Revised 5/5/2021

BRYDE'S WHALE (*Balaenoptera edeni*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bryde's whales occur in tropical and warm temperate waters throughout the world. Leatherwood *et al.* (1982) described the species as relatively abundant in summer and fall on the Mellish and Miluoki banks northeast of Hawaii and around Midway Island. Ohsumi and Masaki (1975) reported the tagging of "many" Bryde's whales between the Bonin and Hawaiian Islands in the winters of 1971 and 1972 (Ohsumi 1977). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 13 Bryde's whale sightings throughout the study area in 2002, 30 in 2010, and 2 in 2017 (Figure 1; Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018). There is currently no biological basis for defining separate stocks of Bryde's whales in the central North Pacific. Bryde's whales were seen occasionally off southern California (Morejohn and Rice 1973) in the 1960s, but their seasonal occurrence has increased since at least 2000 based on detection of their distinctive calls (Kerosky *et al.* 2012).

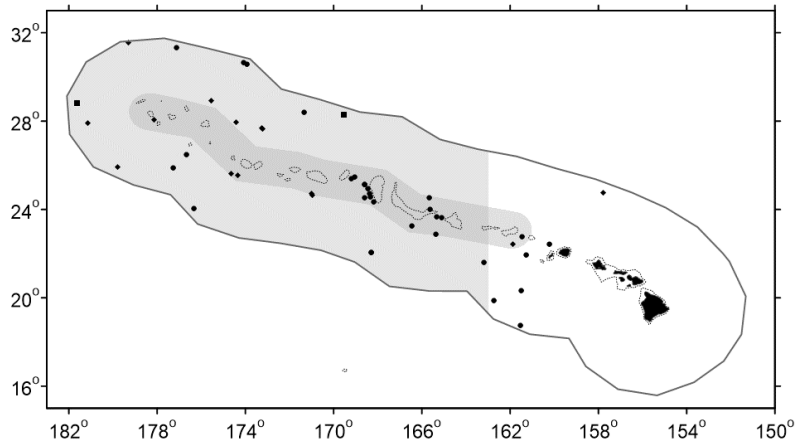

Figure 1. Bryde's whale sighting locations during the 2002 (diamonds), 2010 (circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark gray shading indicates the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

For the MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: 1) Hawaiian waters (this report), and 2) the eastern Pacific (east of 150°W and including the Gulf of California and waters off California). The Hawaiian 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 U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated, resulting in updated model-based abundance estimates of Bryde's whales in the Hawaii EEZ (Becker *et al*. 2021) (Table 1).

Table 1. Model-based line-transect abundance estimates for Bryde's whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker *et al*. 2021).

Year	Model-based Abundance	CV	95% Confidence Limits
2017	602	0.22	397-842
2010	822	0.20	554-1,220
2002	562	0.21	375-842

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall 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 Bryde's whales from Barlow *et al*. (2015). Bradford *et al*. (2021) produced design-based abundance estimates for Bryde's whales for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Bradford *et al*. (2021) found through simulation that the pronounced decrease in the design-based estimates between 2010 and 2017 could not be explained by encounter rate variation alone and likely reflected true changes in distribution of Bryde's whales in the study area between those survey years. The model based-estimates demonstrated a much smaller decrease between 2010 and 2017, but are based on the implicit assumption that changes in abundance are attributed to environmental variability alone. There are insufficient data to include explicitly incorporate a trend term into the model due to the insufficient sample size. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford *et al*. 2017) used a subset of the dataset used by Becker *et al*. (2021) and Bradford *et al*. (2021) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here.

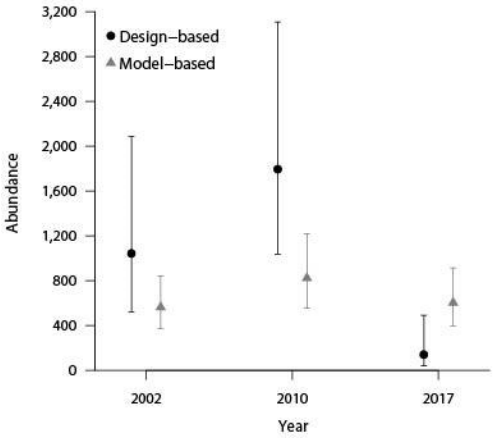

Figure 2. Comparison of design-based (circles, Bradford *et al*. 2021) and model-based (triangles, Becker *et al*. 2021) estimates of abundance for Bryde's whales for each survey year (2002, 2010, 2017).

Tillman (1978) concluded from Japanese and Soviet CPUE data that the stock size in the North Pacific pelagic whaling grounds, mostly to the west of the Hawaiian Islands, declined from approximately 22,500 in 1971 to 17,800 in 1977. An estimate of 13,000 (CV=0.202) Bryde's whales was made from vessel surveys in the eastern tropical Pacific between 1986 and 1990 (Wade and Gerrodette 1993). The area to which this estimate applies is mainly southeast of the Hawaiian Islands, and it is unknown if these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

Minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 abundance estimate, or 501 Bryde's whales.

Current Population Trend

The model-based abundance estimates for Bryde's whales from Becker *et al.* (2021) do not explicitly allow for examination of population trend other than that driven by environmental factors. Although annual encounter rate variation may have a large impact on abundance estimates for species with low density and patchy distribution, Bradford *et al.* (2021) suggest that the very high sighting rate in 2010 and very low sighting rate in 2017 cannot be explained through encounter rate variation alone and that there may be true fluctuations in Bryde's whale abundance within the Hawaii EEZ. Model-based examination of Bryde's whale population trends including sighting data beyond the Hawaii EEZ is 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.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Bryde's whales is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (501) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known

fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 5.0 Bryde's whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: 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 2014 and 2018, no Bryde's whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (18-22% observer coverage) (Bradford 2018a, 2018b, 2020, Bradford and Forney 2017, McCracken 2019). Large whales have previously been observed entangled in longline gear off the Hawaiian Islands (Forney 2010).

Historical Mortality

Small numbers of Bryde's whales were taken near the Northwestern Hawaiian Islands by Japanese and Soviet whaling fleets in the early 1970s (Ohsumi 1977). Pelagic whaling for Bryde's whales in the North Pacific ended after the 1979 season (IWC 1981), and coastal whaling for this species ended in the western Pacific in 1987 (IWC 1989).

STATUS OF STOCK

The Hawaii stock of Bryde's whales is not considered strategic under the 1994 amendments to the MMPA. The status of Bryde's whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Bryde's whales 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 within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson *et al.* 1995, Weilgart 2007).

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