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STRIPED DOLPHIN (*Stenella coeruleoalba*): Hawai‘i Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Striped dolphins are found in tropical to warm-temperate waters throughout the world (Perrin *et al.* 2009). Sightings have historically been infrequent in shallow waters (Shallenberger 1981, Mobley *et al.* 2000), though they are common, even nearshore, in waters greater than 3500m (Baird 2016). Striped dolphins are often seen offshore throughout the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands during periodic shipboard surveys (Figure 1).

Striped dolphins have been intensively exploited in the western North Pacific, where three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993). In the eastern tropical Pacific, all striped dolphins are provisionally considered to belong to a single stock (Dizon *et al.* 1994). There is insufficient data to examine finer stock structure within Hawaiian waters, though available data do not suggest island-associated populations (Baird 2016).

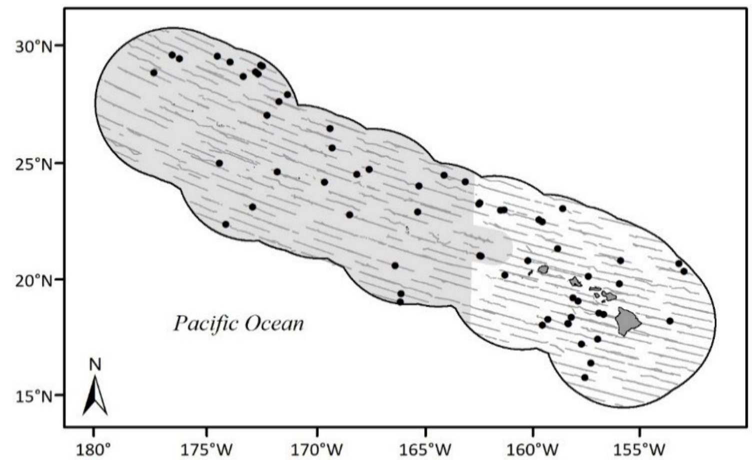

Figure 1. Striped dolphin sighting locations (circles) and survey effort (gray lines) during the 2002 (Barlow 2006), 2010 (Bradford *et al.* 2017), and 2017 (Yano *et al*. 2018) shipboard surveys of the U.S. EEZ around the Hawaiian Islands (outer black line). The Papahānaumokuākea Marine National Monument in the western portion of the EEZ is shaded gray.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, striped dolphins within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington, and 2) waters around Hawai‘i (this report), including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawai‘i stock is evaluated based on data from the U.S. EEZ around the Hawaiian Islands (NMFS 2023). Striped dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

POPULATION SIZE

Encounter data from shipboard line-transect surveys of the Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in updated model-based abundance estimates of striped dolphins in the entirety of the Hawaiian Islands EEZ (Becker *et al.* 2021, 2022; Table 1).

Sighting data from 2002 to 2020 within the Hawaiian Islands EEZ were used to derive habitat-based models of animal density for two periods: 2002-2017 (Becker *et al.* 2021) and 2017-2020 (Becker *et al.* 2022). The most recent set of models include three notable changes from the 2002-2017 models: use of calibrated group size estimates, as in Bradford *et al.* (2021), exclusion of a spatial term on model selection, requiring more explicit reliance on environmental variables, and incorporating new approaches (Miller *et al.* 2022) for more comprehensively estimating uncertainty in model predictions that account for the combined uncertainty around all parameter estimates. The modeling framework incorporated Beaufort-specific trackline detection probabilities for striped dolphins from Barlow *et al.* (2015). Models were used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney *et al.* 2015, Becker *et al.* 2016). When model-based estimates are available for 2017 from both analyses, the results are largely similar for most species; however, striped dolphins are a notable exception, with 2017 estimates from Becker *et al,* (2022) nearly double those from Becker *et al.* (2021). Although Becker *et al.* (2022) attribute this change to the use of new calibrated group size, detailed review of the functional form of the model predictors reveals a shift from a linear decline in density with depth in Becker *et al.* (2021) to a thresholded form in Becker *et al.* (2022), with density constant at depths less than 3000m, leading to higher densities in shallow depths than the previous models. Bradford *et al.* (2021) produced design-based abundance estimates for striped dolphins in 2002, 2010, and 2017 that can be used as a point of comparison to the model-based estimates for those years.

Table 1. Model-based line-transect abundance estimates for striped dolphins in the Hawaiian Islands EEZ in 2002 and 2010 (Becker *et al.* 2021) and 2017 and 2020 (Becker *et al.* 2022), derived from NMFS surveys in the central Pacific since 2000. The Becker *et al.* (2022) analysis incorporates a more comprehensive model-based approach to estimating model uncertainty, such that the CVs and 95% confidence limits for 2002/2010 and 2017/2020 are not directly comparable.

Year	Model-based Abundance	CV	95% Confidence Limits
2020	64,343	0.28	37,822-109,462
2017	59,493	0.28	35,050-100,981
2010	36,886	0.22	24,004-56,681
2002	35,817	0.22	23,384-54,861

There is substantial variability within and between the design and model-based estimates across the time series (Figure 2), suggesting additional survey data are needed to develop a well-parameterized model for this species. Despite the substantial variability in the abundance estimates for this species, the model-based estimates are considered the best available estimate for each survey year. Becker *et al.* (2022) and Bradford *et al.* (2022) evaluated seasonal changes in the abundance of striped dolphins within the main Hawaiian Islands using summer-fall data from 2017 and winter survey data from 2020. Seasonal predictions using the model showed no reliance on dynamic variables, and design-based estimates were broadly similar (with broad and overlapping confidence intervals). Previously published abundance estimates for the Hawaiian Islands EEZ (e.g. Barlow 2006, Becker *et al.* 2012, Forney *et al.* 2015, Bradford *et al.* 2017) used a subset of the dataset used by Becker *et al.* (2021, 2022) and Bradford *et al.* (2021) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. The best estimate of abundance is based on the 2020 survey, or 64,343 (CV=0.28) striped dolphins.

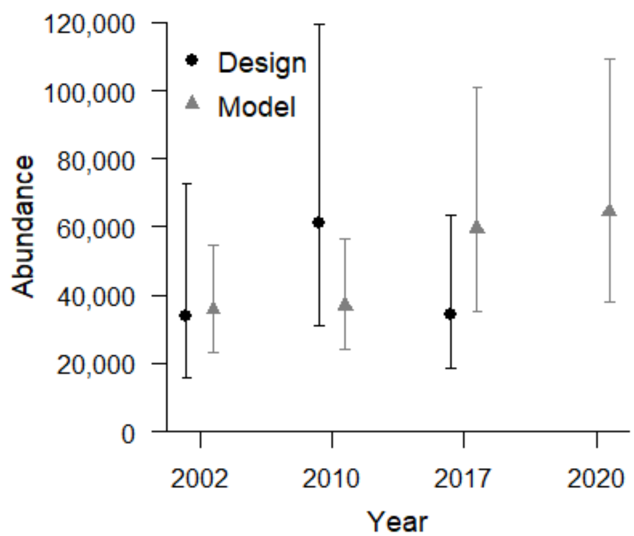

Figure 2. Comparison of design-based (black circles, Bradford *et al.* 2021) and model-based (gray triangles, Becker *et al.* 2021, 2022) estimates of abundance for striped dolphins for each survey year (2002, 2010, 2017, 2020).

Population estimates are available for Japanese waters (Miyashita 1993) and the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

The minimum population estimate is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2020 abundance estimate (from Becker *et al.* 2022), or 51,055 striped dolphins.

Current Population Trend

The model-based abundance estimates for striped dolphins provided by Becker *et al.* (2021, 2022) are highly variable and do not explicitly allow for examination of population trend. Model-based examination of striped dolphin population trends including sighting data beyond the Hawaiian Islands EEZ will be required to more fully examine trend for this stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawai‘i stock of striped dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (51,055) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with no known fishery mortality and serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 511 striped dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta and Henderson, 1993). In 2021, a striped dolphin stranded on Maui with scarring on its rostrum consistent with a previous hooking and scarring on its peduncle consistent with a previous entanglement, although these findings were not considered to be related to the cause of death (Bradford and Lyman in press). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

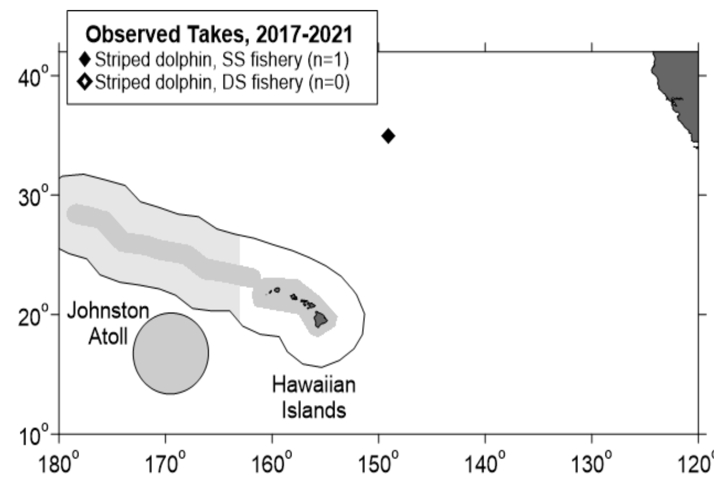

Figure 3. Location of a striped dolphin take within the shallow-set fishery (filled diamond) in Hawaii-based longline fisheries, 2017-2021. Solid lines represent the U.S. EEZs. Gray shading notes areas closed to longline fishing.

There are currently two distinct longline fisheries based in Hawai‘i: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2017 and 2021, one striped dolphin was observed hooked or entangled in the SSLL fishery (100% coverage) outside of the U.S. EEZ, and no striped dolphins were observed hooked or entangled in the DSLL fishery (15-21% observer coverage) (Figure 3, Bradford 2018, 2020, 2021, 2023, in review). The striped dolphin was considered not seriously injured based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2023b).

The total estimated number of dead or seriously injured dolphins is calculated based on observer coverage rate, the location of the observed take (inside or outside of the EEZ), and the ratio of observed dead and seriously injured whales versus those judged to be not seriously injured. Observer coverage is measured on a per-trip basis throughout the calendar year as described by McCracken (2019). In years with large fluctuations in observer coverage, such as during the early days of the COVID-19 pandemic when observer coverage dropped to less than 10% during the second quarter of the year, the annual bycatch estimation process may be subset into several periods, as described in McCracken and Cooper (2022a). Average 5-yr estimates of annual mortality and serious injury for 2017-2022 are 0.2 dolphins outside of the U.S. EEZ, and 0 within the Hawaiian Islands EEZ (Table 2).

Table 2. Summary of available information on incidental mortality and serious injury (MSI) of striped dolphin (Hawai‘i stock) in commercial longline fisheries, within and outside of the U.S. EEZ (McCracken and Cooper 2022b). Mean annual takes are based on 2017-2021 data unless otherwise indicated. Information on all observed takes (T) and

MSI is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Outside U.S. EEZ		Hawaiian Islands EEZ	
				Observed T/MSI	Estimated MSI (CV)	Observed T/MSI	Estimated MSI (CV)
Hawai'i-based deep-set longline fishery	2017	Observer data	20%	0	0 (-)	0	0 (-)
	2018		18%	0	0 (-)	0	0 (-)
	2019		21%	0	0 (-)	0	0 (-)
	2020		15%	0	0 (-)	0	0 (-)
	2021		18%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV) 2017-2021					**0 (-)**		**0 (-)**
	2017	Observer data	100%	1/0	1	0	0
	2018		100%	0	0	0	0
	2019		100%	0	0 (-)	0	0 (-)
	2020		100%	0	0 (-)	0	0 (-)
	2021		100%	0	0 (-)	0	0 (-)
Mean Annual Takes (100% coverage) 2017-2021					**0.2**		**0**
Minimum total annual takes within U.S. EEZ (2017-2021)							**0 (-)**

STATUS OF STOCK

The Hawai'i stock of striped dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of striped dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Striped dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries in the U.S. EEZ, total fishery mortality and serious injury for striped dolphins can be considered insignificant and approaching zero. Several serious diseases have been found in stranded striped dolphins in Hawai'i. One striped dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov 2010), two for *Morbillivirus* (Jacob *et al.* 2016), and one for beaked whale circovirus (Clifton *et al.* 2023). *Brucella* is a bacterial infection that if common in the population may limit recruitment by compromising male and female reproductive systems, and can also cause neurological disorders that may result in death (Van Bressem *et al.* 2009). Although M*orbillivus* is known to trigger lethal disease in cetaceans (Van Bressem *et al.* 2009), its impact on the health of the stranded animals is not known as it was found in only one tested tissue within each animal (Jacob *et al.* 2016). Beaked whale circovirus has been only recently described in cetaceans, with effects on the brain, lungs, and lymph system that may result in immunosuppression. Its role in the death of the striped dolphin was not clear, although all 6 tested tissues were positive for the disease. The presence of beaked whale circovirus and *Morbillivirus* each in 10 species (Clifton *et al.* 2023, Jacob *et al.* 2016) and *Brucella* in 3 species (Cherbov 2010, West unpublished data) raises concerns about the history and prevalence of these diseases in Hawai'i and the potential population impacts on Hawaiian cetaceans. It is not known if any of these diseases are common in the Hawai'i stock of striped dolphins.

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