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ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Hawai‘i Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Rough-toothed dolphins are found throughout the world in tropical and warm-temperate waters (Perrin *et al*. 2009), with genetic analysis of samples from all ocean basins revealing divergence between rough-toothed dolphins in the Atlantic versus those in the Indian and Pacific Oceans, suggesting the occurrence of two subspecies (Albertson *et al*. 2022). They are present around all the main Hawaiian Islands, though are relatively uncommon within the Maui Nui region (Baird *et al*. 2013), and have been observed close to the islands and atolls at least as far northwest as Pearl and Hermes Reef (Bradford *et al*. 2017). Rough-toothed dolphins are occasionally seen offshore throughout the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands during periodic shipboard surveys (Figure 1). Rough-toothed dolphins have also been documented in American Samoan waters (Oleson 2009).

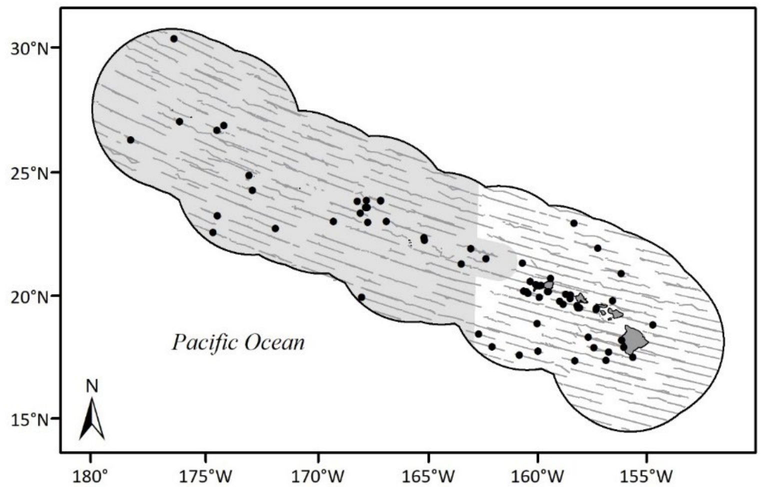

Figure 1. Rough-toothed dolphin sighting locations (circles) and survey effort (gray lines) during the 2002 (Barlow 2006), 2010 (Bradford *et al.* 2017), and 2017 (Yano *et al.* 2018) shipboard cetacean surveys of the U.S. EEZ around the Hawaiian Islands (outer black line). The Papahānaumokuākea Marine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

Population structure in rough-toothed dolphins was recently examined using genetic samples from several tropical and sub-tropical island areas in the Pacific. Albertson *et al*. (2016) found significant differentiation in mtDNA and nuDNA from samples collected at Hawai‘i Island versus all other Hawaiian Island areas sampled. Estimates of differentiation among Kaua‘i, O‘ahu, and the northwestern Hawaiian Islands (NWHI) were lower and not statistically significant. Based on their result, Albertson *et al.* (2016) suggested that Hawai‘i Island warranted designation as a separate island-associated stock. Evaluation of individual rough-toothed dolphin encounters indicate differences in group sizes, habitat use, and behavior between groups seen near Hawai‘i Island and those seen near Kaua‘i and Ni‘ihau (Baird *et al*. 2008). Photographic identification studies suggested that dispersal rates between the islands of Kaua‘i/Ni‘ihau and Hawai‘i do not exceed 2% per year (Baird *et al.* 2008). Resighting rates off the island of Hawai‘i are high, with 75% of well-marked individuals resighted on two or more occasions, suggesting high site fidelity and low population size. Movement data from 17 individual rough-toothed dolphins tagged near Kaua‘i and Ni‘ihau show all individuals remained associated with Kaua‘i with exception of one individual that moved from Kaua‘i and O‘ahu and back (Baird 2016). The available genetics, movements, and social affiliation data suggest that there is at least one island-associated stock in the main Hawaiian Islands (MHI). Delineation of island-associated stocks of rough-toothed dolphins in Hawai‘i is under review (Martien *et al*. 2016).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks: 1) the Hawai‘i Stock (this report), and 2) the American Samoa Stock. The Hawai‘i stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from the U.S. EEZ of the Hawaiian Islands (NMFS 2023a).

POPULATION SIZE

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

Table 1. Line-transect abundance estimates for rough-toothed dolphins in the Hawaiian Islands EEZ in 2002, 2010, 2017, and 2020, derived from NMFS surveys in the central Pacific since 1986 (Becker *et al.* 2022, Bradford *et al.* 2021).

Year	Design-based Abundance	CV	95% Confidence Limits	Model-based Abundance	CV	95% Confidence Limits
2020	-	-	-	83,915	0.49	34,025-206,958
2017	76,375	0.41	35,286-165,309	86,068	0.49	34,857-212,519
2010	74,001	0.39	35,197-155,586			
2002	65,959	0.39	31,344-138,803			

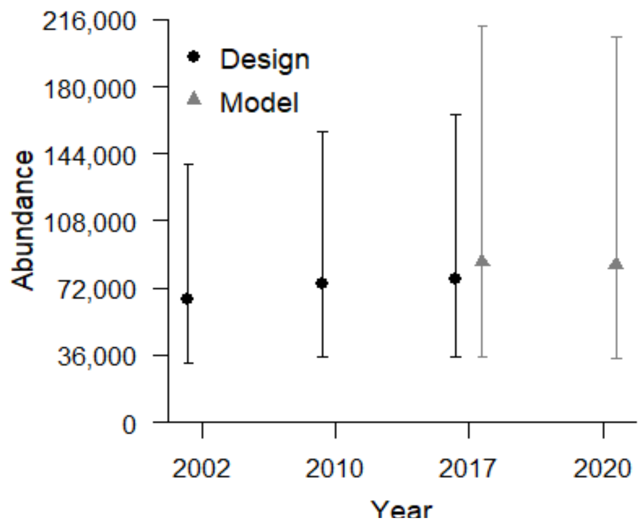

Figure 2. Comparison of design-based (black circles, Bradford *et al.* 2021) and model-based (gray triangles, Becker *et al.* 2021, 2022) estimates of abundance for rough-toothed dolphins for each survey year (2002, 2010, 2017, 2020).

Sighting data from 2002 to 2020 within the Hawaiian Islands EEZ were used to derive habitat-based models of animal density for the 2017 to 2020 period. The models were then 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). The modeling framework incorporated Beaufort-specific trackline detection probabilities for rough-toothed dolphins from Barlow *et al.* (2015). Although model-based estimates were previously derived for years 2002, 2010, and 2017 (Becker *et al.* 2021), those estimates did not include any dynamic environmental covariates, such that they were uninformative for individual survey years. Model-based estimates were derived only for the most recent years (2017-2020), such that direct comparison of model and design-based estimates for the full survey time series is not possible at this time. Bradford *et al.* (2021) produced design-based abundance estimates for rough-toothed dolphins for each full EEZ survey year, with the 2017 design-based and 2017 and 2020 model-based estimates largely similar in the mean estimate and confidence limits (Figure 2). Current model based-estimates are based on the implicit assumption that annual changes in abundance are attributed to environmental variability alone. Explicitly incorporating a trend term into the model is not possible due to the insufficient sample size to test for temporal effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for the most recent survey year. Becker *et al.* (2022) and Bradford *et al.* (2022) evaluated seasonal changes in the abundance of rough-toothed dolphins within the main Hawaiian Islands using summer-fall data from 2017 and winter survey data from 2020 and found no significant difference, with no reliance on dynamic variables within the model-based approach, but roughly 30% higher density in summer-fall (though with broad and overlapping confidence intervals) based on the design-based estimates. Previously published design-based estimates for the Hawaiian Islands EEZ from 2002 and 2010 surveys (Barlow 2006, 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 83,915 (CV=0.49) rough-toothed dolphins.

A population estimate for this species has been made in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. Mark-recapture estimates for the islands of Kaua‘i/Ni‘ihau and Hawai‘i were derived from identification photographs obtained between 2003 and 2006, resulting in estimates of 1,665 (CV=0.33) around Kaua‘i/Ni‘ihau and 198 (CV=0.12) around the island of Hawai‘i (Baird *et al.* 2008). Such estimates may be representative of smaller island-associated populations at those island areas.

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 56,782 rough-toothed dolphins within the Hawaiian Islands EEZ.

Current Population Trend

The available abundance estimates for this stock have broad and overlapping confidence intervals, precluding robust evaluation of population 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.

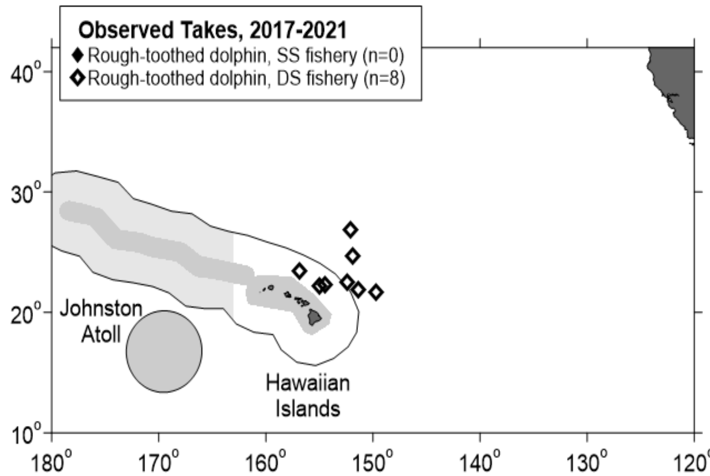

Figure 3. Locations of observed rough-toothed dolphin takes within the deep-set fishery (open diamonds) in the Hawaii-based longline fishery, 2017-2021. Solid lines represent the U.S. EEZ. Gray shading notes areas closed to longline fishing.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaiʻi stock of rough-toothed dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (56,782) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.45 (for a stock of unknown status with Hawaiian Islands EEZ mortality and serious injury rate CV > 0.30; Wade and Angliss 1997), resulting in a PBR of 511 rough-toothed 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. Rough-toothed dolphins are known to take bait and catch from several Hawaiian sport and commercial fisheries operating near the main islands (Shallenberger 1981; Schlais 1984; Nitta & Henderson 1993). They have been specifically reported to interact with the day handline fishery for tuna (palu-ahi), the night handline fishery for tuna (ika-shibi), and the troll fishery for billfish and tuna (Schlais 1984; Nitta & Henderson 1993). Baird *et al*. (2008) reported increased vessel avoidance of boats by rough-toothed dolphins off the island of Hawaiʻi relative to those off Kauaʻi or Niʻihau and attributed this to possible shooting of dolphins that are stealing bait or catch from recreational fisherman off the island of Hawaiʻi (Kuljis 1983). Rough-toothed dolphins have been observed in nearshore waters with serious injuries resulting from fishing gear trailing from or wrapped around their bodies, though the source of the gear was not identified (Bradford and Lyman 2018). Photographs of 52 individuals with greater than 50% of the mouthline photographed showed evidence of injuries consistent with interactions with hook and line fisheries (Welch 2017). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaiʻi: 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, but are prohibited from operating within the Papahānaumokuākea Marine National Monument (PMNM) and within the Longline Exclusion Zone around the main Hawaiian Islands and the Pacific Remote Islands and Atolls (PRIA) MNM around Johnston Atoll. The PMNM originally included the waters within a 50 nmi radius around the Northwestern Hawaiian Islands. In August, 2016, the PMNM area was expanded to extend to the 200 nmi EEZ boundary west of 163° W. Between 2017 and 2021, no rough-toothed dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage), but eight rough-toothed dolphins were observed taken in the DSLL fishery (15-21% observer coverage) (Figure 3, Bradford 2018, 2020, in press, in review,

Table 2. Summary of available information on incidental mortality and serious injury (MSI) of rough-toothed dolphins (McCracken & Cooper 2022b). Mean annual takes are based on 2017-2021 data unless indicated otherwise. 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%	1/0	3 (1.2)	0	0 (-)
	2020		15%	3/2	14 (0.5)	2/2	10 (0.6)
	2021		18%	1/1	5 (0.9)	1/1	6 (0.9)
Mean Estimated Annual Take (CV) 2017-2021					**4.4 (0.5)**		**3.2 (0.6)**
Hawai'i-based shallow-set longline fishery	2017	Observer data	100%	0	0	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**		**0**
Minimum total annual takes within U.S. EEZ (2017-2021)							**3.2 (0.6)**

McCracken & Cooper 2022b). In the DSLL fishery, 5 rough-toothed dolphins were taken outside the U.S. EEZ, including 1 rough-toothed dolphin found dead, 2 considered seriously injured, and 1 considered non-seriously injured based on an evaluation of the observer's description of each interaction and following criteria for assessing serious injury in marine mammals (NMFS 2023b). Inside of the Hawaiian Islands EEZ, 2 were observed dead and 1 determined to be seriously injured.

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 U.S. EEZ), and the ratio of observed dead and seriously injured dolphins 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 rough-toothed dolphins during 2017-2021 are 4.4 (CV=0.5) rough-toothed dolphins outside of the Hawaiian Islands EEZ, and 3.2 (CV=0.6) rough-toothed dolphins within the Hawaiian Islands EEZ (Table 2, McCracken and Cooper 2022b).

STATUS OF STOCK

The Hawai'i stock of rough-toothed dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of rough-toothed dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Rough-toothed dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries related to nearshore fisheries; however, there is no systematic monitoring for interactions with protected species within nearshore fisheries that may take this species, thus total mean annual takes are undetermined. The total number of estimated rough-toothed dolphins killed or seriously injured by longline fisheries inside (3.2) and outside (4.4) of the Hawaiian Islands EEZ is less than 10% of PBR (51), such that the fishery-related mortality or serious injuries rate for the entire Hawai'i stock can be considered to be insignificant and approaching zero. Island-associated populations of rough-toothed dolphins may experience relatively greater rates of fisheries mortality and serious injury. One rough-toothed dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov 2010) and another for *Morbillivirus* (Jacob 2012). *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 *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem *et al.* 2009), its impact on the health of the stranded animal is not known as it was found in only a few tested tissues (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species (Jacob *et al*. 2016) and *Brucella* in 3 species (Chernov 2010) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts, including cumulative impacts of disease with other stressors.

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