species, with only 31 total individuals from the North Pacific within the SWFSC Tissue Collection. Of these, 28 are from Hawaii, 1 from Kingman Reef (2004), 1 from north of the Hawaiian Islands (271 nmi north of Kauai) and 1 from Santa Barbara (no date available).

The pace of data collection for this species is slow given infrequent encounters and its cryptic behavior. Several studies have suggested that beaked whales are vulnerable to strand when exposed to Navy sonar and seismic operations. The use of active sonar from military vessels has been implicated in mass strandings of beaked whales in the Mediterranean Sea during 1996 (Frantzis 1998), the Bahamas during 2000 (U.S. Dept. of Commerce and Secretary of the Navy 2001), and the Canary Islands during 2002 (Martel 2002). Similar military active sonar operations occur around the Hawaiian Islands. The probability of stranding and detection of stranded beaked whales affected by sonar activities in Hawaii is relatively low due to nearshore oceanography and low human population density near many Hawaiian Islands beaches compared with other regions where mass strandings have been more frequently observed (Faerber & Baird 2010). The potential threat to a stock with restricted range is potentially great given high levels of Naval sonar activity in the Hawaiian Islands. Further, the relatively small group size for beaked whales versus some delphinid species suggests impacts on social structure may be greater with removal of only a few animals. Recent evidence for declines in beaked whales off California increase concern about the potential for human-caused mortality (Moore et al. 2013). For these reasons, we propose designation a prospective stock of Blainville's beaked whales within the main Hawaiian Islands with a range of 50 km from the islands, but with unknown abundance. The current estimate of population size for the EEZ-wide stock of Blainville's beaked whales is 2,338 (CV = 1.13) (Bradford et al 2013). The corresponding 20th percentile-based minimum population estimate is 1,088 giving a PBR of 11 Blainville's beaked whale per year for the EEZ-wide stock. This minimum population size is substantially larger than the number of island-associated individual identified within the photographic catalog (76). Localized impacts due to Navy training exercises near the main Hawaiian Islands, as well as localized fishing pressures may lead to increased impacts near the islands and concentrated on this island-associated population. Multinational Naval training exercises (e.g. RIMPAC) have been occurring regularly within Hawaiian waters since the 1970s such that impacts are likely already to have occurred.

Without evidence to the contrary the prospective stock of Blainville's beaked whales would be designated as an island-associated stock at the next update of the Stock Assessment Report. Additional information is requested that may assist with assessment of stock size and stock range, and designation of the stock boundary for an island-associated stock. There were no sightings of Blainville's beaked whales near the main Hawaiian Islands during the 2010 HICEAS cruise. The catalog size (76) may be used as a minimum population estimate, or alternative strategies, potentially including apportioning the EEZ-wide minimum population estimate based on relative population densities in the stock areas, may be appropriate. Further, high beaked whale encounter rates during the 2010 cruise may suggest the existence of a separate or an extension of the same island-associated population into the Northwestern Hawaiian Islands.

Cuvier's beaked whale

This beaked whale has the largest range of any species in its family. Though encountered more frequently than Blainville's beaked whales, sightings of Cuvier's beaked whale in the main Hawaiian Islands are still uncommon, with an average of one sighting for every 5 days of survey effort in deep-water areas (Baird et al. unpublished). Evaluation of 35 encounters near Hawaii Island from 1990 to 2006 revealed 35 well-photographed distinctive individuals, with 40% of those seen more than once and 8 individuals seen in more than one year (McSweeney et al.

2007). A mark-recapture analysis of photo-identification data from 2003 through 2006 resulted in an estimate of 55 marked individuals (CV = 0.26) using the area off the west side of Hawaii Island over that period (Baird et al. 2009).

Eight individual Cuvier's beaked whales have been satellite tagged off Hawaii Island since 2006, with all remaining close to the island of Hawaii for the duration of tag data reception (Baird et al 2013b). Approximately 95% of all recorded locations were within 45 km of shore and the farthest offshore an individual was documented was 67 km (Baird et al. 2013b). The available satellite data suggest that a resident population may occur at Hawaii Island, distinct from surrounding populations of this species. This conclusion is further supported by the long-term site fidelity evident from photo-identification data (McSweeney et al. 2007) and preliminary genetic evidence (Dalebout et al 2005).

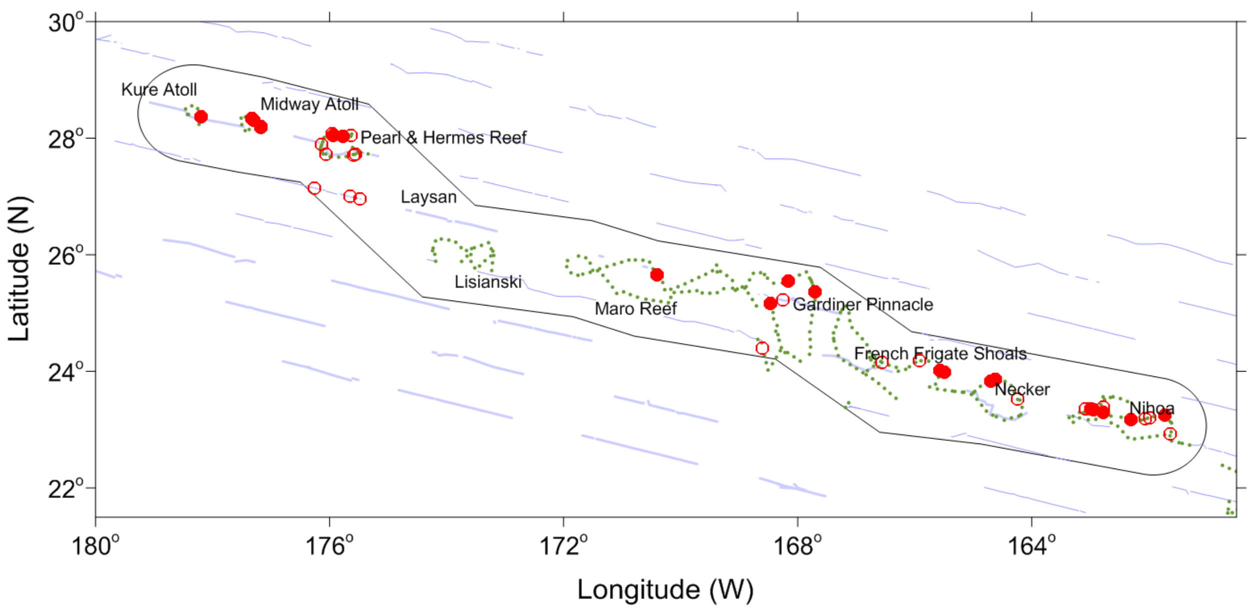


Figure 12. HICEAS 2010 standard (light blue) and non-standard (green dots) effort near the Northwestern Hawaiian Islands. Cuvier's (filled red) and unidentified Ziphiid (open red) beaked whales were very frequently seen near-shore in in the NWHI during this survey.

During the NMFS HICEAS 2010 survey Cuvier's and unidentified beaked whales were very commonly seen nearshore in the Northwestern Hawaiian Islands, with 19 sightings of Cuvier's and 22 sightings of unidentified ziphiid whales occurring within 10km of the islands and atolls (Figure 12). Together this represents 21% of the 192 sightings in this region. Although there are no identification-quality photographs from these sightings and tissue collection was either not attempted or not successful in most cases, the very high sighting rate in this region relative to the broader study area suggests the potential for an island-associated stock(s) of Cuvier's beaked whales throughout the archipelago.

The limited data on Cuvier's beaked whales near the main Hawaiian Islands suggests an island-associated population of this species exists in the Hawaiian Islands. At this time there is insufficient information to thoroughly evaluate population range and boundaries or abundance. Genetics cannot currently be used to assess population structure of this species near Hawaii as there are only 62 individuals from the North Pacific within the SFWSC Tissue Collection, of which 10 are from Hawaii and 52 from other locations, primarily near California. On average, 2 samples per year are added to this collection. The pace of data collection for this species is slow given infrequent encounters.

The potential threat to a stock with restricted range is potentially great given high levels of Naval sonar activity in the Hawaiian Islands. Further, the relatively small group size for beaked whale versus some delphinid species suggests impacts on social structure may be greater with removal of only a few animals. Recent evidence for declines in beaked whales off California increase concern for potential human-caused mortality (Moore et al. 2013). Multinational Naval training exercises (e.g. RIMPAC) have been occurring within Hawaiian waters since the 1970s such that impacts are likely already to have occurred.

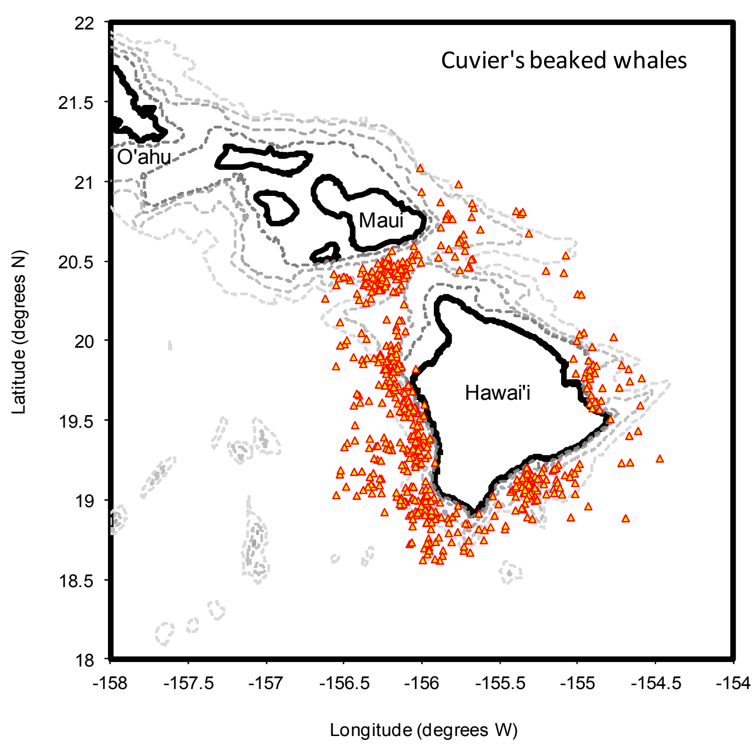


Figure 13. (from Baird et al 2013b) Locations from 8 satellite tagged Cuvier's beaked whales tagged in 2008 through 2011, for an average span of 24.5 days

For these reasons, we propose designation of a prospective island-associated stock of Cuvier's beaked whales within the Hawaiian Archipelago out to 70 km from shore with unknown abundance. The current estimate of population size for the EEZ-wide stock of Cuvier's beaked whales is 1,941 (CV = 0.07) Bradford et al 2013). The corresponding 20th percentile-based minimum population estimate of 1,142 gives a PBR of 11 Blainville's beaked whale per year for the EEZ-wide stock. This minimum population size is substantially larger than the number of island-associated individuals estimated through mark-recapture (55). Localized impacts due to Navy training exercises near the main Hawaiian Islands, as well as localized fishing pressures may lead to increased impacts near the islands and concentrated on this island-associated population.

Without evidence to the contrary the prospective stock of Cuvier's beaked whales would be designated as an island-associated stock at the next update of the Stock Assessment Report. There were no sightings of Cuvier's beaked whales near the main Hawaiian Islands during the 2010 HICEAS cruise to facilitate a line-transect assessment of abundance within the main Hawaiian Islands. In contrast, there was a very high encounter rate for Cuvier's and unidentified beaked whales within 10kmof the islands and atolls within the Northwestern Hawaiian Islands during the 2010 survey, suggesting island-association in that region. The 2003-2006 mark-recapture estimate for the number of individuals occupying the west side of Hawaii Island (55) may serve as an abundance estimate and the 20th percentile of the log-normal abundance estimate provides a minimum population estimate for the prospective stock, though both are likely negatively biased due to the limited geographic scope of the encounters used in the analysis. Alternative strategies, potentially including apportioning the EEZ-wide minimum population estimate based on relative population densities in the stock areas may be appropriate. High beaked whale encounter rates during the 2010 cruise may suggest the existence of a separate stock or an extension of the same island-associated population into the Northwestern Hawaiian Islands.

Pygmy killer whale

Today, pygmy killer whales are known worldwide in tropical and warm temperate waters. However, until the 1950s they were known from just four specimens, two from unknown locations and one each from Japan and Senegal (Yamada 1954). The pygmy killer whale is a rarely encountered pantropical species that is typically oceanic, not known to generally enter shallow near-shore waters. While the species is also rare in Hawaii, a long-term study of pygmy killer whales in the main Hawaiian Islands resulted in 61 encounters between 1985 and 2007 (McSweeney et al 2009), primarily off Hawaii Island, although there have been encounters throughout the main Hawaiian Islands. McSweeney et al (2009) evaluated photographs from all surveys through 2007 and found 112 well-photographed, distinctive individuals off Hawaii Island and no matches to identified individuals from other islands. A large proportion (80%) of distinctive individuals off Hawaii Island have been re-sighted, with some seen over a period of up to 21 years. Individuals have also been encountered off Hawaii Island year-round. Most (103) of the 112 individuals have been linked into single social network (Figure 14), with stable associations between individuals of the same and opposite sex. Since the McSweeney et al. (2009) analyses, movements of one individual between Oahu and Hawaii Island and one individual from Oahu to Lanai have been documented (Baird et al. 2011c).

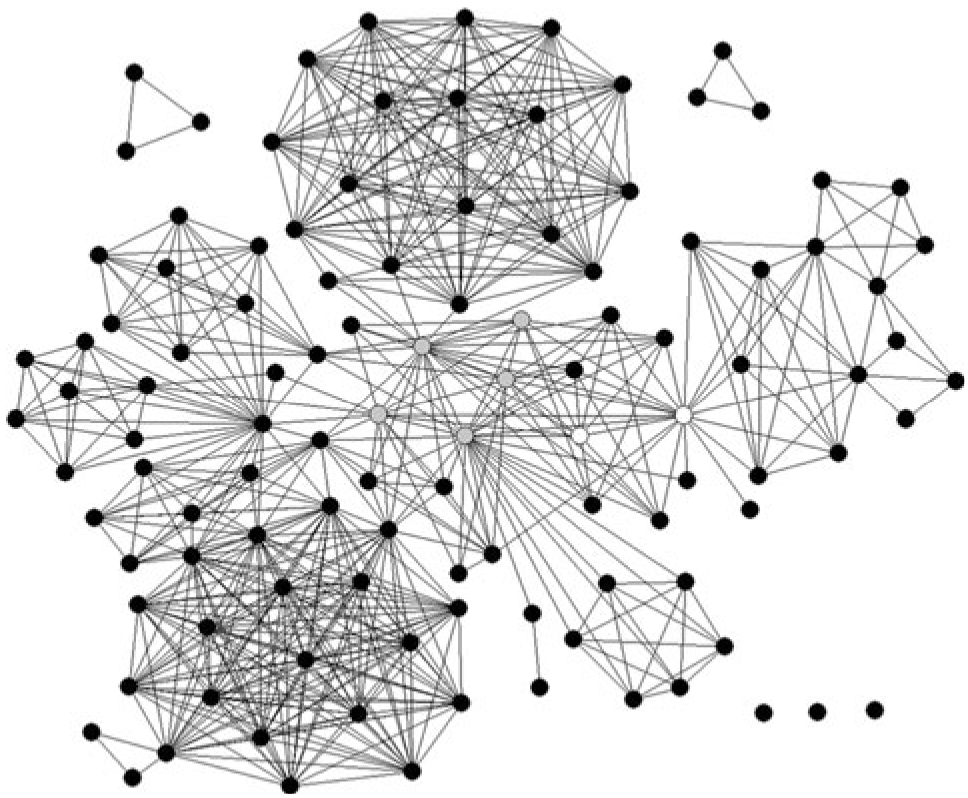


Figure 14. (from McSweeney et al (2009)). A social network diagram showing associations among individual pygmy killer whales documented off the island of Hawaii. All individuals considered distinctive or very distinctive with good or excellent quality photographs are included (*n* = 112). The majority (103, 92%) were linked by association in a single social network.

Evaluation of encounter locations reveals that pygmy killer whales off Hawaii Island are seen up to 16km from shore and in waters as deep as 2,862m. Analyses of sighting rates in relation to seafloor depth sugget an island-associated population (Baird et al. 2013a). Two individuals were tagged off Hawaii Island and provided telemetry records of 10 and 22 days in duration (Baird et al 2011b). Both individuals remained close to Hawaii Island, within 19.9km of shore, and moved around the south point of the island and along the southeast coast. Individuals in two groups have been satellite tagged off Oahu, with locations obtained over spans of 30 and 7 days. Both whales remained associated with the main Hawaiian Islands, one remaining off Oahu and the other moving to Penguin Bank (Baird et al. 2011c).

All pygmy killer whale samples in the SWFSC Tissue Collection (45) have been sequenced. Only 19 of these samples come from the main Hawaiian Islands and 3 are from pelagic waters southwest of Hawaii Island. This small dataset is not sufficient to genetically evaluate the possibility of an island-associated population of this species around the Hawaiian Islands. Given that samples of this species have only been added to the Collection at the rate of 2.4 samples per year over the last two decades, it may be several more decades before a sufficient genetic data set is amassed to address this question.

Re-sighting, habitat use and movement data for pygmy killer whales off Hawaii Island and off Oahu, while limited, does suggests an island-associated population of this species. At this time there is insufficient information to thoroughly evaluate population range and boundaries or abundance. The pace of data collection for this species is slow given infrequent encounters. We propose designation of a prospective island-associated stock of pygmy killer whales within the main Hawaiian Islands with a range of up to 20km from shore. The current estimate of population size for the EEZ-wide stock of pygmy killer whales is 3,433 (CV = 0.52) (Bradford et al 2013). The 20th percentile-based minimum population estimate of 2,274 gives a PBR of 23 pygmy killer whales for the EEZ-wide stock. The minimum population estimate is substantially larger than the number of individuals in the Hawaii Island social network (122). Localized impacts due to Navy training exercises near the main Hawaiian Islands, as well as localized fishing pressures may lead to increased impacts near the islands and concentrated on this island-associated population. The level of impact to date from Naval training since the 1970s and local fishing are unknown.

Without evidence to the contrary the prospective stock of pygmy killer whales would be designated as an island-associated stock at the next update of the Stock Assessment Report. There were two sightings of pygmy killer whales with identification-quality photographs during the 2010 survey. Although both sightings were far from shore and on the same day, and there are no matches between those two sightings or with the existing pygmy killer whale catalog. There is uncertainty about the northwest-ward extent of the stock boundary, whether pygmy killer whales from Oahu and Hawaii Island should be considered separate island-associated stocks, and whether animals within the Northwestern Hawaiian Islands might be part of a larger island-associated network. The number of distinctive individuals in the Hawaii and Oahu catalogs may be used as minimum population estimate, though both would likely be negatively biased due to the limited geographic scope of the encounters. Alternative strategies, potentially including apportioning the EEZ-wide minimum population estimate based on population densities in the two areas may be appropriate.

Dwarf sperm whale

Dwarf and pygmy sperm whales were considered to be a single species until the mid-1960s, when they were distinguished as separate species. Both species occur in tropical and temperature waters worldwide, where dwarf sperm whales are thought to be more coastally distributed and pygmy sperm whales more oceanic. Pygmy sperm whales are rarely seen in Hawaiian waters. In a study between 2002 and 2012, dwarf sperm whales were the 5th most frequently encountered species of odontocete in waters shallower than 1000 m off the west side of Hawaii Island (Baird et al. 2013a). An analysis of sighting rates by depth, corrected for effort, shows a strong peak in sighting rates where depths are between 500 and 1,000 m (Figure 15), suggesting an island-associated population. Photo-identification of distinctive individuals off Hawaii Island since 2003 has provided evidence of long-term site fidelity, with a third of distinctive individuals being seen in more than one year (Mahaffy et al. 2009). Between 2003 and February 2013, 25 individuals have been seen on more than one occasion, with all re-sightings restricted to encounters in waters shallower than 1,600 m and within 20 km of shore (Baird et al. unpublished). One individual has been documented over a 7.5-year span between 2004 and 2012 (Baird et al. unpublished). Combined, the information on habitat use and re-sightings from photo-identification suggest the existence of an island-resident population. At this time there is insufficient information to thoroughly evaluate population range and boundaries or abundance. The SWFSC Tissue Collection currently houses only 14 samples from

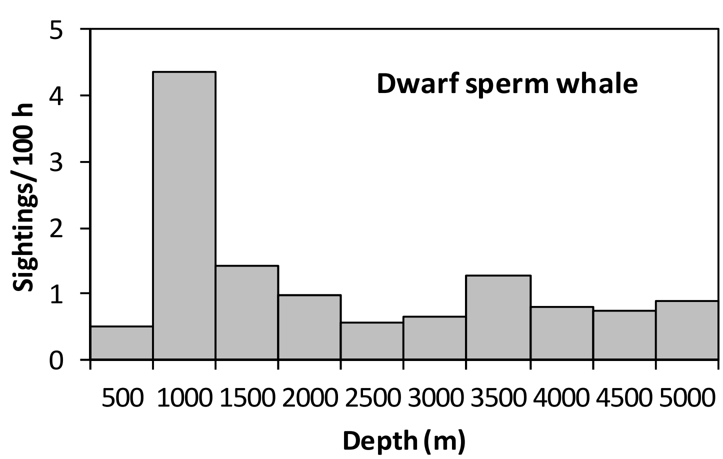


Figure 15. (from Baird et al. 2013a) Sighting rates of dwarf sperm whales from a small-boat based study off the main Hawaiian Islands, by depth of seafloor.

dwarf sperm whales, only five of which were collected within the Hawaiian EEZ. The pace of data collection for this species is slow given the difficulty in approaching individuals and thus the difficulty in obtaining genetic samples or deploying satellite tags.

We propose designating a prospective island-associated stock of dwarf sperm whales around Hawaii Island with a range of up to 20km from shore. There is no current estimate of abundance for dwarf sperm whales within the Hawaii EEZ given no on-effort sighting during the 2010 cruise, so allocating the EEZ-wide density to the Hawaii Island stock area is not possible. The 2002 estimate of abundance for dwarf sperm whales is among the highest of all odontocetes in the EEZ, in part due to the correction for diving animals. The 2002 PBR (25) for the EEZ-wide stock is equal to the number of distinctive individuals in the Hawaii Island catalog. The number of distinctive individuals in the Hawaii Island catalog (25) may be used as a minimum population estimate for the island-associated stock, though this is likely biased low due to the limited geographic scope of the encounters. Application of the observed Hawaii Island population density to the proposed prospective stock range may be more appropriate. Without evidence to the contrary the prospective stock of dwarf sperm whales would be designated as an island-associated stock at the next update of the Stock Assessment Report.

Stock with Increasing Information

Short-finned pilot whales

Short-finned pilot whales are widespread and abundant in tropical and warm temperate regions globally. Different forms of the species have been observed off the coast of Japan, with morphological and genetic differences correlated with differences in distribution and habitat associations. Short-finned pilot whales off California have similar skull morphology to the Japanese northern form, while those off Hawaii are more similar to the Japanese southern form. Such differences may extend to other parts of the species range, but have not been thoroughly examined to date.

Extensive surveys in the main Hawaii Islands have indicated that short-finned pilot whales are the most commonly encountered species of odontocete during near-shore surveys, and represented approximately 25% of all odontocete sightings during surveys by Cascadia Research from 2000 through 2012 (Baird et al. 2013a). The species is also common throughout the Hawaiian Islands EEZ, representing the second most commonly encountered odontocete during NMFS 2000 and 2010 HICEAS cruises (Barlow 2006, Bradford et al 2013). Evaluation of 267 encounters off Hawaii Island occurring from 2003 through 2007 revealed 448 distinctive individuals with good or excellent quality photographs, with 250 (55.8%) of those seen in more than one year. Sighting histories varied from 1 to 29 sightings per individual (median = 3), suggesting site-fidelity, though not in all individuals (Mahaffy 2012). An additional 31 encounters from the same period occurred elsewhere in the main Hawaiian Islands. There is at least one individual within the short-finned pilot whale catalog that was seen in 2012 and has a sighting history dating back to 1986 when photographic research began off Hawaii Island (Mahaffy, pers. comm.).

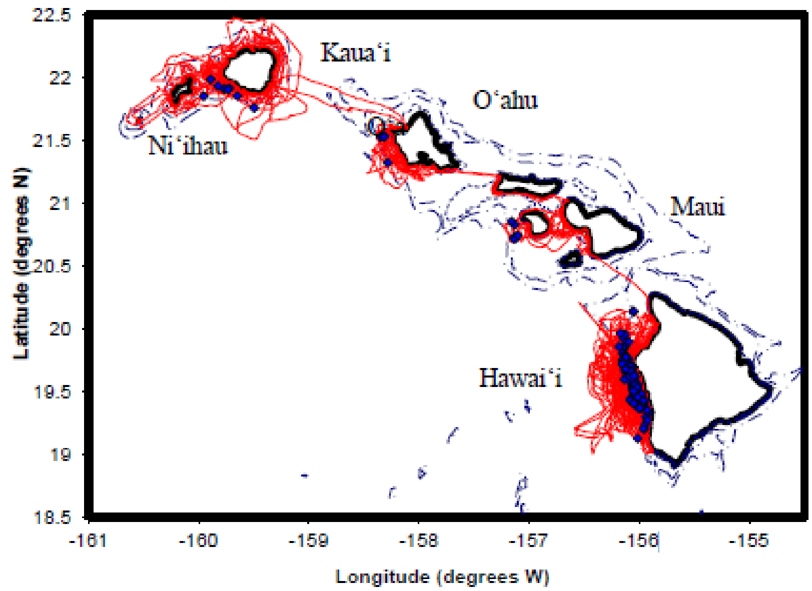


Figure 16. (from Mahaffy 2012) Short-finned pilot whale sightings (blue diamonds) and survey effort (red lines) within the main Hawaiian Islands from 2003 to 2007. The 1000m and 2000m depth contours are shown as broken lines.

Re-sighting and social network analyses of the 2003 through 2007 catalog indicate varying degrees of residency among the re-sighted individuals. Core residents, or those seen at least 5 times over at least 3 years, number at least 154 individuals. Residents, or those seen more than once but not as frequently as core residents, are an additional 150 individuals.   142 individuals were seen only once. A large social network included 72% (322 individuals) of the identified individuals, with remaining individuals spread across several smaller disconnected social clusters suggesting that several populations may use the west side of Hawaii Island. Individual pilot whales were observed to move in and out of the Hawaii Island study area, with an average of 136 individuals in the study area at any one time and individuals remaining in the area for an average of 74 days. Seven distinctive individuals were seen at both Hawaii Island and Kauai, although were not seen associating with any other pilot whales off Kauai.

Short-finned pilot whale encounters near the main Hawaiian Islands are strongly associated with the island slope, with no sightings in the 2003 through 2007 data subset in waters deeper than 2700m (Mahaffy 2012). Most sightings occurred within 5 to 10km from shore, and all were less than 24km from shore. Most (25 of the 36) encounters with short-finned pilot whales during HICEAS 2010 include identification photographs. Although comparison of those photos to the main Hawaiian Islands catalog is still ongoing, eight animals seen in one group at the edge of the Hawaiian Islands EEZ were also previously identified off Oahu in 2009. This was the first re-sighting of these individuals, none of which have been previously tagged or biopsied. There are no links between these individuals and the resident social network, suggesting some animals that use nearshore waters are pelagic. Individuals from two near-shore 2010 HICEAS encounters match to the resident social network. Genetic samples are also being analyzed from several sightings.

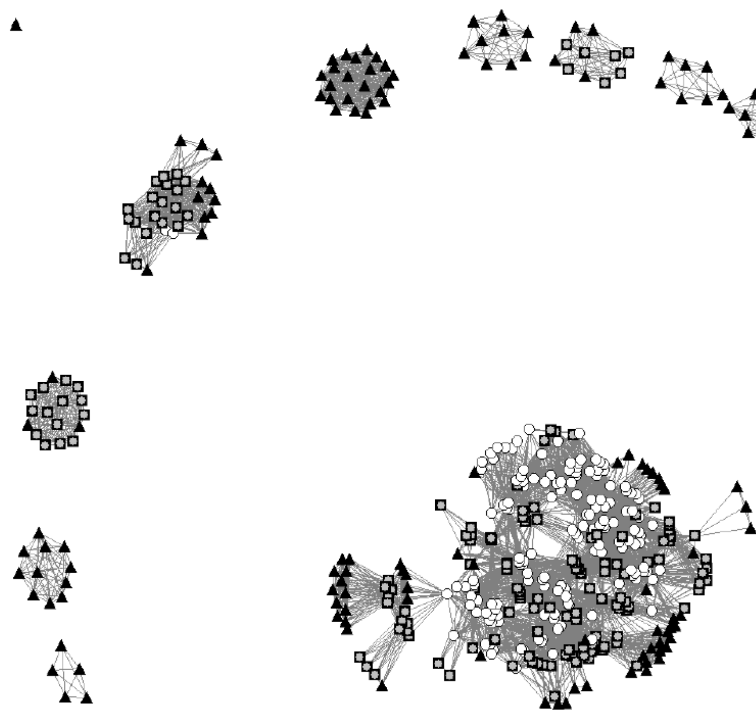


Figure 17. (from Mahaffy 2012). Social network diagram of all distinctive short-finned pilot whales documented off the island of Hawaii from 2003 to 2007. Distances between nodes were deteremined using a spring-embedded algorithm to depict closeness between individuals. *Core residents* are shown as white circles, *residents* are shown as gray boxes, and *visitors* are shown as black triangles. Note the two *core residents* that do not link by association to the main social cluster.

Movement data are available both from photo-identification among the islands (e.g., Baird et al. 2011c) and from satellite tags, which have been deployed on 60 short-finned pilot whales from the island-associated population (Baird et al. unpublished). Satellite tags have been deployed on individuals off most of the main Hawaiian Islands, including Kauai and Niihau, Oahu, Lanai, and Hawaii. As of February 20, 2013 data were still being obtained from one tag. Tagged individuals were members of one of three different social networks, including individuals documented off Kauai, Niihau and Oahu, individuals documented off Oahu and Lanai, and individuals documented primarily off Hawaii Island. All tagged individuals have remained associated with the main Hawaiian Islands. Approximately 95% of locations of tagged individuals were within 40 km of shore, with over 99% of locations within 70 km of shore, although the maximum distance documented from shore was 120 km (Baird et al. unpublished).

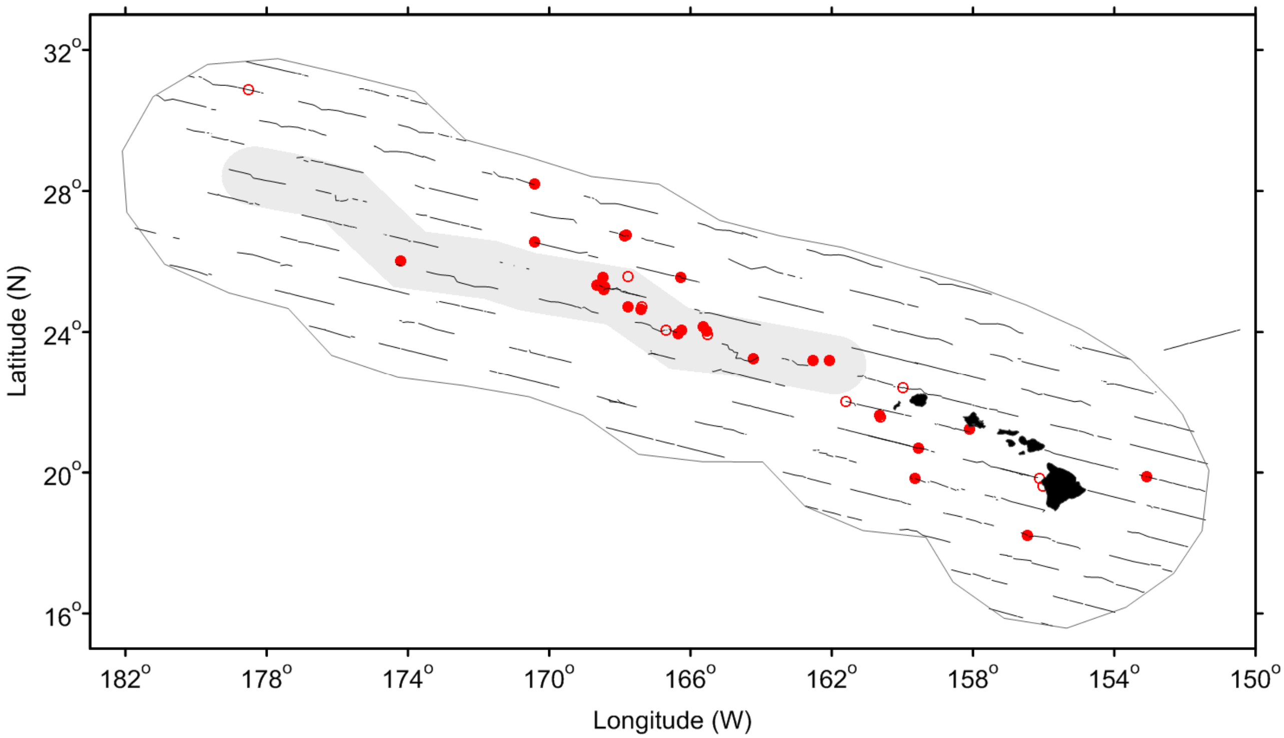


Figure 18. All (on, off, and non-standard effort) HICEAS 2010 short-finned pilot whale sightings with (filled circles) and without (unfilled circles) identification photos

Review of satellite-tag locations transmitted from 55 animals tagged near the main Hawaiian Islands (restricted to high-quality locations LC3, LC2, LC1 only) does reveal a natural boundary for separation of island-associated short-finned pilot whales from a broader pelagic stock. Although individual short-finned pilot whales do occasionally use very deep waters around the main Hawaiian Islands, more than 99% of high-quality locations were within 70km from shore (Figure 19, Baird et al. unpublished), and the maximum distance was 120km from shore. Three individuals were satellite tagged off Oahu and moved between Oahu and Kauai and offshore to just beyond the EEZ boundary (Baird unpublished; Figure 20). These animals are assumed to be part of the Hawaii pelagic stock based on their extensive offshore movements and the lack of any associations with pilot whales known to be part of the resident population.

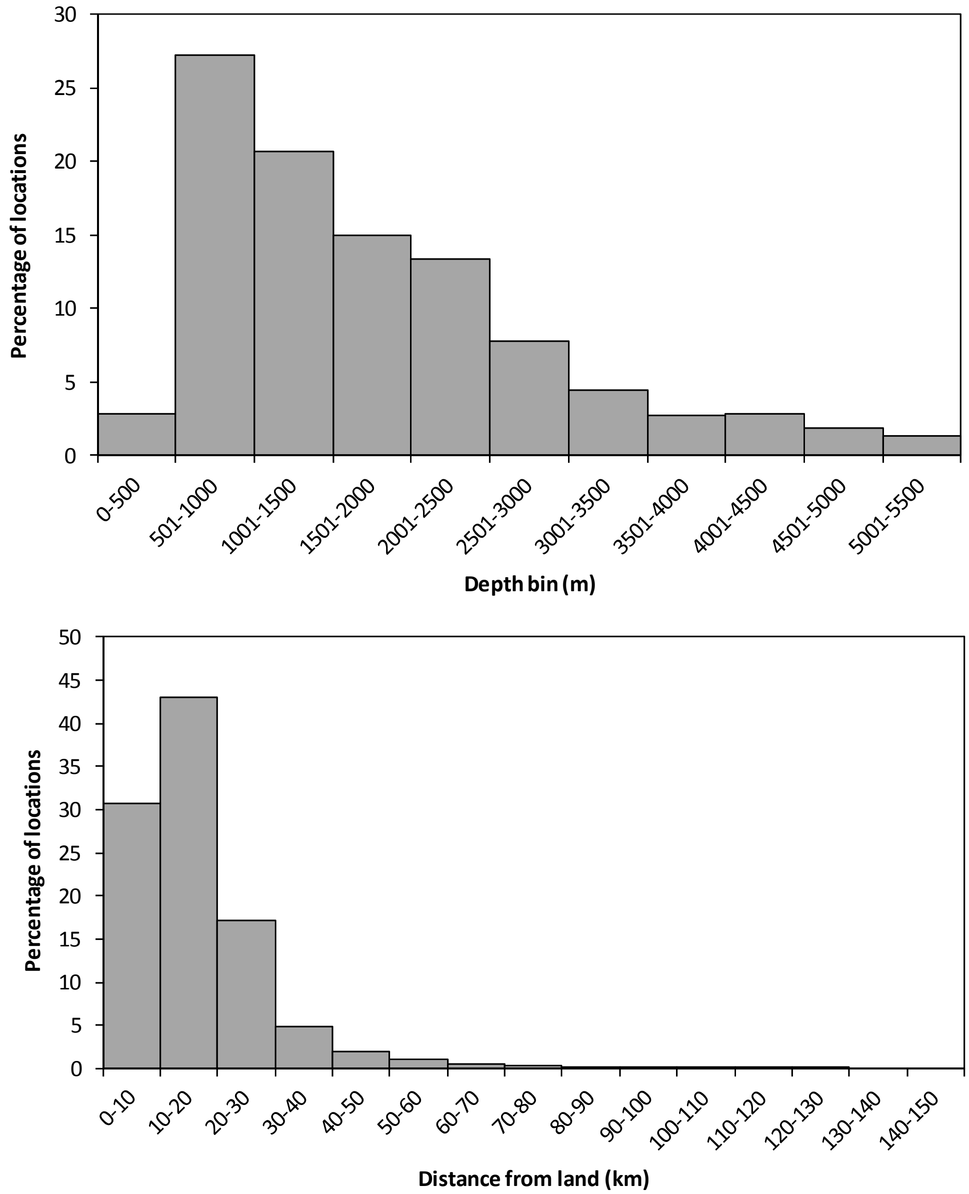


Figure 19. Depth distribution (upper panel) and distance from shore (lower panel) of 55 satellite tagged short-finned pilot whales associated with main Hawaiian Islands (from Baird et al. unpublished).

Phylogeographic analysis of short-finned pilot whales suggested long-term separation between animals found near Hawaii and animals in the ETP and southwestern Pacific (Chivers et al 2003).

A recent ocean basin-wide comparison of mitochondrial sequence data from short-finned pilot whales confirmed that Hawaiian animals (including both main and Northwestern Hawaiian Islands) are strongly differentiated from most of the rest of the Pacific and most are closely related to the Japanese southern form pilot whales (Van Cise unpublished data). Over 93% of Hawaiian pilot whales sequenced so far have the same haplotype. Thus, we cannot examine differentiation among the social clusters identified by Mahaffy (2012) or between the main and Northwestern Hawaiian Islands based only on mtDNA data. However, a project is planned, pending funding, to analyze a significantly expanded sample set (over 200 short-finned pilot whale samples collected within the Hawaiian EEZ) using microsatellite markers. This project will address the possibility of fine-scale structure within the main Hawaiian Islands.

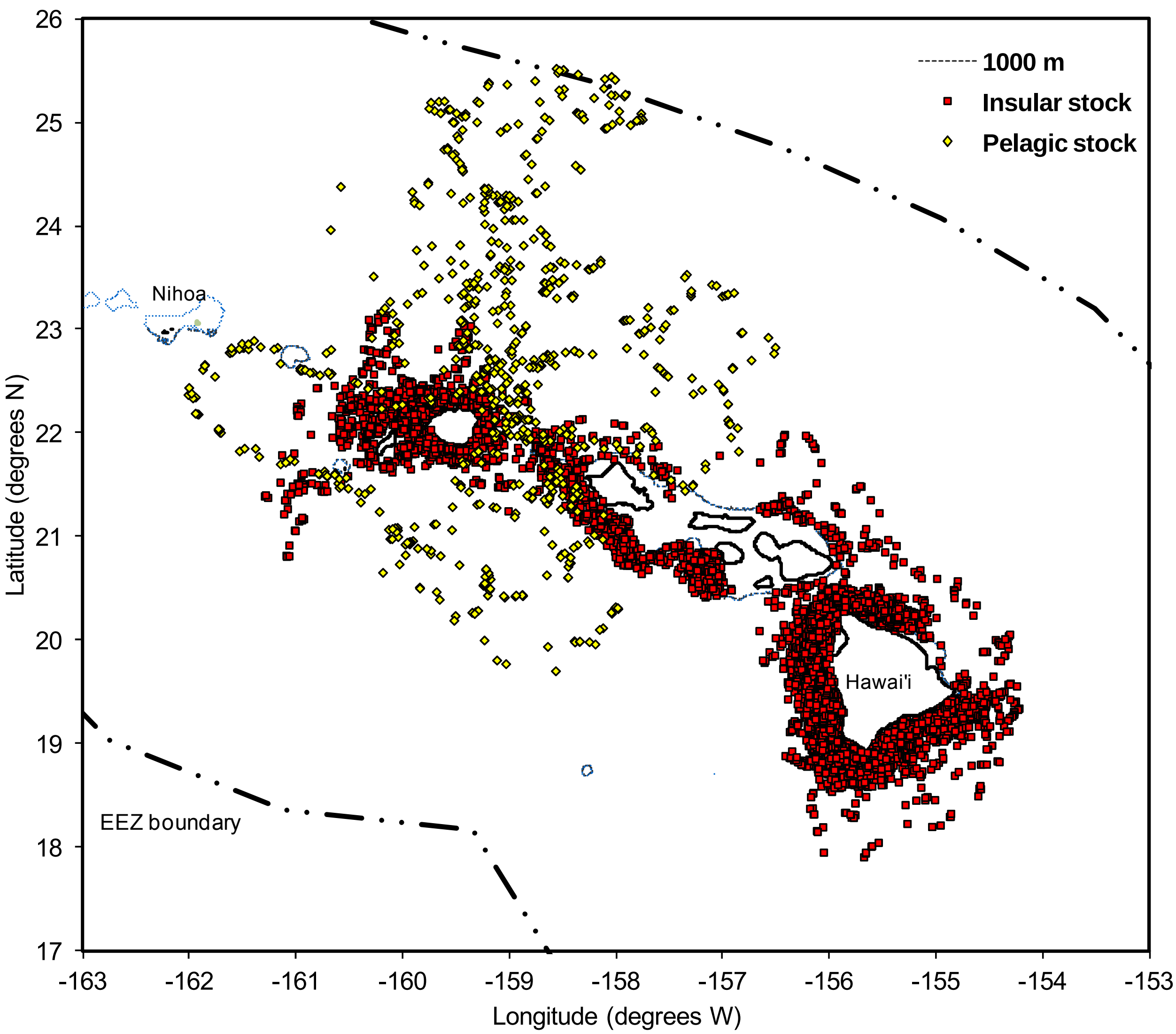


Figure 20. Locations from satellite tagged short-finned pilot whales, including three individuals thought to be from the pelagic stock, and 55 individuals thought to be from the insular stock.

Photo-ID and social network analyses (Mahaffy 2012) and movement data (Baird et al. unpublished) suggest the occurrence of at least two stocks of short-finned pilot whales in Hawaiian waters. Satellite tagging data indicate that individuals that likely belong to a pelagic population also occasionally pass through near-shore waters. Finer-scale population structure or complex social structure may exist within the short-finned pilot whale community in the main Hawaiian Islands given the unique patterns of site-fidelity and movements of some individuals. The presence of a core resident population off Hawaii Island (Mahaffy 2012) suggests that this group may be demographically isolated from other pilot whale populations near the main Hawaiian Islands. Although the quantity of data suggests short-finned pilot whales are well-studied and data-rich, the number of individuals seen only once suggests there is a sector of the population that is rarely encountered given current survey effort patterns. The number of 'visitors' imbedded in the main social cluster also suggests a high degree of gene flow is plausible. Genetic analyses within Hawaii and in the broader Pacific could significantly reduce the uncertainty for any island-associated stock designation. It is plausible that genetic analyses alone will not reduce uncertainty given inadequate sampling in the main Hawaiian Islands, and particularly of windward waters. Addition of recent identification photographs to the short-finned pilot whale catalog, reevaluation of social structure, and assessment of potential morphological differences between island-associated and pelagic animals should also be conducted over the next year or two to assist with determining short-finned pilot whale stock structure in the Hawaiian Islands.

We will revisit the available data on short-finned pilot whales within the next two to three years with a view to evaluating whether proposal of new island-associated stocks of pilot whales is appropriate . This short delay in designating new stocks will provide the opportunity to incorporate a much richer dataset to make robust determinations of stock range and abundance.

Rough-toothed dolphins

Rough-toothed dolphins are generally found throughout the world’s tropical seas as an oceanic species that rarely comes close to land except near islands with steep bathymetry near shore (West et al. 2011). Within the main Hawaiian Islands; however, rough-toothed dolphins are seen relatively frequently during nearshore surveys (Baird et al. 2008) and are the most commonly encountered species in depths greater than 3,000 m (Baird et al. 2013a). This species was also encountered 24 times during the NMFS HICEAS 2010 survey, primarily in off-shore waters (Bradford et al 2013).

Rough-toothed dolphins were seen 72 times during nearshore surveys in the main Hawaiian Islands from 2000 to 2006, including 55 encounters from Hawaii Island, one from Oahu, and 16 from Kauai and Niihau (Baird et al 2008). There have been few sightings of rough-toothed dolphins in the 4-Islands region, although most survey effort in that area is restricted to shallow-water areas not frequented by this species. Well-photographed, distinctive individuals were identified within 60 of 65 photographed encounters during directed research effort, as well as from an additional 10 of 15 opportunistic encounters (Baird et al. 2008). Additional photos are available from 2007 through February 2013 from encounters in the main Hawaiian Islands (Cascadia Research, unpublished), but have not yet been fully analyzed.

Evaluation of individual rough-toothed dolphin encounters indicates differences in group sizes, habitat use, and behavior between groups seen near Hawaii Island and those seen near Kauai and Niihau (Baird et al 2008). Group sizes are significantly higher off Kauai and Niihau than Hawaii Island (median 11 versus 6). Groups encountered off Hawaii Island avoided the research vessel twice as often as groups off Kauai and Niihau (38.2% vs. 18.75%). Social network analysis of re-sighted individuals through 2006 indicates 97 of 124 identified individuals off Hawaii Island link into a single social network and 162 of 209 individuals from Kauai and Niihau link into a separate social network. Two individuals seen near Kauai have also been seen off Hawaii Island; however they were not seen with other individuals previously encountered off Hawaii Island (Baird et al. 2008). The percent of distinct individuals within groups seen more than once was higher off Hawaii than off Kauai/Niihau (75% versus 8%). Together the differences in re-sighting rates, behavior, and group size suggest there may be two populations of rough-toothed dolphins in the main Hawaiian Islands.

Evaluation of tissue samples collected near Hawaii Island and near Kauai and Niihau is underway by Renee Albertson at Oregon State University. The mtDNA results to date indicate that samples taken near Hawaii Island (n=52) are significantly differentiated from those taken near Kauai and Niihau (n=91) and those collected near Gardner Pinnacles (n=13) in the Northwestern Hawaiian Islands, but that Kauai and Niihau and Gardner Pinnacles samples are not significantly differentiated from each other. Microsatellites are still being processed, though the results of those studies will provide significant guidance for the separation of rough-toothed dolphin stocks in the Hawaiian Archipelago.

Re-sighting and social network analyses suggest the occurrence of two different rough-toothed dolphin populations in main Hawaiian Islands. However, because of the on-going genetics work and the potential for connectivity of individuals between Kauai and Niihau and those farther north within the archipelago, we are not designating new stocks at this time. Satellite tags were deployed on eight individuals off Kauai and Niihau in 2011, 2012 and 2013, with movements restricted to those islands (Baird et al 2012, unpublished). We will revisit the available data on rough-toothed dolphins within the next two to three years with a view to proposing new island-associated stocks of rough-toothed dolphins at that time, as appropriate. This short delay in designating new stocks will provide the opportunity to incorporate a much richer dataset to make robust determinations of stock range and abundance.

Summary

We reviewed available data and analyses for eight species of odontocetes in Hawaiian waters where there is some evidence for island association. Our data review indicates that several of these species could be split into one or more island-associated stocks or prospective stocks at this time. The pace of data collection for each species helps to inform when decisions about new stock designations should be made. When the rate of new and ongoing analysis is likely to produce significant new information about population structure in the short-term, we chose to defer determination of whether or not to split a stock, and what the resultant abundance, range, and boundaries of any new stocks would be. Where the pace of data collection is very slow, and it is unlikely that significant new information will be available within the foreseeable future, we propose designation of prospective island-associated stocks in hopes of obtaining additional information or guidance from the Pacific Scientific Review Group and others on whether or not the populations of those species should be split into island-associated and pelagic stocks, and how to infer population size and boundaries with available datasets. For two species, there are sufficient data available now to strongly support designation of new island-associated stocks.

The types of data available for assessing population structure, abundance, and range varies among the species examined. For most species, pantropical spotted dolphins excepted, genetic evaluation of stock structure has not yet been completed, or is not possible given the small sample sizes available. In most cases, we rely on evaluation of dozens to hundreds of encounters of each species and the important information gleaned from detailed photo-identification studies. These studies have revealed strong association with the main Hawaiian Islands for many species. Lack of survey data within the Northwestern Hawaiian Islands remains a significant gap in our ability to define population boundaries for some of these island-associated populations. In all cases, inadequate photo-ID and genetic information from pelagic waters creates uncertainty about the degree of geographic overlap between insular and pelagic stocks. Under the MMPA, current guidance defines demographic isolation, the benchmark for separate management, as the condition where "… the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics)." For several of the eight species we examined lack of data and slow accumulation of new data reduced the certainty in confirming island-association. However, given the potential threats to populations with ranges restricted to the island ecosystem and where Naval training activities are prevalent and nearshore fishing activities are nontrivial, these data gaps do not justify deferring judgment on stock structure.

We propose recognizing new island-associated stocks for two species, designation of Prospective Stocks for four species, and withholding designation of any new stocks until on-going analyses are complete for two species. Melon-headed whales and pantropical spotted dolphins are considered data rick stocks, and we propose a new Kohala resident stock of melon-headed whales and three island-associated stocks (Oahu, 4-Islands, Hawaii) of spotted dolphins. Blainville's and Cuvier's beaked whale, dwarf sperm whales, and pygmy killer whale are considered data poor stocks, and we propose designation of prospective stocks and seek additional information and guidance to guide their assessment. Rough-toothed dolphins and short-finned pilot whales are stocks for which new data and analyses are expected within the next few years that will refine any designation of new stocks in the Hawaiian Archipelago.

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