PACIFIC ISLANDS FISHERIES SCIENCE CENTER

New Island-Associated Stocks for Hawaiian Spinner Dolphins (*Stenella longirostris longirostris*): Rationale and New Stock Boundaries

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INTRODUCTION

The current Marine Mammal Protection Act stock assessment report for spinner dolphins within U.S. Exclusive Economic Zone (EEZ) waters of the central and western Pacific Ocean defines only a single stock, which includes the spinner dolphins within the waters of the Hawaiian Archipelago (Carretta et al., 2009) (Fig. 1). Recent analyses of photo-identification and genetic data indicate the need for a redefinition of the Hawaiian stock of spinner dolphins, as well as the creation of a new stock to include those animals within the U.S. EEZ waters of American Sāmoa (Fig. 2).

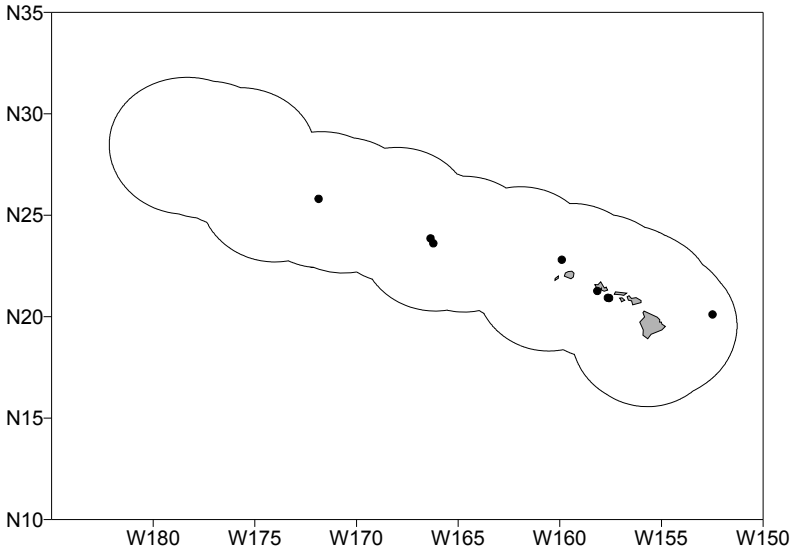

Figure 1.—From Carretta et al., 2009. Spinner dolphin sighting locations during the 2002 shipboard cetacean survey of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow, 2005). Outer line indicates approximate boundary of survey area and U.S. EEZ.

Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and subtropical waters (Perrin and Gilpatrick, 1994; Perryman and Westlake, 1998; Perrin et al., 1991; Perrin et al., 1999). The Gray's (or pantropical) spinner dolphin (*Stenella longirostris longirostris*) is the most widely distributed subspecies and is found in the Atlantic, Indian, central and western Pacific Oceans (Perrin et al., 1991; Norris et al., 1994; Oremus et al., 2007; Johnston et al., 2008). Within the central and western Pacific, spinner dolphins are island-associated and use shallow protected bays to rest and socialize during the day, then move offshore at night to feed (Norris et al., 1994; Reeves et al., 1999; Benoit-Bird and Au, 2003; Lammers, 2004; Karczmarski et al., 2005; Oremus et al., 2007; Johnston et al., 2008). Tracking data of tagged spinner dolphins in Hawai'i have demonstrated that individuals move as far as 8 km offshore during nighttime hours and then return to nearshore waters at sunrise (Norris et al., 1994; Benoit-Bird and Au, 2003). Spinner dolphins are common and abundant throughout the entire Hawaiian Archipelago (Shallenberger, 1981; Norris and Dohl, 1980; Norris et al., 1994) and around American Sāmoa (Reeves et al., 1999). Twenty-six strandings have been reported in the Hawaiian Islands (Maldini et al., 2005).

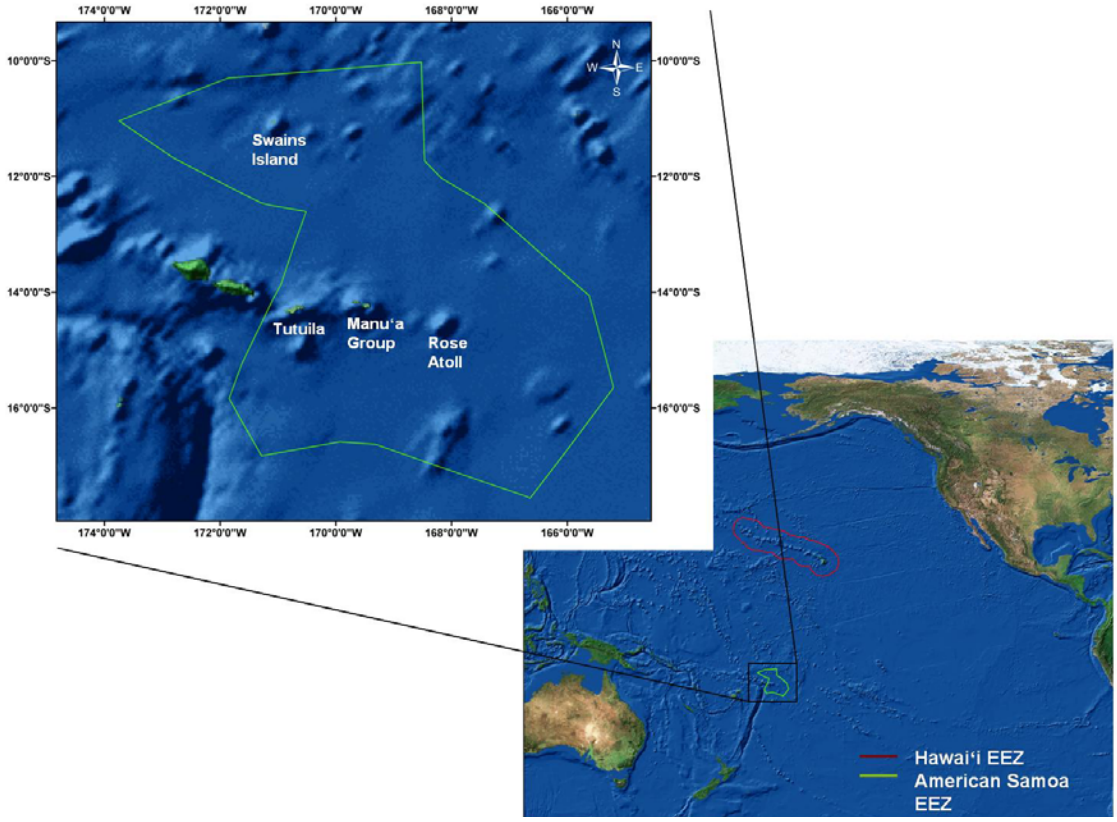

Figure 2.—American Sāmoa EEZ.

NEW GENETIC INFORMATION

Recent studies on the genetic structure of Gray's spinner dolphins in Hawai'i and American Sāmoa support previous conclusions that there is a significant differentiation between dolphins found in Hawaiian waters and those of all other regions (Galver, 2002; Andrews, 2009; Andrews et al., 2010). In addition, Andrews and her colleagues (2009, 2010) found that mitochondrial DNA (mtDNA) control region haplotype and nucleotide diversities of Hawaiian spinner dolphins are low ($h=0.508$; $\pi=0.0045$) compared with those from other geographic regions ($0.867 \leq h \geq 0.987$; $0.0162 \leq \pi \geq 0.0228$) suggesting the existence of strong barriers to gene flow, both geographic and ecological. Their analyses also reveal significant ($p<0.001$) genetic distinction, at both mtDNA and microsatellite loci, between spinner dolphins sampled in American Sāmoa and those sampled in the Hawaiian Islands (Johnston et al., 2008; Andrews, 2009; Andrews et al., 2010). The low genetic diversity of spinner dolphins in Hawaiian waters indicates that dolphin populations in Hawai'i may be particularly vulnerable to environmental change compared with spinner dolphins in other locations (Frankham, 2005; Hughes et al., 2008; Agashe, 2009).

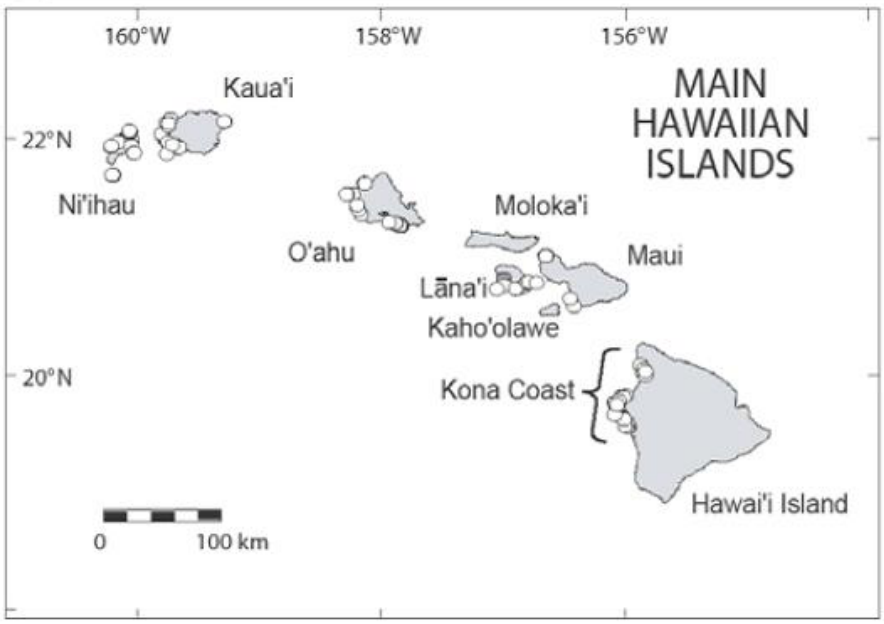

Figure 3.—From Andrews et al., 2010. Spinner dolphin sample location used for population identification analysis in the main Hawaiian Islands.

Andrews et al. (2010) also found significant genetic distinctions between spinner dolphins sampled at different islands within the Hawaiian Archipelago (Table 1). Pairwise F-statistic analyses of mitochondrial and microsatellite data revealed significant genetic differentiation ($p<0.001$) between spinner dolphins sampled along the Kona Coast of the Island of Hawai‘i (Big Island) and spinner dolphins sampled at all other Hawaiian islands including Maui, located only 46 km from the Big Island. Similarly, in the Northwestern Hawaiian Islands, spinner dolphins sampled at Midway and Kure (not genetically distinct from each other) are significantly ($p<0.01$ and $p<0.001$) distinct from those sampled at all other islands. Spinner dolphins sampled at Pearl and Hermes Reef show significant ($p<0.01$ and $p<0.001$) genetic differentiation, at both mtDNA and microsatellite loci, from dolphins sampled at all islands to the southeast and significant genetic distinction, at microsatellite loci, from those at Midway ($p<0.05$) and Kure ($p<0.01$). Photo-identification studies in the Northwestern Hawaiian Islands have demonstrated that the movement of individuals between Pearl and Hermes and Midway and Pearl and Hermes and Kure is much lower than that between Midway and Kure (Karczmarski, unpublished data).

Table 1. From Andrews et al., 2010. Pairwise *F*-statistics for spinner dolphins between locations in the Hawaiian Archipelago and American Sāmoa for 10 microsatellite loci (below diagonals) and a 417-bp fragment of the mtDNA control region (above diagonals). Sample size in parentheses. (a) F_{ST} values for microsatellites and Φ_{ST} values for mtDNA. (b) Standardized F_{ST} (F'_{ST}) values for microsatellites and mtDNA. Φ_{ST} considers genetic distance between haplotypes, but F_{ST} and F'_{ST} do not. Shaded areas indicate significant values: *p<0.05, **p<0.01, ***p<0.001

(a)	Kure (51)	Midway (119)	PHR (47)	FFS (33)	Niʻihau (45)	Kauaʻi (32)	Oʻahu (40)	Maui (59)	Kona (79)	Sāmoa (16)
Kure (51)		0.000	-0.003	-0.011	0.048*	0.061*	0.029	0.077**	0.163***	0.506***
Midway (119)	-0.001		0.018	0.001	0.087***	0.105***	0.054**	0.123***	0.236***	0.643***
PHR (47)	0.009**	0.003*		0.009	0.072**	0.070*	0.049*	0.089**	0.176***	0.531***
FFS (33)	0.013***	0.009***	0.010**		0.013	0.017	-0.002	0.037	0.121***	0.396***
Niʻihau (45)	0.013***	0.012***	0.015***	0.004		0.000	-0.005	0.014	0.051*	0.300***
Kauaʻi (32)	0.012***	0.011***	0.013***	0.005	0.001		-0.009	0.030	0.042*	0.316***
Oʻahu (40)	0.009**	0.007**	0.013**	0.001	0.001	0.003		0.016	0.071**	0.368***
Maui (59)	0.018***	0.015***	0.022***	0.009**	0.012***	0.013***	0.001		0.085***	0.387***
Kona (79)	0.031***	0.028***	0.040***	0.016***	0.021***	0.024***	0.018***	0.025***		0.217***
Sāmoa (16)	0.081***	0.089***	0.090***	0.058***	0.080***	0.077***	0.073***	0.073***	0.058***	

(b)	Kure (51)	Midway (119)	PHR (47)	FFS (33)	Niʻihau (45)	Kauaʻi (32)	Oʻahu (40)	Maui (59)	Kona (79)	Sāmoa (16)
Kure (51)		-0.009	0.025	-0.015	0.042*	0.015	0.017	0.042	0.102***	0.393***
Midway (119)	-0.003		0.052*	-0.015	0.037*	0.025	0.013	0.050**	0.116***	0.416***
PHR (47)	0.030**	0.010*		0.076*	0.155***	0.046*	0.105**	0.082**	0.175***	0.538***
FFS (33)	0.049***	0.033***	0.039**		0.002	0.011	-0.014	0.022	0.070**	0.311***
Niʻihau (45)	0.048***	0.041***	0.053***	0.016		0.043	-0.011	0.054*	0.033*	0.208***
Kauaʻi (32)	0.043***	0.039***	0.045***	0.020	0.002		0.012	0.039	0.055*	0.344***
Oʻahu (40)	0.032**	0.023**	0.045**	0.003	0.004	0.011		0.030	0.035*	0.264***
Maui (59)	0.065***	0.053***	0.078***	0.035**	0.043***	0.048***	0.005		0.120***	0.370***
Kona (79)	0.116***	0.102***	0.147***	0.065***	0.079***	0.090***	0.068***	0.096***		0.192***
Sāmoa (16)	0.337***	0.353***	0.366***	0.269***	0.342***	0.320***	0.318***	0.309***	0.253***	

Andrews et al. (2010) found that none of the pairwise comparisons between French Frigate Shoals, Niʻihau, Kauaʻi, and Oʻahu were statistically significant. In addition, Oʻahu was not significantly differentiated Maui/Lanaʻi. Assignment tests, which may provide information about recent gene flow, show that for most islands and atolls within the Hawaiian Archipelago, more samples were "back-assigned" to the island/atoll at which they were collected than to any other island, suggesting some level of site fidelity (Fig. 4). The exceptions were samples collected at Oʻahu and French Frigate Shoals. Only 15% of the individuals sampled from Oʻahu were "back-assigned" to Oahu and were more often (~28%) assigned to Maui/Lanaʻi. Of the individuals sampled at French Frigate Shoals, only 18.2% were "back-assigned," suggesting a high level of migration.

Spinner dolphin genetic data are lacking from some islands and atolls within the Hawaiian Archipelago (e.g., Molokaʻi, Kahoʻolawe, Nihoa, Mokumanamana (Necker), Gardner Pinnacles, Laysan, Lisianski). Sighting data confirms the presence of spinner dolphins at some of these locations (e.g., Molokaʻi, Kahoʻolawe, Mokumanamana, and Gardner Pinnacles; PIFSC unpublished data), however, without genetic or photo-identification data it is difficult to establish connections between these dolphins and those at other islands.

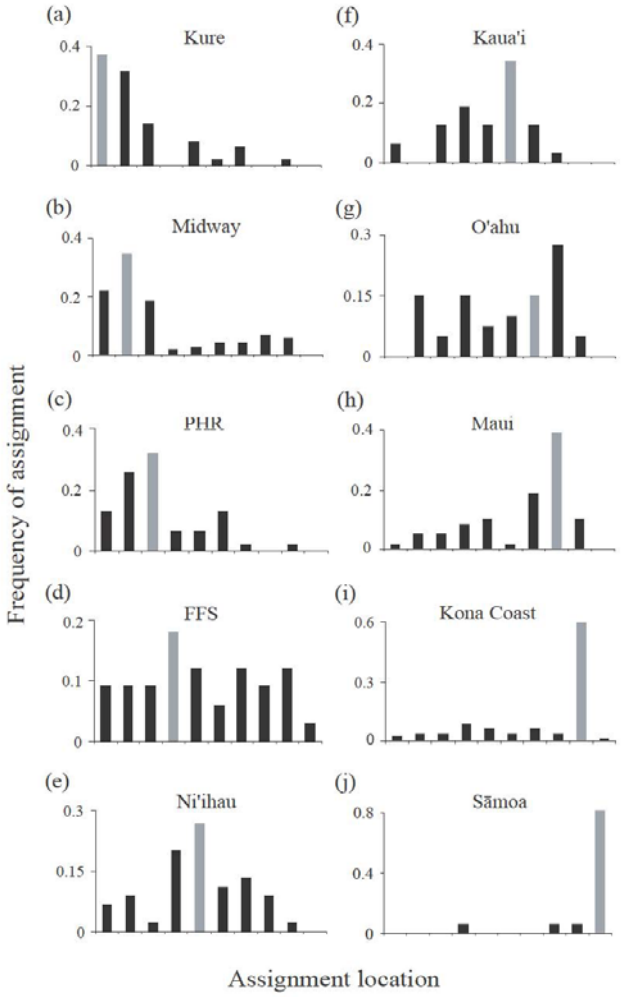

Figure 4. From Andrews et al., 2010. Distribution of assignment locations for spinner dolphins sampled in the Hawaiian Archipelago and American Sāmoa. Graph headings identify the location where the individuals were sampled, and graphs are arranged from (a) the west-most island in the Hawaiian Archipelago to (i) the east-most island in the Hawaiian Archipelago, followed by (j) Sāmoa. "Back-assignments" (assignments to the location at which the individual was sampled) are colored in light gray.

HAWAIIAN ARCHIPELAGO STOCKS

Based on the evidence provided by the analyses of microsatellite and mtDNA genetic data (Andrews, 2009; Andrews et al., 2010), known movement patterns of dolphins (Karczmarski, 2005), and the geographic distances between the Hawaiian Islands, the current Hawaiian stock of spinner dolphins will be divided into the following five separate stocks: 1) Midway Atoll/Kure, 2) Pearl and Hermes Reef, 3) Niʻihau/Kauaʻi, 4) Oʻahu/4-Islands region, 5) Big Island (Figs. 5 and 6). Based on the best available evidence, including sighting and tracking data, boundaries for these stocks are set at 18.5 km (10 nmi) distance around each island or island group. This boundary is based on anecdotal accounts of individual spinner dolphin movements and is likely to be revised as additional information on the offshore movements of island-associated populations is collected. Spinner dolphins beyond 18.5 km from shore are assigned to an additional Hawaiʻi Pelagic stock. Dolphins sampled at French Frigate Shoals will be included in the Hawaiʻi Pelagic stock. Dolphins that may occur around Laysan, Lisianski, Gardener Pinnacles, and Nihoa are also included in this Hawaiʻi Pelagic stock as there is no genetic or sighting information from these islands/atolls and the lack of resting habitat (Rickards et al., 2001) would seem to preclude resident stocks at these locations.

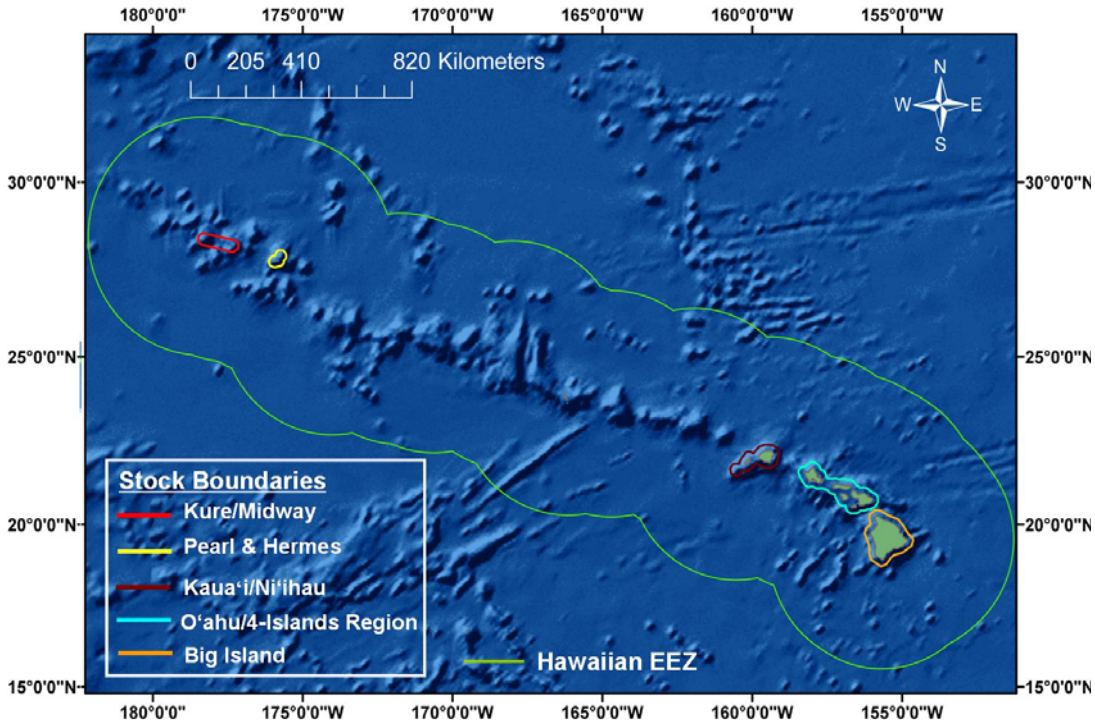

Figure 5. Hawaiian Islands spinner dolphin stock boundaries. Five new stocks: Kure/Midway, Pearl and Hermes Reef, Kauaʻi/Niʻihau , Oʻahu/4-islands region, and the island of Hawaiʻi (Big Island). A sixth Hawaiian pelagic stock will include all other spinner dolphins within the Hawaiʻi EEZ.

The strong differentiation between Niʻihau/Kauaʻi, Maui/Lanaʻi, and the Big Island at the microsatellite loci indicates that these three island groups warrant separate management. The samples from Oʻahu, however, are not significantly differentiated from either Niʻihau/Kauaʻi or Maui/Lanaʻi. The grouping of Oʻahu with Maui/Lanaʻi is based on the high rate of cross-assignments between these island groups in Andrews' (2009) assignment tests and their geographic proximity. The grouping of individuals from Oʻahu and Maui/Lanaʻi may change once additional data are collected. Although there are no data from Molokaʻi and Kahoʻolawe, these dolphins are grouped with those from Maui and Lanaʻi because of their proximity to one another (4-Islands region).

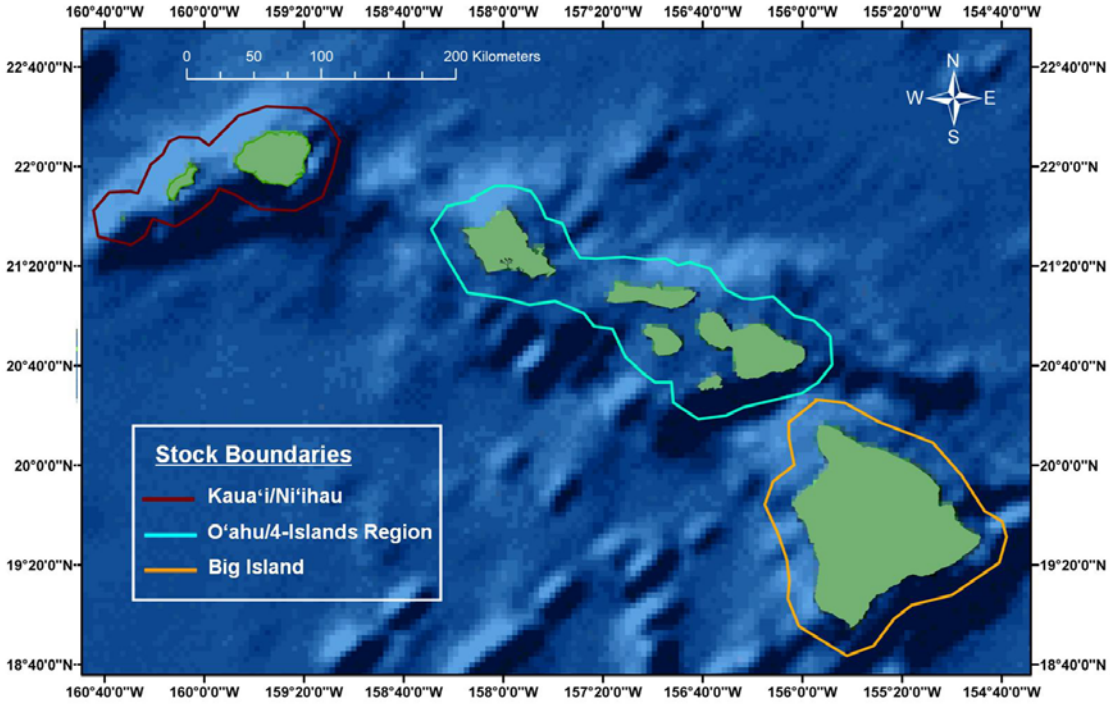

Figure 6.—Detailed view of new spinner dolphin stock boundaries in the main Hawaiian Islands, with new stocks for Kauaʻi/Niʻihau , Oʻahu/4-Islands, and the island of Hawaiʻi (Big Island).

The Pacific Islands Photo-identification Network (PIPIN) is beginning to analyze spinner dolphin photo-data from the main Hawaiian Islands. In the future, this data will be used to establish minimum population estimates of each stock. In addition, PIPIN will look at individual spinner dolphin movements which may result in future refinements to the new stock boundaries.

AMERICAN SĀMOA STOCK

During small-boat surveys (2003–2006) in the waters surrounding the island of Tutuila, the spinner dolphin was the most frequently encountered species (i.e., 34 of 52 sightings—Fig. 7) and was found in waters with a mean depth of 44 m (Johnston et al., 2008). Photo-identification data collected during the surveys indicate the presence of a "resident" population of spinner dolphins in the waters surrounding Tutuila. Approximately one-third of the individuals within the photo-id catalog were sighted in multiple years. In addition, some of these individuals demonstrated strong site fidelity and were encountered within only a few kilometers from one year to the next. During a 2006 shipboard survey, spinner dolphins were also encountered just south of the island of Ta'u, American Sāmoa (Johnston et al., 2008).

It is evident from both the genetic and photo-identification data that spinner dolphins at American Sāmoa are distinct from those in Hawaiian and other tropical Pacific waters and that at least some portion of the population is resident at the island of Tutuila. For this reason, a spinner dolphin stock will be established within American Sāmoa. Although there may be separate island-associated populations, currently there is not enough evidence for support of any such stock division.

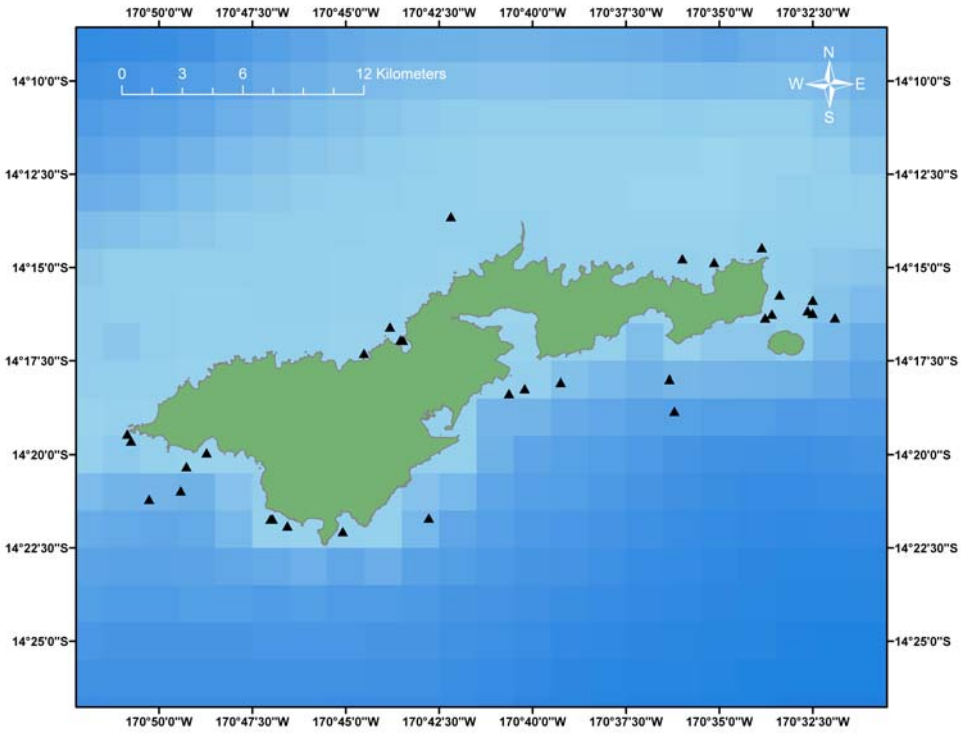

Figure 7.—Spinner dolphin sighting locations around the island of Tutuila in American Sāmoa. Photo-identification matches suggest an island-associated population at Tutuila; however, only a single EEZ-wide stock will be established at this time as data is lacking from other regions in American Sāmoa.

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