Taiwanese Humpback Dolphin
(*Sousa chinensis taiwanensis*)

5-Year Review:
Summary and Evaluation

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National Marine Fisheries Service
Office of Protected Resources
Silver Spring, MD
2024

5-YEAR REVIEW
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1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office:
Heather Austin, Office of Protected Resources, 301-427-8422
Kiah Matthews, Office of Protected Resources, EPP/MSI Scholar

1.2 Methodology used to complete review

A 5-year review is a periodic analysis of a species' status conducted to ensure that the listing classification of a species currently listed as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 – 17.12) is accurate. The 5-year review is required by section 4(c)(2) of the Endangered Species Act of 1973, as amended (ESA) and was prepared pursuant to the joint National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service's 5-year Review Guidance and Template (NMFS and USFWS 2018). The NMFS Office of Protected Resources (OPR) conducted the 5-year review. Information was updated from the status review report (Whittaker and Young 2018) based on peer-reviewed publications, government and technical reports, conference papers, workshop reports, dissertations, theses, and personal communications. We gathered information through June 2023. The information on the Taiwanese humpback dolphin biology and habitat, threats, and conservation efforts were summarized and analyzed in light of the ESA section 4(a)(1) factors (see Section 2.3.2) to determine whether a reclassification or delisting may be warranted (see Section 3.0).

NMFS initiated a 5-year review of the Taiwanese humpback dolphin and solicited information from the public on May 2, 2023 (88 FR 27451). One public comment was received and incorporated as appropriate in this review.

1.3 Background

1.3.1 FRN Notice citation announcing initiation of this review

88 FR 27451, May 2, 2023

1.3.2 Listing History

<u>Original Listing</u>
FR notice: 83 FR 21182
Date listed: 5/09/2018
Entity listed: *Sousa chinensis taiwanensis*
Classification: Endangered

1.3.3 Associated rulemakings

None

1.3.4 Review History

The initial status review (Whittaker and Young 2018) concluded that the Taiwanese humpback dolphin is at a high risk of extinction and recommended its classification be 'endangered'.

1.3.5 Species' Recovery Priority Number at start of 5-year review

No recovery priority number has been issued for the Taiwanese humpback dolphin.

1.3.6 Recovery Plan or Outline

A recovery plan was not prepared for the Taiwanese humpback dolphin. This is in accordance with NMFS' May 4, 2020 finding that a recovery plan would not promote its conservation as this subspecies occurs entirely in foreign waters (i.e. the territorial waters of Taiwan) and therefore the threats to this subspecies occur under foreign jurisdiction.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy[1]

2.1.1 Is the species under review a vertebrate?

__X_**Yes**
____**No**

2.1.2 Is the species under review listed as a DPS?

_____**Yes**
__X__**No**

2.1.3 Is there relevant new information for this species regarding the application of the DPS policy?

_____**Yes**
__X__**No**

[1] To be considered for listing under the ESA, a group of organisms must constitute a "species," which is defined in section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment [DPS] of any species of vertebrate fish or wildlife which interbreeds when mature". NMFS and USFWS jointly published a policy regarding the recognition of DPSs of vertebrate species under the Endangered Species Act (61 FR 4722, February 7, 1996). "DPS" is not a scientifically defined term; it is a term used in the context of ESA law and policy. Furthermore, when passing the provisions of the ESA that give us authority to list DPSs, Congress indicated that this provision should be used sparingly. We have discretion with regard to listing DPSs and, in order to be consistent with the directive of the Congressional report that followed the introduction of the DPS language in the ESA to identify DPSs sparingly. We will generally not, on our own accord, evaluate listings below the taxonomic species.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan[2] containing objective, measurable criteria?

_____**Yes**
__X_**No**

Not applicable. A recovery plan was not prepared for the Taiwanese humpback dolphin. This is in accordance with NMFS' May 4, 2020 finding that a recovery plan would not promote its conservation as this species occurs entirely in foreign waters (i.e. the territorial waters of Taiwan) and therefore the threats to this species occur under foreign jurisdiction.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history

In this section, we present new information since the initial status review on the Taiwanese humpback dolphin (Whittaker and Young 2018), was completed in 2018.

The Taiwanese humpback dolphin (*S. c. taiwanensis*) is a subspecies of the Indo-Pacific humpback dolphin (*Sousa chinensis*) that is only found in a small, narrow band of estuarine water off the western coast of Taiwan (Whittaker and Young 2018). This subspecies' population is currently estimated to be fewer than 75 individuals and declining (Wang and Araujo-Wang 2018; Taylor *et al.* 2019; Araújo-Wang *et al.* 2022). This subspecies was first described in 2002 during an exploratory survey of coastal waters off of western Taiwan (Whittaker and Young 2018) but did not receive formal description and recognition until 2015 (Committee on Taxonomy 2015; Wang *et al.* 2015). The Taiwanese humpback dolphin is geographically isolated and phenotypically distinguishable from other populations of the species (Brownell Jr *et al.* 2019) and is the only marine mammal that is endemic to the waters of Taiwan (Taylor *et al.* 2019).

Life History

Since the initial status review for the Taiwanese humpback dolphin was completed in 2018, information on the life history parameters for this subspecies remain sparse compared to other small odontocete cetaceans (Taylor *et al.* 2019). This is mostly due to lack of specimens available for direct examination (Taylor *et al.* 2019). Even data resulting from dead, beached individuals can be controversial because the carcasses may not necessarily represent the life history parameters of living individuals (Taylor *et al.* 2019). Additionally, for small populations the number of animals sampled tends to be too small to produce precise estimates of certain parameters (Wang and Araujo-Wang 2018; Taylor *et al.* 2019). Nevertheless, long-term photo-identification of individual Taiwanese

[2] Although the guidance generally directs the reviewer to consider criteria from final approved recovery plans, criteria in published draft recovery plans may be considered at the reviewer's discretion.

humpback dolphins has made it possible to estimate some life history parameters of the living population (Taylor *et al.* 2019).

<u>Survival</u>

The mean apparent survival rate for individually recognizable dolphins (not including calves) from 2007 to 2010 was 0.985 (95% CI=0.832-0.998) (Wang *et al.* 2012b; Taylor *et al.* 2019) and slightly lower from 2011 to 2013 at 0.978 (95% CI=0.92-0.99) (Taylor *et al.* 2019). An updated estimate for survival rates for the Taiwanese humpback dolphin was given by Araújo-Wang *et al.* (2022) – apparent survival rate ranged from a maximum of 0.96 (95% CI [0.92, 0.99]) in 2012 to a minimum of 0.92 (95% CI [0.75, 0.98]) in 2017. Apparent survivorship is likely the same as, or very similar to, actual survivorship because this subspecies is comprised of a very small population where all individuals are known, and no new individuals are being identified (with the exception of the recruitment of young calves) (Taylor *et al.* 2019). Therefore, the identities of recognizable individuals do not change over time; there is no immigration or emigration; and there is a high probability that all living recognizable individuals are photographically identified within 2 years (Taylor *et al.* 2019).

In terms of calf survival, fewer than 3 calves survive annually to the age of one year, with survival of calves declining across the initial three years of life from 0.778 at the age of 6-months to 0.667 at 1 year, 0.573 at 2 years and 0.563 at 3 years of age (Chang *et al.* 2016a; Whittaker and Young 2018). Additionally, Chang *et al.* (2016) hypothesized that the relatively low calf survival observed in the Taiwanese humpback dolphin population is more likely due to anthropogenic factors (e.g., fisheries interactions and habitat destruction) rather than natural causes. Thus, the information on survival rates for this subspecies indicates that it is very limited in terms of its capacity to resist anthropogenic stress (Whittaker and Young 2018; Taylor *et al.* 2019).

<u>Reproduction and Growth</u>

Sexual Maturation

Published information on sexual maturation for the Taiwanese humpback dolphin is lacking. However, direct data from a long-term photo-identification project identified two females as young calves which were then monitored until these individual females produced calves themselves (Taylor *et al.* 2019). The ages of these individual females when first seen with a calf were 11 and 12 years (Taylor *et al.* 2019). If gestation of approximately one year is assumed, these females would have been sexually mature at 10 or 11 years (Taylor *et al.* 2019). It is possible that these two females were sexually mature earlier but had either not been impregnated, had failed pregnancies, or gave birth to calves that did not survive long enough to be photo-identified. However, this age of sexual maturation is similar to what has been reported by Jefferson *et al.* (2011) for the Chinese white dolphin females in Hong Kong (Taylor *et al.* 2019). Furthermore, the photo-identified 11- and 12-year-old Taiwanese humpback dolphin females had a similar coloration pattern to other sexually mature Taiwanese humpback dolphin females of unknown age (e.g. almost entirely gray but with considerable amounts of light spotting) (Taylor *et al.* 2019; J.Y. Wang, unpublished data).

There are no data on the age or coloration of Taiwanese humpback dolphin males at sexual maturity, since this type of information is difficult to obtain as it is virtually impossible to determine in the field when males begin producing sperm (Taylor *et al.* 2019).

Calving Interval

Generally, it has been assumed that the subspecies' experiences long calving intervals, between 3 and 5 years (Jefferson *et al.* 2011; Whittaker and Young 2018). However, data from a long-term photo-identification program in Taiwan, based on observing six calving intervals, suggest a 5- to 6-year calving interval (Taylor *et al.* 2019; J.Y. Wang, unpublished data). Other published studies by Chang (2011), Huang *et al.* (2014), and Chang *et al.* (2016) presented life history parameters using another dataset and found that calving intervals varied from 2.90 ± 1.28 (SD) years to 3.52 ± 0.28 (SD) years. It is important to note that the low estimates from these studies were likely underestimated because the dataset spanned only 4 years; therefore, females with potentially longer calving intervals would not have been observed or recorded (Taylor *et al.* 2019).

A further potential source of bias when estimating calving intervals is that the mothers of young Taiwanese humpback dolphin calves are difficult to identify since calves are very difficult to recognize individually, are almost always found in groups with other mothers and calves, and calves may also have strong bonds with individuals other than their mothers (Taylor *et al.* 2019). Considerable long-term photo-identification and behavioral data are needed for better identification of mother-calf pairs, as errors in assigning mother-calf relationships can greatly affect understanding of the calving interval.

Mother-Calf Association

Jefferson *et al.* (2012) reported that in Hong Kong waters, mother-calf association for the Indo-Pacific humpback dolphin usually lasts about 24 months, but a few individuals associate for 3-4 years and, in one extreme case, for 9 years (this was probably the last offspring of the female) (Taylor *et al.* 2019). However, the association period appears to be longer for the Taiwanese humpback dolphin (Taylor *et al.* 2019; J.Y. Wang, unpublished data). Calves appear to be reared together in groups containing mother-calf pairs and lone mother-calf pairs are very rarely observed (Dungan *et al.* 2016; Taylor *et al.* 2019). Thus, the size of groups is heavily dependent on the presence of mother-calf pairs. No mother-calf pairs are known to have separated after only 2 years, and 3-4 years appears to be the minimum while most continue to associate for approximately 6-7 years (Taylor *et al.* 2019). The longest-lasting observed association was also 9 years (again, probably the females last offspring) (Taylor *et al.* 2019). However, it is important to note that the apparent pattern of longer-duration mother-calf association found in the Taiwanese humpback dolphin does not preclude mothers from having new calves. Females with a new calf have been observed being accompanied by their older offspring, who may contribute to the care of their younger sibling (Taylor *et al.* 2019). Furthermore, given the small population size for the Taiwanese humpback dolphin, there is a relatively high probability for independent young dolphins to be seen in a group that includes their mother, which could increase the chances of prolonged mother-calf associations to be observed (Taylor *et al.* 2019).

Reproductive Output

Information is sparse regarding reproduction of the Taiwanese humpback dolphin and estimating life history parameters for the subspecies has proven difficult over the years due to the lack of carcasses available for study (Whittaker and Young 2018; Taylor *et al.* 2019). In some cases, comparison of the Taiwanese humpback dolphin population with other populations may be appropriate, but one needs to be cautious about making these comparisons, as environmental factors such as food availability and habitat status may affect important rates of reproduction and generation time in different populations (Whittaker and Young 2018). An analysis of life history patterns for individuals in the Pearl River Estuary (PRE) population of *S. chinensis* off the coast of China may offer an appropriate proxy for understanding life history parameters for the Taiwanese humpback dolphin; the PRE population similarly inhabits estuarine and freshwater-influenced environments affected by comparable threats of pollution, as well as industrial development and fishing activity (Jefferson *et al.* 2011; Taylor *et al.* 2019). Life history traits of the PRE population have been reported to be similar to the South African population, *S. plumbea,* suggesting that some general assumptions of productivity can be gathered, even on the genus-level (Jefferson and Karczmarski 2001; Jefferson *et al.* 2011; Whittaker and Young 2018). Maximum longevity for PRE and South African populations are at least 38 and 40 years, respectively; thus, it can be assumed that Taiwanese humpback dolphins experience a similar life expectancy (Jefferson and Karczmarski 2001; Jefferson *et al.* 2011; Whittaker and Young 2018).

Thus, assuming a maximum life span of 40 years for females, age of first reproduction of 10 years and a calving interval of 5 or 6 years, the number of calves produced during the lifetime of an average female would be no more than 5 or 6 because a final birthing even at age 40 would be unlikely to lead to a successfully reared offspring (Taylor *et al.* 2019). Preliminary indications also suggest that female Taiwanese humpback dolphins may not reproduce for the last 5-10 years of their lives (J.Y. Wang, unpublished data), and thus lifetime reproductive potential would be further reduced by one or two calves (Taylor *et al.* 2019). Additionally, it has been noted by Wells *et al.* (2005) that with cetaceans, calves of first-time mothers often have lower survivorship. Considering all these factors, it is logical to assume that an average female produces no more than 3 to 5 calves in a lifetime, and it is unlikely that all offspring survive to reproduce (Taylor *et al.* 2019).

From field observations, Araújo-Wang *et al.* (2022) estimated that, on average, the Taiwanese humpback dolphin population produces approximately two neonates per year, with some years yielding no newborns and some years up to six. These are minimum numbers, as more calves could have been born but died before being photographed in the field. Furthermore, it is important to note that not all neonates will survive to reach adulthood and be recruited into the population. Regardless, it is apparent that Taiwanese humpback dolphins have low reproductive potential, and years with low calf production will result in low recruitment, making this subspecies especially vulnerable to anthropogenic stress.

Maximum Rate of Increase

There are no data on maximum rate of increase specific to the Taiwanese humpback dolphin. However, Moore (2015) estimated intrinsic rate of increase and generation time for the genus *Sousa*. Overall, with variable figures used for final calculations of calving interval, survivorship, time of sexual maturity and reproductive lifetime, the rate of increase is low; approximately 3% per year (Taylor *et al.* 2019). This means that these dolphins can sustain very few deaths in addition to natural mortality. With no human-caused mortality, it would take the Taiwanese humpback dolphin at least 15 years to increase from about 65 to 100 individuals (Taylor *et al.* 2019). Therefore, rapid recovery is impossible and it will likely take years (possibly decades) to confirm a significant and sustained shift in the population's trajectory.

<u>Feeding and Diet</u>

The Taiwanese humpback dolphin is considered a generalist and opportunistic piscivore (Whittaker and Young 2018). While information on this subspecies' foraging behavior and diet is sparse, Taylor *et al.* (2019) notes that direct observations of feeding dolphins showed an opportunistic diet of primarily small (<~30 cm) estuarine fish (e.g. sciaenids, mugilids, congrids, clupeoids, and polynemids). Similar to other humpback dolphin species, neither cephalopods (e.g. octopus, squid) nor crustaceans appear to comprise a noticeable part of this subspecies' diet (Wang and Araujo-Wang 2018; Whittaker and Young 2018; Taylor *et al.* 2019).

While the subspecies has not exhibited the same attraction to fishing vessels as other populations of *Sousa chinensis* (e.g. the PRE population where *S. chinensis* was frequently observed feeding behind bottom trawlers off the coast of Hong Kong before trawling was banned there in 2012) (Taylor *et al.* 2019), some evidence indicates that Taiwanese humpback dolphins may opportunistically feed in proximity to deployed fishing gear (Slooten *et al.* 2013; Wang and Araujo-Wang 2018; Whittaker and Young 2018; Taylor *et al.* 2019). For example, the subspecies has been observed around and behind set gillnets and trawl nets, respectively (Slooten *et al.* 2013; Whittaker and Young 2018; Taylor *et al.* 2019). As is common to the species as a whole, the Taiwanese subspecies uses echolocation and passive listening to find its prey. In general, the prey species of the Taiwanese humpback dolphin is believed to include small fish which are generally not commercially valuable to local fisheries (Wang and Araujo-Wang 2018; Whittaker and Young 2018; Taylor *et al.* 2019).

<u>Social Structure and Behavior</u>

Unlike most other humpback dolphin populations (*Sousa* spp.), which generally have weak social associations in "fission-fusion" societies, the Taiwanese humpback dolphin appears to form stronger, lasting relationships (especially mother-calf pairs) with no apparent segregation into distinct social communities (Dungan *et al.* 2016; Wang *et al.* 2016; Whittaker and Young 2018). Strong associations for *S. c. taiwanensis* (mean half-weight association index (HWI)[3] = 0.14, Chang 2011; mean HWI = 0.12, Dungan *et al.* 2016)), appear unique and likely resultant of a very small population (68–73 individuals[4]; Araújo-Wang *et al.* 2022) in an isolated narrow strip of coastal waters, where individuals have higher probabilities to form groups with the same limited number of potential associates within a restricted spatial range (Chan *et al.* 2023). Additionally, short-term associations in this subspecies, like those similar to the "fission-fusion" structure observed in other humpback dolphin populations, appear to occur on a scale of hours or days, whereas long-term associations among individuals are very stable, lasting for years (Whittaker and Young 2018; Taylor *et al.* 2019). This high social cohesion is most likely related to cooperative calf rearing, wherein raising offspring with the assistance of peers or kin can increase offspring survivorship and thereby increase the fitness of the population (Dungan *et al.* 2016; Whittaker and Young 2018). Calves and their inferred mothers seem to have central positions in the social network, which suggests that mother–calf pairs may be the key underlying factor for overall network structure (Dungan *et al.* 2016; Whittaker and Young 2018; Taylor *et al.* 2019). Adult dolphins without calves form small groups (~3 individuals on average), whereas groups with

[3]Chan *et al.* 2023 measured the strength of dyadic association between individuals with the half-weight association index (HWI), which is commonly used in cetacean studies to reduce potential biases when not all associating individuals were identified even with the best effort (see Lusseau *et al.* 2006 and Whitehead 2008).

[4] Please note that the abundance estimate numbers in the Abstract of the paper by Araújo-Wang *et al.* 2022 are inconsistent with the abundance estimate numbers in the text of Araújo-Wang *et al.* 2022. The abundance estimate numbers in the text are correct, and that is what we are citing to here in this 5-year review (*i.e.*, "a maximum of 73 (95% CI [66, 79]) in 2010 and a minimum of 68 (95% CI [65, 70]) in 2017") (Araújo-Wang, Pers. Comm. 2023).

mother-calf pairs tend to consist of approximately 12 individuals, but groups of more than 40 individuals have been recorded (Taylor *et al.* 2019).

The subspecies' social stability is thought to be an adaptive response to living in a spatially restricted, resource limited environment, with very few remaining individuals with which to associate and where long-term relationships facilitate transmission of important information that can improve fitness (e.g. related to feeding or rearing offspring) (Taylor *et al.* 2019). The estuarine ecosystem off the western coast of Taiwan was almost certainly more productive before the fairly recent, industrialization of the coast and its waters, so it is possible that the present social organization of the Taiwanese humpback dolphin is a result of human impacts on the subspecies and their habitat (Taylor *et al.* 2019).

Movement

Movements of the Taiwanese humpback dolphin have been reported to be fairly rapid across the subspecies range (which is small by cetacean standards) (Taylor *et al.* 2019). One individual was recorded covering a minimum distance of more than half the subspecies' full range within 9 days (Taylor *et al.* 2019). The average minimum linear home range of recognizable individuals is > 70 km, and their average minimum areal home range is > 175 km² (Taylor *et al.* 2019; J.Y. Wang, unpublished data). Additionally, individual dolphins have been observed moving along the length of set and drifting trammel and gill nets, possibly searching for injured or net-entangled fish (Wang and Araujo-Wang 2018).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Until recently, only two scientific estimates of abundance for the Taiwanese humpback dolphin have been reported. The first, based on surveys conducted between 2002 and 2004 using boat-based line-transects to count dolphins, estimated a population size of 99 individuals (CV=52%, 95% CI=37-266) (Wang *et al.* 2007b; Whittaker 2018; Taylor *et al.* 2019). Despite the low precision, the 2007 international workshop on the conservation and research needs of the Taiwanese humpback dolphin population suggested that the true number of individuals may be lower than this estimate (Whittaker and Young 2018; Taylor *et al.* 2019). The second abundance estimate was the result of a reanalysis of population abundance conducted on data collected between 2007 and 2010 using mark-recapture analyses of photo-identification data, and this resulted in more precise annual abundance estimates (Whittaker and Young 2018; Taylor *et al.* 2019). Yearly population estimates from this study ranged from 54 (in 2009) to 74 individuals (in 2010; CV varied from 4% to 13%); these estimates were 25% to 45% lower than those from 2002-2004 (Wang *et al.* 2012a) and appeared to be on a declining trajectory (Araujo-Wang *et al.* 2014; Huang *et al.* 2014; Araújo-Wang *et al.* 2022).

Although a long-term monitoring project has collected annual photo-identification data on these dolphins since 2007, the last demographic study was based on the data collected between 2007 and 2010. Despite information from the modelled decline, there was no direct evidence of decline from the mark–recapture data, and data obtained from 2011 to 2018 had yet to be analyzed. Thus, in 2022, Araújo-Wang *et al.* provided an update on the demographic information and provided a new abundance estimate for the Taiwanese humpback dolphin (Araújo-Wang *et al.* 2022). Araújo-Wang *et al.* (2022) used multistate robust design mark-recapture models fitted under a Bayesian framework to estimate demographic parameters and trends for the population from 2010 to 2018. Differences in these parameters by age category were also explored.

Abundance estimates varied from a maximum of 73 (95% CI [66, 79]) in 2010 and a minimum of 68 (95% CI [65, 70]) in 2017[4]. In the oldest age category, abundance estimates varied from 10 (95% CI [10, 11]) in 2011 to 13 (95% CI [13, 14]) in 2016[5] and showed no discernible trend over time (Araújo-Wang *et al.* 2022). Additionally, modelling indicated that, over time, the abundance of dolphins in the oldest age group remained stable, while the remainder of the population, which included reproductive individuals, experienced a steady decline (Araújo-Wang *et al.* 2022). Additionally, results from the Araújo-Wang *et al.* (2022) study showed that the Taiwanese humpback dolphin population is declining at an estimated rate of about two individuals per year, with this decline being mainly due to the decline of individuals in the 'others' age category, primarily in the breeding population. The estimated number of individuals in this 'others' category of 49 in 2017 is evidence of an alarming decline in the size of the Taiwanese humpback dolphin breeding population of more than 18% since the start of this study in 2010 (Araújo-Wang *et al.* 2022). This decline likely affects the demographic recovery of the Taiwanese humpback dolphin. Because modelling did not detect any declining trend in the abundance of the 'pinkest' (i.e. oldest individuals), the continued decline in annual abundance was driven by a decline in the remainder of the population (excluding young calves). These results are concerning as it shows that the decline is happening in the subset of the population that includes current and future contributors to recruitment (i.e. the 'others' age category). In addition to contributing to recruitment, breeding females with calves are known to play an important role in social interactions and in the maintenance of long-term social stability for this population (Dungan *et al.* 2016; Whittaker and Young 2018; Taylor *et al.* 2019). Consequently, the decline in this portion of the population may affect not only the potential demographic recovery but also disrupt important social interactions, which contribute to reproductive success of other breeding females as well as calf survivorship (Araújo-Wang *et al.* 2022).

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[5] Please note that the abundance estimate numbers for the oldest age category in the Abstract of the paper by Araújo-Wang *et al.* 2022 are inconsistent with the oldest age category abundance estimate numbers in the text of Araújo-Wang *et al.* 2022. The numbers in the text are correct, and that is what we are citing to here in this 5-year review (*i.e.,* "Estimates of the number of dolphins in the 'pinkest' category in Model 2 varied from 10 (95% CI [10, 11]) in 2011 to 13 (95% CI [13, 14]) in 2016") (Araújo-Wang, Pers. Comm. 2023).

Although Taiwanese humpback dolphin survival rates continue to be relatively high (see section 2.3.1.1 and Araújo-Wang *et al.* 2022), as is expected for a long-lived mammal (Taylor *et al.* 2007), the numbers in the Araújo-Wang *et al.* 2022 study were lower than previous estimates (Wang *et al.* 2012) but comparable to other populations of humpback dolphins and similar species in decline. For example, humpback dolphins from Xiamen Bay (China) have a survival probability of around 0.957 (95% CI [0.918, 0.978]; (Chen *et al.* 2018a)), whereas bottlenose dolphins in Doubtful Sound (New Zealand) had adult survivorship of 0.9374 (95% CI [0.9170, 0.9530]; (Currey *et al.* 2008)). However, it has been noted by Araújo-Wang *et al.* (2022), that even with these relatively high survival rates, these populations showed decreasing trends in population size, as a result of serious conservation concerns due to anthropogenic impacts affecting their existence.

Two independent Population Viability Analyses (PVAs) simulated population dynamics for the Taiwanese humpback dolphin under different scenarios of impacts from bycatch mortality and habitat loss/degradation and suggest that the population is declining due to synergistic effects of habitat degradation and detrimental fishing interactions (Araujo-Wang *et al.* 2014; Taylor *et al.* 2019). Both of these PVAs indicated a likely continued decline for the subspecies. Araújo *et al.* (2014) showed the subspecies' population declining under the present scenario at approximately 3% per year, and found that bycatch mortality (particularly when females were removed) had a larger impact on the population's vulnerability than habitat loss. In contrast, the rates of increase determined by Huang *et al.* (2014) varied widely, from a strong decline of -0.113 to a moderate increase of 0.0317. However, the positive population growth rates in Huang *et al.* (2014) were likely due to an assumed high rate of reproduction arising from an unrealistically short calving interval (Taylor *et al.* 2019). Huang *et al.* (2014) found that scenarios of habitat loss had a greater impact on the subspecies' population trajectory than bycatch. However, both authors recognized that the full effects of habitat modification were likely underestimated because sub-lethal effects are poorly understood and so were not included (Taylor *et al.* 2019). Furthermore, the Potential Biological Removal (PBR) value of one individual every 7-7.6 years (see Slooten *et al.* 2013 and Wang and Araujo-Wang 2018), showed that even minimal human-induced mortality poses a great risk to the continued existence of this subspecies.

The authors note that while genetic data is lacking for the Taiwanese humpback dolphin, their low population size is well below the minimum number necessary (i.e., at least 250 adults; see Whittaker and Young 2018 and Huang *et al.* 2014) for marine mammals to resist stochastic genetic diversity loss. Consequently, if genetic data were available, the authors assumed their results would likely generate predictions of higher extinction risk than what they reported (Huang *et al.* 2014; Whittaker and Young 2018; Taylor *et al.* 2019). Thus, there is evidence to suggest that the population is small, and rates of decline are high, unsustainable, and potentially even underestimated.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

We found no new information on the genetics or genetic variation of the subspecies. However, it has been noted by Whittaker and Young (2018) and reaffirmed by Taylor *et al.* (2019) that the Taiwanese humpback dolphin's low population size is below the minimum number necessary (i.e. at least 250 adults; see Huang *et al.* 2014) for marine mammals to resist stochastic genetic diversity loss.

2.3.1.4 Taxonomic classification or changes in nomenclature:

There has been no change in taxonomic classification or nomenclature since the initial status review on the subspecies was completed in 2018 (Whittaker and Young 2018).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

Taiwanese humpback dolphins are confined to the coastal waters of central western Taiwan (Wang and Araujo-Wang 2018; Taylor *et al.* 2019; Figure 1). The subspecies' known distribution includes roughly 750 km^2, but their primary distribution occupies ~330 km^2 in a strip of water 110 km long, from the estuaries of the Houlong and Jhonggang rivers (Miaoli County) in the north to Jiangjyun Harbor (Tainan City) in the south (Wang and Araujo-Wang 2018; Taylor *et al.* 2019; Figure 1). The Taiwanese humpback dolphin is generally found in higher densities in and adjacent to major estuaries in waters 5 to 8 meters deep, although they can be seen in waters less than 1 meter deep (Wang and Araujo-Wang 2018; Taylor *et al.* 2019). They are rarely seen in waters deeper than 20 meters, except in shipping channels that have been artificially deepened (Wang and Araujo-Wang 2018; Taylor *et al.* 2019).

Most documented sightings occur within 3 km of shore, and in waters less than 20 meters deep, but a few individuals have been sighted crossing deeper (>30m), dredged, shipping channels leading to/from the ports of Taichung Harbor and Mailiao Industrial Park (Dares *et al.* 2014; Wang and Araujo-Wang 2018). Dolphin schools have been frequently sighted parallel to the coastline just off the surf zone and around (or over) sandbars (when the tides permit) (Dares *et al.* 2014; Wang and Araujo-Wang 2018). Most individuals within the subspecies have been sighted in and around major estuaries of western Taiwan such as the Dadu River (Taichung City/Changhua County) (Wang and Araujo-Wang 2018). Recently, however, there have been a few confirmed sightings of this subspecies much further north (in the waters of Taoyuan County) (Wang, Pers. Comm. 2023), and survey data from Chou *et al.* 2019 have also confirmed that this subspecies inhabit waters farther north in suitable habitat identified by Ross *et al.* (2010). Additionally, a single dolphin was observed at the mouth of Fugang Harbor (Taitung County) where adjacent waters are deep and oceanic (which are not the preferred habitat of any humpback dolphins) (Wang and Araujo-Wang

2018). However, it was determined that this individual was a vagrant as it was observed on one day and was never seen again (Wang and Araujo-Wang 2018).

A recent study by Araújo-Wang *et al.* 2022, found that spatial heterogeneity of the subspecies indicates that some areas (with consistently high occurrences) likely represent important areas for biological functions (i.e. still-functioning estuaries, which have been suggested as an important factor for the presence of the Taiwanese humpback dolphin (Whittaker and Young 2018; Dares 2019)). Considerable variation in the temporospatial distribution patterns of the Taiwanese humpback dolphin off of the Yunlin County coast of Taiwan was recently shown to be associated with rapid changes in local environmental factors, including turbidity, pH, water depth, and construction activities (Lin and Chou 2021). For example, Lin and Chou (2021) noted that drastic changes observed in turbidity and pH coincided with the dolphins temporarily abandoning their usual habitat. In addition, in 2017, a submarine cable was laid from Penghu to southern Yunlin and it is speculated that related construction activities may have led to the dolphins abandoning the habitat by 2018 (Lin and Chou 2021). However, it is not known yet if the dolphins will return. Thus, the aforementioned environmental factors could play key roles on dolphin distribution patterns, and serve as good indicators for habitat suitability for this vulnerable subspecies (Lin and Chou 2021).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Suitable habitat for the Taiwanese humpback dolphin extends from slightly south of the subspecies' currently confirmed distribution (see Figure 1) all the way to the northern tip of Taiwan (Ross *et al.* 2010; Taylor *et al.* 2019). Water depth, access to inshore estuarine waters, chlorophyll-*a* concentration, and the distribution and availability of prey species, are likely the main factors that underpin habitat use and distribution of this subspecies (Ross *et al.* 2010; Huang *et al.* 2018; Whittaker and Young 2018; Taylor *et al.* 2019). The input of freshwater to the habitat is thought to be important in sustaining estuarine productivity, and thus supporting the availability of prey for the dolphins (Huang *et al.* 2018; Whittaker and Young 2018). Across the Taiwanese humpback dolphin's habitat, bottom substrate consists of soft sloping muddy sediment with elevated nutrient inputs primarily influenced by river deposition (Whittaker and Young 2018). Huang *et al.* (2018) notes that chlorophyll-*a* concentration was the primary factor affecting distribution of the Taiwanese humpback dolphin, asserting that significant decreases in chlorophyll-*a* indicates reduced ecosystem productivity and an insufficient capacity of prey resources to support a large humpback dolphin population, which may contribute to changing distribution patterns of this subspecies.

Taylor *et al.* (2019) notes that the highest observed densities of the Taiwanese humpback dolphin have been in waters influenced by the Dadu River estuary, with no evidence of large seasonal movements (Wang and Yang 2011; Dares *et al.* 2017). This is largely because elevated nutrient inputs primarily from freshwater river input, support high primary production, which fuels upper trophic levels contributing to the dolphin's source of food and availability of inshore, estuarine prey (Taylor *et al.* 2019). It has also been noted by Taylor *et al.* (2019) that even though considerable differences in water temperature and other environmental parameters exist between wet and dry seasons, the overall pattern of habitat use does not appear to differ seasonally for this subspecies. The

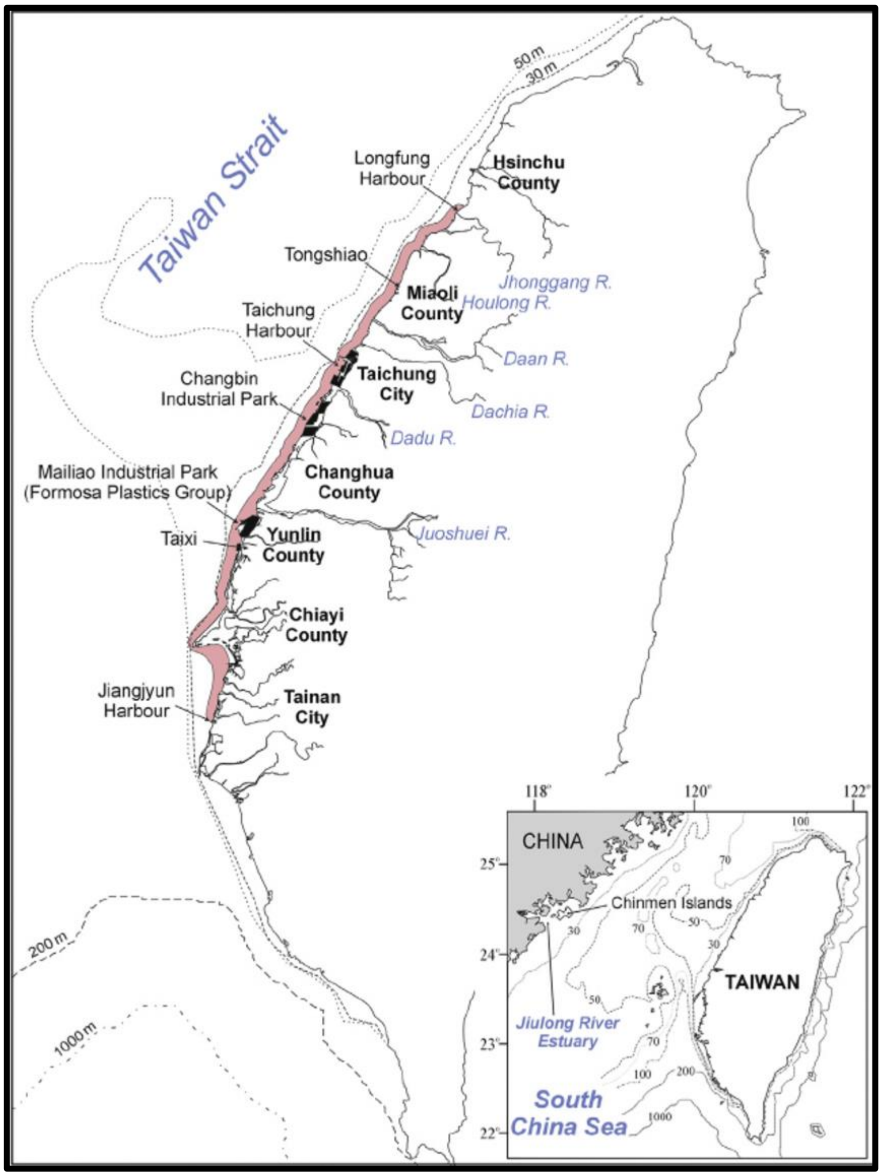


Figure 1. Distribution map of the Taiwanese humpback dolphin (pink shaded area). Large-scale industrial development projects over coastal waters are represented by black irregularly shaped polygons (Source: Wang and Araujo-Wang 2018).

characteristics defining distribution and habitat use of the Taiwanese humpback dolphin are similar to those of other humpback dolphin populations (Whittaker and Young 2018).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Existing threats to the Taiwanese humpback dolphin's habitat are increasing, which include coastal development and land reclamation activities, freshwater diversion, and contamination and pollution (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022, Ministry of Economic Affairs, 2023). Additionally, potential new threats to the subspecies are emerging with the increased construction of wind farms in the dolphins limited coastal water habitat, (i.e. the potential for contamination and pollution from the cleaning, operation, and maintenance of the wind turbines, and shifts in human use of the subspecies' habitat, such as fishing and ship traffic) (Ross *et al.* 2018; Taylor *et al.* 2019; Wang, Pers. Comm. 2024).

Coastal Development and Land Reclamation
The Taiwanese humpback dolphin is an obligatory shallow water inshore species known for its restricted distribution and narrow habitat selectivity. Thus, degradation of coastal habitats can have significant consequences for the subspecies' population, including impacts to persistence and distribution of the subspecies (Whittaker and Young 2018). Similar to other estuarine habitats, the Taiwanese humpback dolphin is negatively impacted by highly concentrated human activity. Out of Taiwan's human population of 23 million, approximately 90% live in counties bordering the west coast of Taiwan, which is adjacent to the Taiwanese humpback dolphin's habitat (Whittaker and Young 2018; Taylor *et al.* 2019). In addition to the high human population density, the west coast of Taiwan continues to experience persistent industrial development and reclamation activities which continue to destroy and degrade the estuarine habitat upon which the Taiwanese humpback dolphin depends (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022).

Over the past century, the west coast of Taiwan has been rapidly industrialized. Between 1995 and 2007, 20% of the Taiwanese humpback dolphin habitat was lost as the coastline was altered by erosion and for flood control, fishing ports, power plants and other public facilities (Taylor *et al.* 2019). To relieve pressures on agricultural and residential land needs, multi-purpose industrial areas were built over coastal waters (i.e. through land reclamation activities), directly reducing and degrading dolphin habitat (Taylor *et al.* 2019). As of 2007, 59 large-scale industrial projects were underway or already completed (including the Mailiao Industrial Park, Changbin Industrial Park, and Taichung Harbor) (Taylor *et al.* 2019).

More recently, Taiwan is overseeing the construction of one of the largest offshore wind energy projects in the world (Araújo-Wang *et al.* 2022). The proposed projects occur in the shallow coastal waters off western Taiwan, with a long-term target to supply at least 3,500 megawatt (MW) by the year 2025; an additional 5,000 MW is also planned by 2030 with an estimated 1,000 MW to be added annually thereafter (Ross *et al.* 2018; Taylor *et al.* 2019; Dearden 2020). The wind turbine installations will entail at least 1,000 turbines that border or overlap the Taiwanese humpback dolphin's habitat (3 km from shore) (see Figure 2) (Ross *et al.* 2018; Taylor *et al.* 2019). As of August 2019, two turbines and the base structures for 20 more have been installed offshore of Miaoli County in Taiwan (Taylor *et al.* 2019). This project may cause temporary or permanent hearing loss (especially during the construction phase if the animal is close enough to the pile or exposed for long durations), resulting in direct habitat loss and deterioration, behavioral disturbance (e.g., avoidance, cessation of feeding), and temporary displacement from important areas (Ross *et al.* 2018; Taylor *et al.* 2019; Wright *et al.* 2020; Araújo-Wang *et al.* 2022). Since sound is capable of transmitting readily over large distances underwater, the construction of wind turbines could have concerning impacts on the Taiwanese humpback dolphin (Ross *et al.* 2018), especially given the significant overlap of the offshore wind farms and the dolphin's priority habitat. Wind farms can also result in shifts in human use of the Taiwanese humpback dolphin's habitat, such as fishing and ship traffic (Taylor *et al.* 2019). If fishing effort is displaced away from the vicinity of the wind farms and into nearshore habitat, this could both increase the dolphins' risk of entanglement in gill and trammel nets and reduce their food supply because of competition with intensified fishing (Taylor *et al.* 2019). These impacts can increase stress levels and significantly impact the health and resilience of the Taiwanese humpback dolphin (e.g. Wright *et al.* 2007). Moreover, Araújo-Wang *et al.* (2022) note that synergistic effects of these new impacts with existing threats may be considerable and a catalyst for accelerating the dolphins' extinction. A study by Huang (2022), that obtained sighting rates from boast-based line-transect surveys, noted that there had been a decrease in sighting rates after offshore wind farm installations, indicating reduced utilization of a once-important habitat. This study also notes that offshore wind farm construction may influence Taiwanese humpback dolphin prey abundance and composition, specifically soniferous fish which are important prey for this subspecies. Huang (2022) also notes that the cumulative impact of low-frequency noise from operating turbines may mask the choruses of soniferous fishes and alter their vocal activity, which could compromise the feeding success of humpback dolphins. Additionally, offshore wind farm construction can cause acute stress to the Taiwanese humpback dolphin from piling noise; while operational noise may mask the chorus of prey fish (Huang 2022).

Currently, there are many projects being proposed off the west coast of Taiwan. These coastal development projects include wind farm development in and adjacent to the Taiwanese humpback dolphin habitat, expansion of the Taichung Port for a Liquefied Natural Gas (LNG) terminal, expansion of several power plants along the coast, and construction of a large LNG facility in Taoyuan on land and waters of suitable Taiwanese humpback dolphin habitat, where recent sightings of the subspecies have been confirmed (Taylor *et al.* 2019). All of these coastal development projects are further degrading the quantity and quality of the remaining confirmed and suitable habitat for the Taiwanese humpback dolphin (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022). The expansion of one of Taiwan's largest ports, Taichung Port, via the Taichung Outer Port Area Expansion Project, is particularly concerning, since it is located in the middle of the Taiwanese humpback dolphin's habitat, and situated on the current north shore of the Dadu Estuary (an area where this subspecies is commonly sighted) (Wang, Pers. Comm. 2024) (Reeves *et al.* 2023). The Dadu Estuary is already very degraded and reduced by the Taichung Port, which was built in the 1970s, and used to have a wider north shore, but is now bordered by the concrete walls of a thermal/coal power plant connected to the Taichung Port (Wang, Pers. Comm. 2024; Port of Taichung) (see Figure 3).

As with prior port construction, this project will involve land reclamation, a process that destroys nearshore marine and river mouth habitat, and in this case almost directly in the center of the subspecies distribution (Araújo-Wang *et al.* 2022; Animal Welfare Institute 2023; Reeves *et al.* 2023). Additionally, the expansion would force this subspecies further offshore as they attempt to travel to and from waters north and south of Taichung Port (Animal Welfare Institute 2023).

Moreover, the threat of coastal development due to offshore wind farm projects is increasing within the Taiwanese humpback dolphin's habitat (Ministry of Economic Affairs 2023). For example, to meet future domestic green energy demand and support the development of local industry supply chains, the Ministry of Economic Affairs plans to release offshore wind capacity of 15 gigawatt (GW) per year from 2026 to 2035 and continues to steadily promote the next phase of their development project of offshore wind installations (Ministry of Economic Affairs 2023). Additionally, there have been no measurable reductions of the threat of coastal development to the dolphins or their habitat, even though the population is very small, has a restricted distribution, and is declining (Araújo-Wang *et al.* 2022).

Freshwater Diversion

The Taiwanese humpback dolphin is dependent upon freshwater inflow to support the productivity and ecosystem health of its estuary habitat (Whittaker and Young 2018). Reductions in freshwater flow affect this subspecies mainly through reductions in estuarine prey (Taylor *et al.* 2019). In Taiwan, freshwater flow from all major rivers to estuaries has decreased by as much as 80% due to anthropogenic diversion (Ross *et al.* 2010; Whittaker and Young 2018). Freshwater flow continues to be reduced by dams, flood control, and river diversions related to industrial development and diversion for agricultural, municipal, and residential purposes (Ross *et al.* 2018; Taylor *et al.* 2019). Several major rivers along the west coast of Taiwan have been diverted in their upstream sections to provide water for agriculture, industry, power generation and household use (Taylor *et al.* 2019). This continued reduction of freshwater flow reduces soft-bottom habitat and sedimentation occurring in the estuaries and

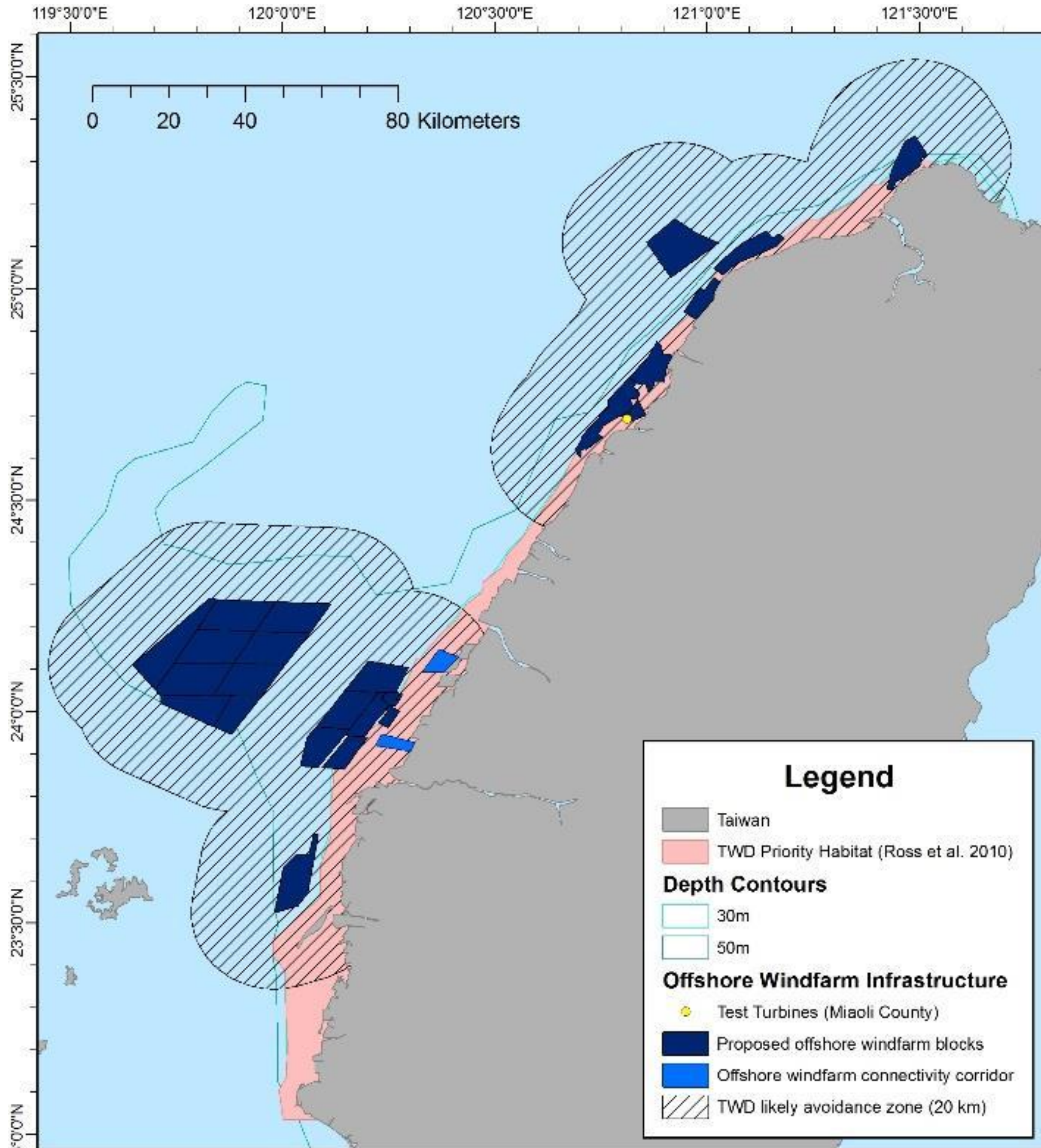


Figure 2. The location of proposed wind farm blocks and designated priority habitat of the Taiwanese humpback dolphin and the 20 km zone within which noise from construction of the wind turbines (if unmitigated) can affect dolphins and other cetaceans. Wind farm blocks that overlap with and are closest to priority Taiwanese humpback dolphin habitat are of particular concern, as standard noise mitigation techniques may not be sufficient to prevent negative impacts (e.g. from percussive pile driving). (Source: Ross *et al.* 2018).

Figure 3. Taichung power plant and artificial shoreline as observed in 2012 (left) and 2013 (right). Photographs by: Dr. John Y. Wang / CetAsia Research Group Ltd. The copyrights of these photographs do not belong to NOAA/NMFS, so any use or redistribution requires the express consent of the photographer to which the copyright belongs.

coastal areas where the subspecies' population occurs. This has resulted in continued widespread loss of estuarine mudflat habitat, known to be vital to Taiwanese humpback dolphin foraging and productivity (Ross *et al.* 2018; Whittaker and Young 2018; Taylor *et al.* 2019). Moreover, there have been no measurable reductions to the threat of freshwater diversion to the dolphins' habitat, even though the population is very small, has a restricted distribution and is declining (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022).

Contamination/Pollution

Habitat contamination and pollution continue to pose a threat to the health of the Taiwanese humpback dolphin (Taylor *et al.* 2019). The coastal regions bordering the Taiwanese humpback dolphin's habitat have a wide variety (and high concentration) of industrial complexes, including petroleum oil storage facilities, petrochemical plants, harbor-fueling stations and thermal (coal) power plants (Taylor *et al.* 2019). Due to the concentrated industrial and human activity, high levels of pollution are discharged into the habitat of the Taiwanese humpback dolphin and directly affect the quality of habitat for the subspecies and their prey (Ross *et al.* 2018; Whittaker and Young 2018; Taylor *et al.* 2019). Sources of these pollutants include marine boat repair, fish processing, fueling stations, ship dumping, pipeline leakage, municipal and residential waste, industrial effluent, and livestock runoff (Ross *et al.* 2010; Ross *et al.* 2018). The discharge of toxic pollutants into coastal waters of Taiwan remains largely unregulated (Taylor *et al.* 2019).

Currently, little is known about the impacts of chronic exposure to contaminants on Taiwanese humpback dolphins. Ingestion of contaminated prey is the main vector for exposure to pollutants, but the dolphins also inhale airborne contaminants in an area where air quality is frequently extremely poor and are exposed to water-borne contaminants through their skin (Taylor *et al.* 2019). Heavy metals and persistent organic pollutants are particularly damaging because they can accumulate in tissues to levels that can compromise cetacean health, and are associated with carcinogenic and teratogenic properties (Haraguchi *et al.* 2000; Simmonds *et al.* 2002; Whittaker and Young 2018; Taylor *et al.* 2019). This may pose a substantial concern to the Taiwanese humpback because the largest reintroduction of these materials into the ocean environment happens during the construction phase of offshore wind farm development (during dredging and pile driving) (Ross *et al.* 2018). Furthermore, during offshore wind farm operation, contaminants may be introduced through the scouring of any contaminated hard substrate (such as concrete containing coal ash) added to provide protection to the pile itself (Ross *et al.* 2018). The large proportion of Taiwanese humpback dolphin habitat that might be affected by these contaminant sources is a substantial concern, and the subspecies may have a reduced ability to withstand such exposure (Ross *et al.* 2018; Taylor *et al.* 2019). Moreover, it is not uncommon to encounter large groups (the largest reported was 41 individuals, see Dares *et al.* 2014) of Taiwanese humpback dolphins, which means that any additional point source pollution within their restricted range may have impacts on a disproportionate number of animals (Ross *et al.* 2018).

Summary
Habitat threats remain a substantial concern and are increasing in scope and scale, especially in regards to the construction of planned offshore wind farms within the subspecies' restricted range. Additionally, potential new threats to the subspecies are emerging from the construction of wind farms in the dolphins limited coastal water habitat (Ross *et al.* 2018; Taylor *et al.* 2019). Widespread industrial, municipal, agricultural, and residential development has resulted in extensive land reclamation, pollution, and freshwater diversion, all of which continue to degrade and eliminate the subspecies' natural estuarine habitat, which is restricted to a small area off western Taiwan (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022). Habitat fragmentation resulting from these activities continues to have serious implications for the subspecies, particularly due to the cohesive nature of the population and reliance on undisturbed dynamics of mother-calf groups (Taylor *et al.* 2019; see section 2.3.1.1). These activities have exhibited increasing trends over the past several decades, with little to no indication that these activities will cease in the foreseeable future (Taylor *et al.* 2019; Araújo-Wang *et al.* 2022). The impacts of these threats on the Taiwanese humpback dolphin will likely continue and intensify in the foreseeable future. Thus, the best available scientific and commercial data indicate that existing habitat threats in the form of coastal development, freshwater diversion, and contamination and pollution coupled with the emergence of potential new threats from offshore wind farm developments significantly affect overall population recovery.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

No threats related to overutilization have been identified for this subspecies since it was listed in 2018 (83 FR 21182, May 9, 2018).

Whale and Dolphin Watching
The development of boat-based whale and dolphin watching tours and recreational observation of marine mammals off the coast of Taiwan continues to occur (Taylor *et al.* 2019). However, it is unlikely that these activities are a threat to the Taiwanese humpback dolphin. Yet, some tours targeting the Taiwanese humpback dolphin have been permitted to operate despite recommendations against any boat-based dolphin watch tour targeting the subspecies (Wang *et al.* 2007a; Whittaker and Young 2018). Therefore, while whale watching tours on their own are unlikely to pose a significant threat to this subspecies, any additional stressor on the population likely acts synergistically with other more prominent threats and has the potential to negatively affect the Taiwanese humpback dolphin (Taylor *et al.* 2019).

Scientific Monitoring
It is also unlikely that scientific monitoring has a negative impact on the Taiwanese humpback dolphin. The dolphin was only first observed in 2002, and since then several scientific surveys have sought to characterize its status and abundance (Whittaker and Young 2018; Taylor *et al.* 2019). The low frequency of these surveys, and reliance on non-invasive photo identification, are also unlikely to pose serious threats to the subspecies.

Summary
Overutilization for commercial, recreational, scientific, or educational purposes in the form of boat-based whale and dolphin watching tours and scientific monitoring activities do not currently pose a significant threat this subspecies, but could become so in the future (Whittaker and Young 2018; Taylor *et al.* 2019). However, we acknowledge that while whale and dolphin watching activities may cause relatively lower levels of stress on their own, they can act synergistically with other more prominent threats. Scientific monitoring, which predominantly utilizes non-invasive photo identification, is unlikely to affect the subspecies and has the potential to aid population recovery as it helps elucidate abundance and distribution trends, and life history parameters of the living population.

2.3.2.3 Disease or predation:
Disease
Increased interaction with anthropogenic activity, and close proximity to Taiwan's dense human population, can put the Taiwanese humpback dolphin at a greater risk of pathogen exposure (Taylor *et al.* 2019; Ho *et al.* 2023). This negative interaction has been directly observed in this subspecies in a recent study conducted by Ho *et al.* (2023), which visually assessed and quantified the prevalence of skin marks in the *S. c. taiwanensis* population along the coasts of central Taiwan. Skin mark prevalence may be an indicator of environmental or anthropogenic stressors in the ecosystem, which could lead to individual and/or population-level health concerns (Ho *et al.* 2023). 50, 28, and 34 individuals were identified in 2018, 2019, and 2021, respectively (Ho *et al.* 2023). At least one category of skin lesion was observed in 33 of 57 distinctive individuals (58%),

and a high prevalence of skin lesions was found in mature individuals (Ho *et al.* 2023). The prevalence of skin lesions was 62% (31/50) in 2018, 39% (11/28) in 2019, and 41% (14/34) in 2021 (Ho *et al.* 2023). Among the 57 distinctive individuals, the prevalence of the six categories of skin lesions was as follows: nodules (51%), orange/yellow patch (44%), hypertrophic scars (30%), barnacles (12%), white patch (2%), and black patch (2%) (Figure 4 and Table 1). Skin lesions may be viral, fungal, or bacterial in origin, but nodules (noted as the most prevalent skin lesion in each year and presented as circumscribed and swollen skin lumps) are potentially caused by fungal or bacterial infections (Ho *et al.* 2023). Specifically, the known potentially etiological agents of skin nodules in odontocetes include fungi (*Lacazia loboi*, *Fusarium* spp., *Paracoccidioides brasiliensis*, and *Trichophyton* spp.), the bacteria *Streptococcus iniae*, and papillomaviruses. Bottlenose dolphins (*Tursiops truncatus*) infected by *L. loboi* from the Indian River Lagoon, Florida, demonstrated marked impairment in adaptive immunity that can be potentially related to prolonged exposure to these environmental stressors (Reif *et al.* 2009; Ho *et al.* 2023). On the other hand, the salinity and temperature fluctuations of water also play their role in susceptibility to infection (Reif *et al.* 2009).

While there have not been any direct observations of parasites in the Taiwanese humpback dolphin, a handful of parasites have been identified that affect the Indo-Pacific humpback dolphin (*S. chinensis*). Internal parasites include the nematode *Anisakis alexandri* and *Halocerus pingi*, which affect the stomach and liver, respectively (Whittaker and Young 2018). Additionally, a recent study conducted by Li *et al.* (2021) which summarized the postmortem investigations of 73 cetaceans stranded off the coast of Taiwan between 2001 and 2013 (including 51 Delphinidae) found severe parasite infestation in 36 (i.e. 49%) of the cases. Additionally, this study noted that the prevalence of severe parasite infestation of stranded cetaceans in Taiwan (49%) was higher compared to studies within Hong Kong waters (Parsons and Jefferson 2000; Li *et al.* 2021). Previous studies in cetaceans and humans have indicated that compromised immune function may increase the susceptibility to parasite infestation (Siebert *et al.* 1999; Tourchin *et al.* 2002; Evering and Weiss 2006). While the Taiwanese humpback dolphin was not included in this study, and direct observations of parasites within this subspecies remain absent, the results of Li *et al.* (2021) imply that cetacean populations around Taiwanese waters may face a level of stress that could compromise their immune function (Chen *et al.* 2018b; Marsili *et al.* 2019; Li *et al.* 2021).

Documented evidence stated that cetaceans in the Taiwanese region have comparatively lower levels of polychlorinated biphenyls (PCBs), mercury (Hg), and polybrominated diphenyl ethers (PBDEs) (Chen *et al.* 2002; Chou *et al.* 2004; Ko *et al.* 2014; Ho *et al.* 2023), but later it was proven that these water bodies are contaminated with heavy metals such as silver (Ag) and Cadmium (Cd), which are potential health threats (Chen *et al.* 2017; Li *et al.* 2018a; Li *et al.* 2018b). The higher prevalence of skin lesions in this study provides important supporting evidence for the bioaccumulation of pollutants (Ho *et al.* 2023). A greater prevalence of skin lesions was found in mature animals, and a moderate-to-low prevalence of skin lesions was found among immature animals (Ho *et al.* 2023; Figure 5). Similar findings were reported in a previous study conducted between 2006 and 2010 on the whole population (Yang *et al.* 2013). Furthermore, the prevalence of skin lesions from Ho *et al.* (2023) was higher compared to a previous study conducted (from calf to unspotted: 7.7%, 32%, 37.9%, 92.3%, and 75% in Yang *et al.* (2013) versus 10%, 24%, 88%, 100%, and 100% in Ho *et al.* (2023)), indicating potentially significant health risks in this population. Taiwanese humpback dolphin lesion prevalence and severity can be influenced by environmental factors, such as sea surface temperature and salinity, and anthropogenic influences, including chemical pollutants (Ho *et al.* 2023). Thus, the moderate-to-high prevalence of skin lesions in this study is designated as a warning of risks to the subspecies (Ho *et al.* 2023). However, direct impacts of increased pathogen exposure and immune health remain unknown.

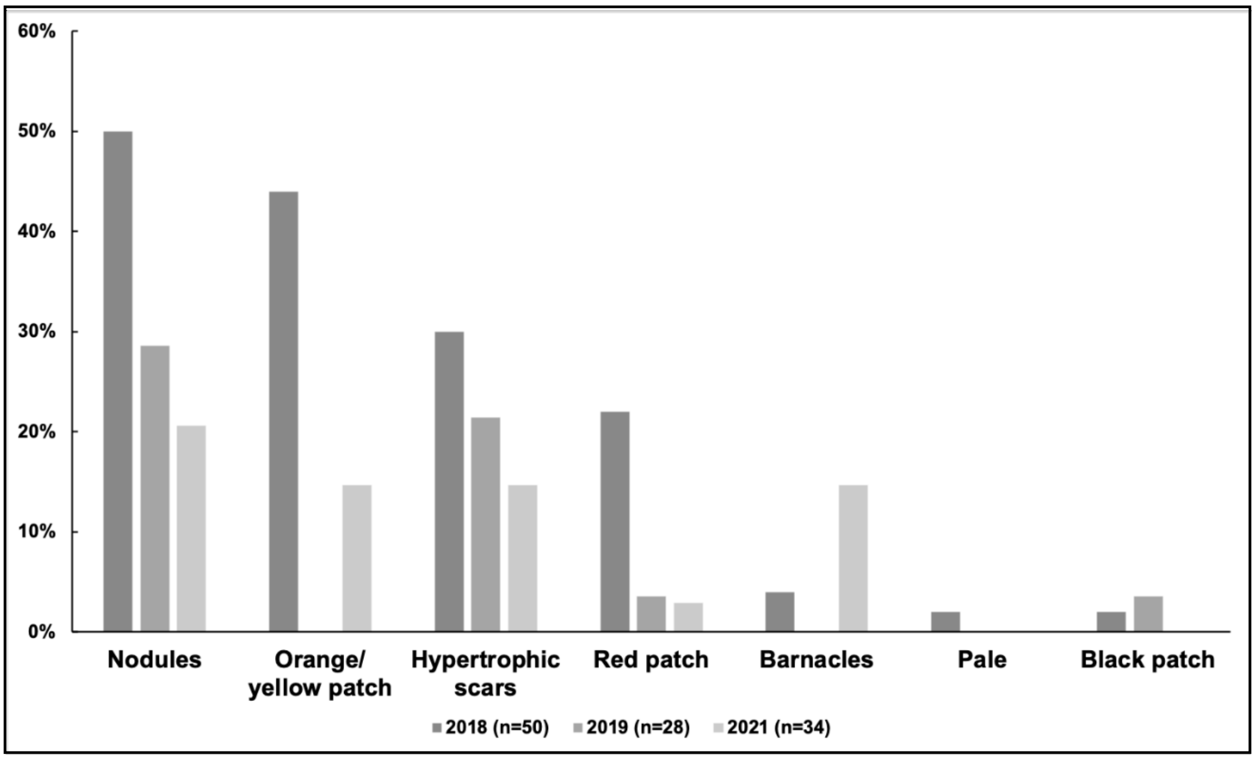


Figure 4. The prevalence of different skin lesion categories in each year (n = 50, 28, and 34). *Source:* Ho *et al.* 2023.

Table 1. Prevalence of skin lesions in 2018, 2019, and 2021. *Source*: Ho *et al.* 2023.

Stage (n = 2018, 2019, 2021)	Nodules	Orange/Yellow Patch	Hypertrophic Scars	Red Patch	Barnacles	Pale	Black Patch
Calf (n = 5,3,8)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(1,0,0)	(0,0,0)
Mottled stage (n = 16,7,11)	(1,1,1)	(2,0,1)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0,0,0)
Speckled stage (n = 15,10,10)	(11,4,2)	(9,0,3)	(5,4,3)	(6,0,1)	(0,0,4)	(0,0,0)	(1,1,0)
Spotted adult (n = 12,7,5)	(11,3,4)	(9,0,1)	(9,2,2)	(5,1,0)	(1,0,1)	(0,0,0)	(0,0,0)
Unspotted adult (n = 2,1,0)	(2,0,0)	(2,0,0)	(1,0,0)	(0,0,0)	(1,0,0)	(0,0,0)	(0,0,0)

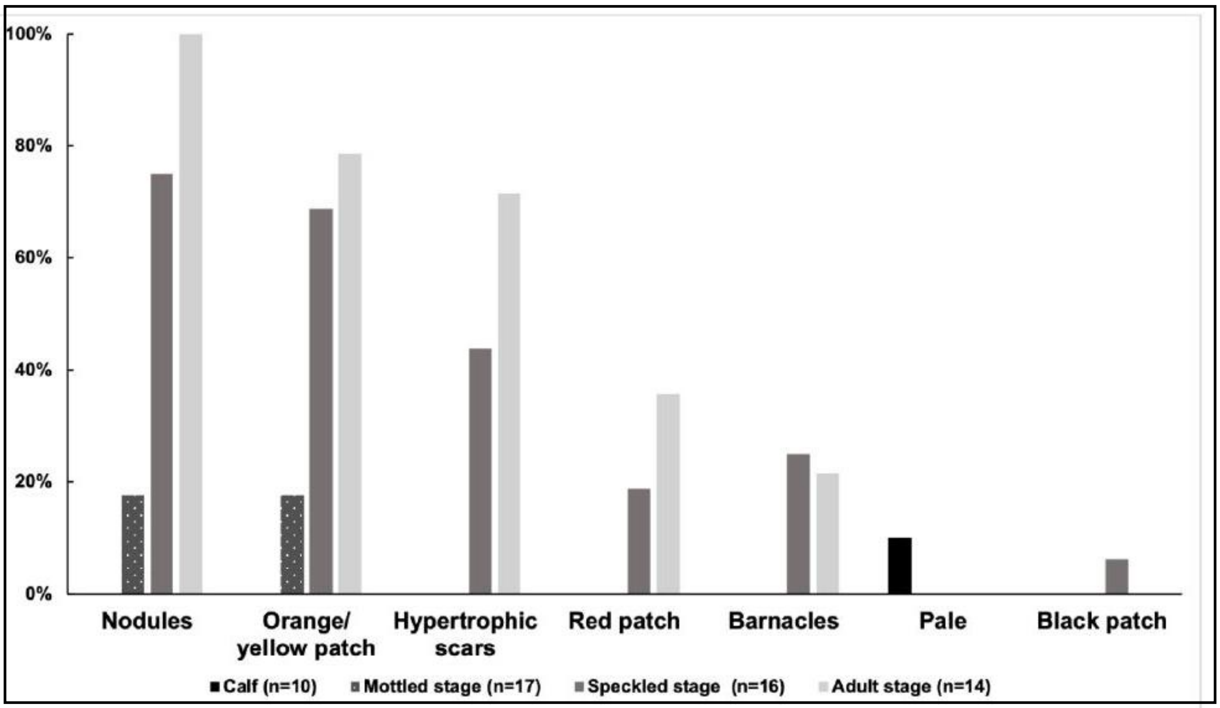


Figure 5. The prevalence of different skin lesion categories in each coloration stage from 2018 to 2021 (n = 57). *Source:* Ho *et al.* 2023.

Predation

Studies regarding interactions between humpback dolphins and sharks are scarce. However, shark bite rates have been quantified using photo-identification data for the Indian Ocean humpback dolphin (*S. plumbea*) (Cockcroft 1991), the Australian humpback dolphin (*S. sahulensis*) in Western Australia (Smith *et al.* 2018), and the Taiwanese humpback dolphin, *S. chinensis taiwanenesis* (Wang *et al.* 2017). Wang *et al.* (2017) used data from a long-term photo identification program on this subspecies to assess and examine major injuries quantitatively, including shark bites (Wang *et al.* 2017). In total, Wang *et al.* (2017) recorded 93 major injuries on 46 Taiwanese humpback dolphin individuals. Three individuals (belonging to the oldest age class) exhibited injuries to their tail region that were likely from failed shark attacks (Wang *et al.* 2017). The three individuals with injuries likely due to sharks represented 3.8% of the 78 individuals examined and 6.5% of the 46 injured individuals, while the three injuries represented 3.2% of the 93 injuries recorded in this population (Wang *et al.* 2017). Additionally, humpback dolphins have been known to react to sharks, demonstrating either avoidance or aggressive behavior (Whittaker and Young 2018). Thus, while rare, shark attacks have been documented within the Taiwanese humpback dolphin population. Even though it is probable that sharks pose a predatory threat across the subspecies' range, predation by sharks in coastal waters of Taiwan is not likely a major source of mortality and injury for the Taiwanese humpback dolphin.

Summary

Increased interaction with human activity may increase the dolphin's exposure to new and invasive pathogens, which has been directly observed in this subspecies by Ho *et al.* (2023). Skin mark prevalence may be an indicator of environmental or anthropogenic stressors in the ecosystem, which could lead to individual and/or population-level health concerns. Additionally, newly described cases of several potential pathogens identified as the cause of skin lesion prevalence and severity in the Taiwanese humpback dolphin could pose a potential threat to the population (Ho *et al.* 2023). However, further research is required to assess whether these cases are indicators of marine coastal environmental health, and are directly affecting the subspecies' immune function and overall population recovery.

Attacks by sharks, while rare, have been documented within this subspecies' population. However, predation by sharks in coastal waters of Taiwan is not likely a major source of mortality and injury for the Taiwanese humpback dolphin, and thus predation is not a factor affecting population recovery.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The Taiwanese humpback dolphin is listed under Taiwan's Wildlife Conservation Act as a Level I protected species, which grants species the highest level of legal protection. Article 4 of the Act designates humpback dolphins as "protected wildlife", and Article 18 states that these animals are "not to be disturbed, abused, hunted [or] killed" (Wang *et al.* 2016; Whittaker and Young 2018). However, associated regulatory or enforcement actions for the prevention of bycatch and entanglement of the population, or extensive habitat degradation appear to be minimal at best to non-existent throughout the subspecies' range (Wang and Araujo-Wang 2018; Taylor *et al.* 2019). Furthermore, those regulatory and enforcement actions that do exist appear inadequate to control the primary threats to the subspecies (i.e. bycatch and entanglement in fishing gear, coastal development, and land reclamation activities) and have thus far proven unsuccessful in slowing population decline (Wang and Araujo-Wang 2018; Taylor *et al.* 2019).

In 2020, Taiwan's Ocean Affairs Council designated a major wildlife habitat (MWH) for the Taiwanese humpback dolphin, covering an area of 763 square km, which combines marine and estuarine ecosystems (Taiwan 2020; Jhan *et al.* 2022) (Ocean Conservation Administration, Ocean Affairs Council). This major wildlife habitat covers approximately 70-80 percent of confirmed habitat for the subspecies, but perhaps as little as 50 percent of the MWH is confirmed suitable habitat (Wang *et al.* 2016; AWI 2023). Additionally, this designated area is identical to the proposed MWH announced for the dolphins by the Forestry Bureau of Taiwan back in 2014, which did not cover the minimum area recommended for protection of the subspecies (Wang *et al.* 2016). Thus, while the 2020 MWH designation by Taiwan's Ocean Affairs Council is an important step forward, it may be more symbolic than substantive, as legal fishing activities in the original MWH area proposed in 2014may continue(which is concerning, as fisheries interactions represent a major threat to the subspecies – see section 2.3.2.5 below), and other development has only been minimally restricted (Jhan *et al.* 2022). Furthermore, the main purpose of the MWH is to monitor and control development, but it lacks sufficient conservation and management programs (Jhan *et al.* 2022). Thus, it has not been effective at ameliorating the primary threats to the subspecies (Ross *et al.* 2018; Taylor *et al.* 2019; Araújo-Wang *et al.* 2022; Jhan *et al.* 2022; AWI 2023). For example, in addition to the thousand-plus offshore wind turbines that the Taiwanese government plans to have installed in and adjacent to the Taiwanese humpback dolphin habitat by the year 2035, expansion of commercial ports, gas fired power plants, and major construction to expand the Taichung Port for a LNG terminal continues unabated (Ross *et al.* 2018; Taylor *et al.* 2019; Dearden 2020; Wright *et al.* 2020; Araújo-Wang *et al.* 2022). Therefore, based on current knowledge of the population, and despite providing the highest level of legislative protection, the Wildlife Conservation Act and the 2020 designation of the MWH appears inadequate to control the primary threats to the subspecies and has thus far proven unsuccessful in slowing population decline.

In August 2019, experts in humpback dolphin biology and international and Taiwanese policy, including NOAA Fisheries, participated in a workshop of the Taiwanese White Dolphin Advisory Panel (TWDAP) in Ontario, Canada (Taylor *et al.* 2019). The workshop participants concluded that available knowledge was sufficient to justify moving forward with the following six actions: (1) establishing a ban on gill and trammel nets in Taiwanese humpback dolphin habitat (along the entire west coast of Taiwan); (2) locating any new development and related impacts away from the Taiwanese humpback dolphin habitat; (3) establishing mandatory routes and speed limits for vessels to reduce both noise and the risk of vessel strikes in Taiwanese humpback dolphin habitat; (4) reducing pollution (air, water, and soil); (5) increasing natural river flows; and (6) establishing regulations to limit human-caused underwater noise levels in Taiwanese humpback dolphin habitat (Taylor *et al.* 2019). These actions are all related to the known threats faced by the Taiwanese humpback dolphin, which were identified in previous workshops (conducted in 2004, 2007, 2011, 2014, and

2017) to identify and define the dolphin's conservation status, threats, and potential protection measures (Taylor *et al.* 2019; AWI 2023). Workshop participants agreed unanimously that a ban on gill and trammel nets is the single most urgent action needed (Taylor *et al.* 2019). If effectively enforced, it would likely halt the decline in the Taiwanese humpback dolphin's population size. The majority of workshop participants agreed on the remaining five other actions, which would reduce the negative impacts of pollution, habitat degradation, vessel strikes, and noise that are essential for sustained recovery for the subspecies (Taylor *et al.* 2019). However, workshop participants noted that, unlike the net ban, the benefits of these actions would take time to show effects on the subspecies' population (Taylor *et al.* 2019). The participants in that workshop developed a draft recovery plan (Taylor *et al.* 2019), which they shared with relevant authorities in Taiwan, in the hope that the Taiwanese central government would adopt it and implement actions that would allow this subspecies to persist into the future (Taylor *et al.* 2019; AWI 2023). However, the recovery plan for this subspecies has yet to be adopted and proposed actions from the recovery plan have yet to be implemented (AWI 2023).

All *Sousa* spp., including the Taiwanese subspecies, are listed under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The CITES Appendix I regulates species in order to reduce the threat of international trade. Appendix I addresses those species deemed threatened with extinction by international trade and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial, meets criteria for other types of permits, and can otherwise be legally done without affecting the sustainability of the population, for instance for scientific research. In these exceptional cases, trade may take place provided it is authorized by the granting of both an import permit and an export permit (or re-export certificate). However, there is no evidence that trade of the Taiwanese humpback dolphin is occurring. In this respect, the CITES listing is not failing in its mission.

Summary

Although many recommendations have been made to guide the future conservation and recovery of the Taiwanese humpback dolphin (Ross *et al.* 2018; Wang and Araujo-Wang 2018; Taylor *et al.* 2019; Jhan *et al.* 2022; Ho *et al.* 2023), current regulatory mechanisms in place are either ineffective or completely lacking to effectively address major threats to this subspecies and its future viability. Development and industrialization of the region are largely unregulated. Additionally, fishing and marine mammal bycatch also remains unregulated. For example, fishing along the western coast of Taiwan is heavily supported by the Taiwanese government, due to fuel subsidies for boats actively fishing for > 90 days per year (Lin 2020). While some regulations are in place, such as the Taiwanese Wildlife Conservation Act listing and CITES trade restrictions, these regulations are either not adequately enforced, or do not address the primary threats to the subspecies' population (i.e. bycatch and entanglement in fishing gear, coastal development, and land reclamation activities). Furthermore, while a recovery plan was drafted in 2019 by international species experts, which outlines actions to aid in the recovery of the Taiwanese humpback dolphin, this recovery plan has yet to be adopted or implemented by the Taiwanese government. Thus, inadequacy of existing regulatory mechanisms, particularly due to lack of enforcement, implementation, or effectiveness continues to be a factor affecting overall population recovery. The best available scientific and commercial information does not indicate that existing measures are sufficient to counter threats to the subspecies across its entire range.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

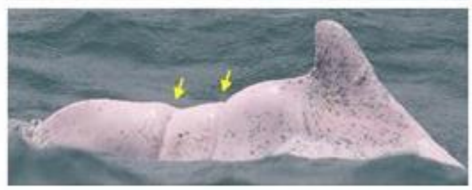
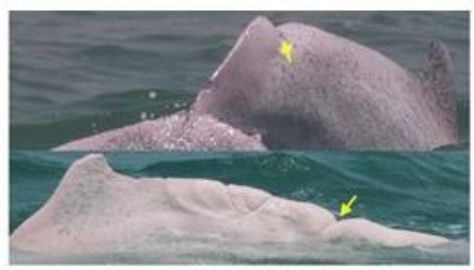
Bycatch and entanglement by fishing gear

Entanglement and mutilation due to interactions with fishing gear continue to be a serious direct and immediate threat to the Taiwanese humpback dolphin (Brownell Jr *et al.* 2019; Taylor *et al.* 2019; Ho *et al.* 2023). Legal gillnet fishing (mostly with trammel nets) and illegal bottom trawling within 3 nautical miles from shore continue in the subspecies' habitat, although in 2019 the local coast guard promised stricter enforcement (Brownell Jr *et al.* 2019). Furthermore, bycatch poses a significant threat to small cetaceans in general, where entanglement in fishing gear results in widespread injury and mortality (Brownell Jr *et al.* 2019; Taylor *et al.* 2019; Ho *et al.* 2023). A study on the Taiwanese humpback dolphin, conducted from 2007 to 2010, showed that more than 30% of this population exhibited injuries caused by fishing gear (Slooten *et al.* 2013). Another study by Wang *et al.* (2017) determined that more than half of the total observed individuals (n = 78, 2007–2015) examined in their research sustained significant injuries during human activities, with a total of 93 major injuries recorded on 46 individuals. This signifies that the potential risk of dolphin injuries inflicted by human activity is ongoing.

Recently, Ho *et al.* (2023) conducted a study, which visually assessed and quantified the prevalence of marks of anthropogenic origin in the Taiwanese humpback dolphin population along the coasts of central Taiwan. Ho *et al.* (2023) identified fifty, twenty-eight, and thirty-four individuals in 2018, 2019, and 2021, respectively. Injuries were classified into five categories: dorsal fin/fluke mutilation, narrow-spaced linear marks, wide-spaced linear marks, back indentation, and others (Ho *et al.* 2023; Table 2). At least one category of injury was observed in 47 of 57 distinctive individuals (82%) from 2018 to 2021, and adults showed a higher prevalence of deep injuries such as dorsal fin/fluke mutilation, wide-spaced linear marks, and back indentation than the other coloration stages of this subspecies (Table 2 and Figure 6). The prevalence of injuries was 80% (40/50) in 2018, 82% (23/28) in 2019, and 71% (24/34) in 2021 (Ho *et al.* 2023). Among the 57 distinctive individuals, the prevalence of the five categories of injuries was as follows: narrow-spaced linear marks (68%), others (28%), dorsal fin/fluke mutilation (21%), back indentation (16%), and wide-spaced linear marks (5%) (Ho *et al.* 2023). The most prevalent injury in each year were narrow linear marks (Figure 7, Table 2, and Table 3). The prevalence of injuries of the 57 distinctive individuals in each coloration stage was as follows: calf (70%, 7/10), mottled stage (76%, 13/17), speckled stage (81%, 13/16), and adult stage (100%, 14/14) (Ho *et al.* 2023). The adult stage showed a higher prevalence of dorsal fin/fluke mutilation, wide-spaced linear marks, and back indentation (Ho *et al.* 2023; Figure 6)

Although a narrow linear mark might barely pose a threat to a dolphins' health and survival, it still indicates dolphin-fishery interactions (Ho *et al.* 2023; Table 2). In contrast, the other marks, such as mutilation, wide-spaced linear marks, and V-shaped indentations, have been associated with deep injuries attributed to human interactions and with different degrees of severity (Ho *et al.* 2023; Table 2). Dolphins exhibit an extraordinary capacity to heal deep soft-tissue injuries such as shark bites and anthropogenic trauma, and the deep wounds in the dolphins may heal in a regenerative manner rather than repair (Su *et al.* 2022). However, Ho *et al.* (2023) notes that these scars significantly alter the physiology and behavior of the dolphins and occasionally lead to death. For example, a juvenile male *S. c. taiwanensis* was found stranded in south Taiwan on 21 January 2022, with injuries caused by past gillnet entanglement (Ho *et al.* 2023). The necropsy report showed that the acute bacterial infection and severe blunt force trauma were the direct causes of death, while the past gillnet entanglement injuries may be the contributory cause (Ho *et al.* 2023). Furthermore, dolphins caught in driftnets may sustain injuries inflicted by fishermen, such as deep indentations or mutilations of stuck appendices (Ho *et al.* 2023). This can result in serious infections that may reduce swimming activities, causing higher energy expenditure and starvation leading to death (Ho *et al.* 2023). Previous studies on *T. truncatus* and other species demonstrated a relationship between the incidence of injury and fishery activities and that occurrence of skin injuries proportionally increased with higher fishery interactions (Wells *et al.* 2008; Ho *et al.* 2023). Overall, the moderate-to-high prevalence of skin marks within the study by Ho *et al.* (2023) is an indicator of anthropogenic stressors, specifically bycatch and entanglement from fishing gear, upon the Taiwanese humpback dolphin.

Table 2. Definitions of injury (arrows and circles) categories and potential causes for the Taiwanese humpback dolphin. *Source*: Ho *et al.* 2023.

Injury Categories	Description	Examples	Potential Causes
Dorsal fin/fluke mutilation	Missing the apex of the dorsal fin/fluke, with a sharp edge or a linear cut down the dorsal fin		cut from net entanglement or other object
Narrow-spaced linear marks	Serial linear marks, including both shallow and deep marks, especially those appearing along the spine of the peduncle		net entanglement or inherent deformities
Wide-spaced linear marks	Serial linear marks that extend from one side of the peduncle to the other side, with a long and equal interval between each mark		net entanglement or ship strike
Back indentation	V-shaped indentation located along the spine; size varies		net entanglement or ship strike

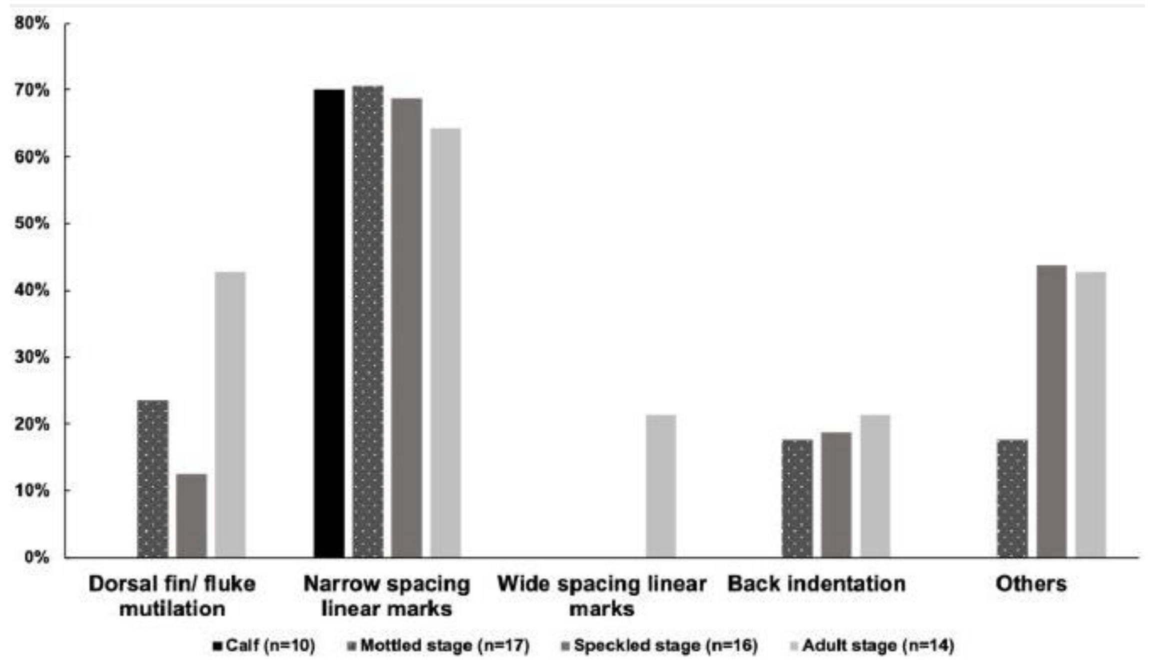


Figure 6. The prevalence of different injury categories in each coloration stage from 2018 to 2021 (n = 57). *Source:* Ho *et al.* 2023.

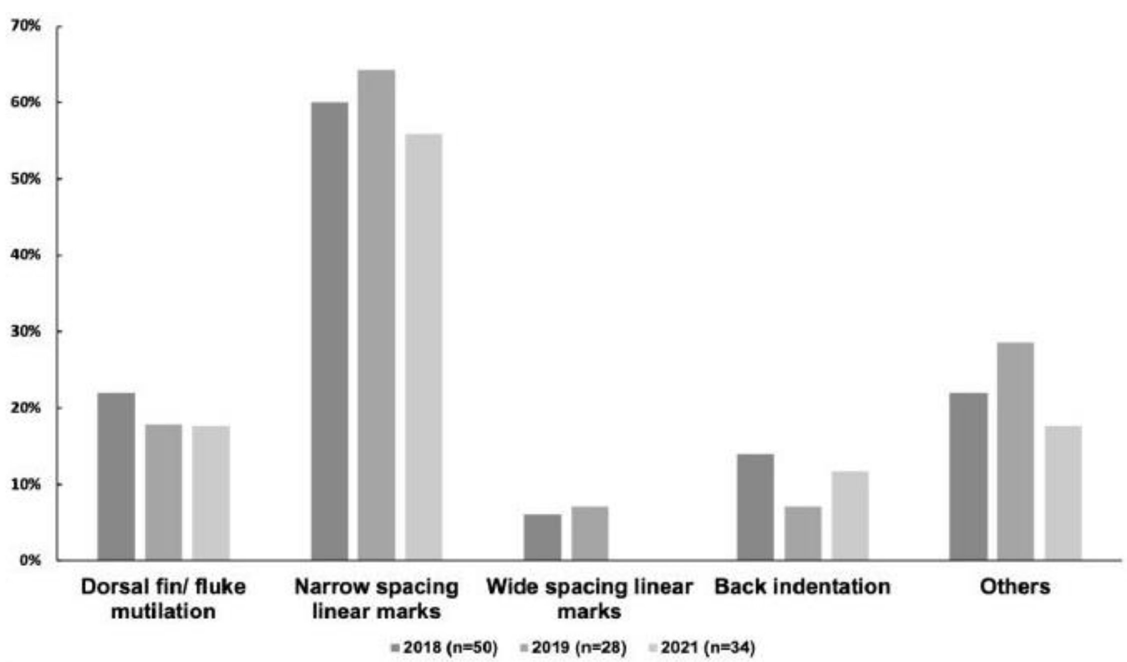


Figure 7. The prevalence of different injury categories in each year (n = 50, 28, and 34). *Source:* Ho *et al.* 2023.

Table 3. Prevalence of injuries in 2018, 2019, and 2021. *Source*: Ho *et al.* 2023.

Stage (n = 2018, 2019, 2021)	Dorsal Fin/Fluke Mutilation	Narrow-Spaced Linear Marks	Wide-Spaced Linear Marks	Back Indentation	Others
Calf (n = 5,3,8)	(0,0,0)	(3,2,4)	(0,0,0)	(0,0,0)	(0,0,0)
Mottled stage (n = 16,7,11)	(3,1,2)	(10,5,5)	(0,0,0)	(2,0,1)	(1,2,1)
Speckled stage (n = 15,10,10)	(2,2,2)	(9,7,6)	(0,0,0)	(3,2,2)	(4,4,3)
Spotted adult (n = 12,7,5)	(6,2,2)	(7,4,4)	(2,2,0)	(2,0,1)	(5,2,2)
Unspotted adult (n = 2,1,0)	(0,0,0)	(1,0,0)	(1,0,0)	(0,0,0)	(1,0,0)

Vessel Strikes

In addition to bycatch and entanglement, fishing activities and the construction of offshore windfarms can also affect the Taiwanese humpback dolphin by increasing the likelihood of vessel strikes due to increased boat traffic. The coastal water of Taiwan continues to be highly concentrated with human boat activity, including transportation, industrial shipping, commercial fishing, offshore windfarm construction, sand extraction, harbor dredging, and commercial dolphin watching (Whittaker and Young 2018; Taylor *et al.* 2019; Hu *et al.* 2022). To meet increasing energy demands and drive toward cleaner energy, these activities continue to be unmitigated, and their concentration has continued to increase within the past few decades along the western coast of Taiwan (Hu *et al.* 2022). In fact, the trend in boating and fishing activity in the region has increased by more than 750% since the 1950s, and its increase is expected to continue into the foreseeable future (Whittaker and Young 2018). Fishing vessels alone contribute a large fraction of this boating activity; an estimated 6,300 fishing vessels are currently active inside the dolphins' habitat (operating from ports in the six coastal counties fronting the dolphins' habitat), and 45% of them are regularly engaged in fishing coastal waters (Slooten *et al.* 2013; Taylor *et al.* 2019).

More recently, however, increased concentration of vessel activity is largely from recent offshore windfarm development within the Eastern Taiwan Strait, due to wind turbine installation and service craft (Ross *et al.* 2018; Wright *et al.* 2020; Hu *et al.* 2022). The increase in offshore structures will inevitably pose enormous stress on marine communities, for instance, by intensifying vessel traffic and its associated noise (Wright *et al.* 2020). Vessel noise may result in behavioral disturbances of the dolphins, which rely upon acoustic sensory systems to communicate, forage, and interact with their environment, and thus increase the potential for a strike (Whittaker and Young 2018; Hu *et al.* 2022). In addition, individuals, especially females and calves, may be attracted to fishing vessels due to elevated prey concentration, which can lead to mortality via vessel strike (Whittaker and Young 2018; Taylor *et al.* 2019). In many cetacean habitats, the addition of these support vessels does not appreciably increase the intensity of ship traffic, as such traffic may already be high (Ross *et al.* 2018). However, in the habitat of restricted range cetaceans, the loss of even one individual to a vessel strike is of critical concern. Therefore, the slight increase in risk of a support vessel striking a Taiwanese humpback dolphin carries more weight than with abundant cetaceans (Ross *et al.* 2018; Hu *et al.* 2022). Humpback dolphins off the coast of Hong Kong, which interact with comparable levels of vessel traffic and face similar threats to habitat, have demonstrated evidence of propeller cuts on their bodies, and vessel strikes have been determined to be the conclusive cause of mortality in a high proportion of stranding incidents (Whittaker and Young 2018; Piwetz *et al.* 2021; Kot *et al.* 2022).

Acoustic Disturbance

Small odontocete cetaceans, including the Taiwanese humpback dolphin, rely upon a highly developed acoustic sensory system and echolocation to navigate, feed, and whistles to communicate with other individuals in the marine environment (Hung *et al.* 2021). It is widely recognized that underwater noise from activities such as construction, shipping, and oil and gas exploration may reach sufficient amplitude and duration such that the health and/or behavior of marine mammals are detrimentally affected (Finneran 2015; Ross *et al.* 2018; Hu *et al.* 2022). Loud and persistent noise in the ocean can have various impacts, ranging from altering the distribution of prey, to impacting the ability of marine mammals to effectively forage and communicate (Richardson and Wursig 1997; Simmonds *et al.* 2004; Nowacek *et al.* 2007; Weilgart 2007). Additionally, noise disturbance has been shown to elicit a variety of stress responses from other cetacean species, such as the bottlenose dolphin and beluga whale, and prolonged or chronic exposure to noise, or exposure to noise of short duration (if loud enough), may also result in hearing loss and increased stress hormones (Gordon and Moscrop 1996; Richardson and Wursig 1997; Nowacek *et al.* 2007; Weilgart 2007).

Taiwanese humpback dolphins are highly social and are commonly found in groups (Hu *et al.* 2022). Their social behavior is essential for successful foraging and reproduction (Wang *et al.* 2007b; Dungan *et al.* 2016) and, therefore, population survival. Each dolphin may identify itself with a signature signal used for individual recognition, which can include both whistles and echolocation clicks (Tyack 2000; Cheng *et al.* 2017). The Taiwanese humpback dolphins may also use these signature whistles for social interaction and linkage, signaling position and physiological state, and rearing offspring. Taiwanese humpback dolphins also produce broadband echolocation clicks for navigation and prey and object identification (Lin *et al.* 2013; Lin *et al.* 2015). Increasing anthropogenic activities along the Eastern Taiwan Strait may affect the Taiwanese humpback dolphin by making the dolphin more susceptible to auditory masking, and consequently, interfere with social networks and disrupt foraging and reproductive success (Lin *et al.* 2015; Wright *et al.* 2020).

Recent offshore windfarm development has led to increased vessel traffic in the Eastern Taiwan Strait, which is part of the Taiwanese humpback dolphin's habitat (Hu *et al.* 2022). Until recently, data on possible effects on the behavior of the Taiwanese humpback dolphin were lacking and the influences of transiting vessel noise on Taiwanese humpback dolphin vocalizations in their natural habitat were yet to be explored. However, in a recent study conducted by Hu *et al.* (2022), Taiwanese humpback dolphins' acoustic behavior associated with shipping noise was observed in the Miaoli area (an offshore windfarm with significant vessel transits, where the Taiwanese humpback dolphin has frequently been spotted) (Wang and Araujo-Wang 2018). The dolphins' whistles and clicks were analyzed before, during, and after vessel transit (Hu *et al.* 2022). This study showed a significant drop in the whistling and clicking rates of the Taiwanese humpback dolphin and significantly shorter whistles during and after vessel transit (Hu *et al.* 2022; Figure 8). For example, before vessel transit, the median rate of dolphin whistles and clicks was 100 and 1,550 counts per minute, which significantly reduced to less than 8 and 170 counts per minute during and after vessel transit (Hu *et al.* 2022). Additionally, the study found that dolphins produced significantly shorter whistles during (0.07 s) and after (0.15 s) vessel transit (Hu *et al.* 2022). This study indicated that Taiwanese humpback dolphins altered vocalizing behavior in response to the presence of vessel traffic (Hu *et al.* 2022; Figure 8). Additionally, Hu *et al.* (2022) showed that vocalizing behavior for this subspecies may be affected by vessel transit, which, if sustained, could possibly influence the individual communication and feeding success of the population (Hu *et al.* 2022; Figure 8). Amid the increasing vessel traffic, shipping noise is considered a significant threat to the Taiwanese humpback dolphin. The study by Hu *et al.* (2022) indicates that changes in vocalization behavior may be due to acoustic interference, enhanced vigilance, reduced abundance, and stress. The Taiwanese humpback dolphin may respond to vessel transit by dropping its whistling and clicking rates (Hu *et al.* 2022; Figure 8). Additionally, when noise is sustained for prolonged periods, the subsequent reduction in the calling rate may influence the dolphins' efforts to communicate and sustain social cohesion (Hu *et al.* 2022).

The offshore windfarm project in the Taiwan Strait began in 2016 and is planned to continue until 2030, with the capability to achieve 15 GW of power production (Qiao 2020; and see section 2.3.2.1). This project will contribute to a substantial rise in vessel traffic and construction activities, contributing to elevated noise levels and the risk of vessel strikes in the habitat of the Taiwanese humpback dolphin (Hu *et al.* 2022). Additionally, the impact of piling noise on marine mammals, especially Taiwanese humpback dolphins, is concerning in the environmental impact assessment of the development of offshore windfarms in Taiwan. The Taiwanese government restricts underwater noise to a single strike sound exposure level (SEL) of no more than 160 dB (re 1 $\mu Pa^2 s$) at a distance of 750 m from the piling (Hu *et al.* 2022). In order to ensure this standard, noise mitigation measures such as bubble curtains are used, which are supposed to lower the risk of a temporary hearing threshold shift (TTS) or a permanent threshold shift (PTS) in humpback dolphins (Hu *et al.* 2022). The whistle of the humpback dolphins is susceptible to auditory masking by vibratory piling noise, which can negatively impact the social behavior of the species (Wang *et al.* 2014).

Summary

Interaction with fisheries (e.g., incidental bycatch and entanglement), vessel strikes, and acoustic disturbance are other natural or manmade factors that are increasing in scope and scale, especially in regards to the construction of planned offshore wind farms within the subspecies' restricted range (Brownell Jr *et al.* 2019; Taylor *et al.* 2019; Hu *et al.* 2022; Ho *et al.* 2023). Bycatch and entanglement in fishing gear continues to pose a significant threat to the subspecies (Ho *et al.* 2023). Vessel strikes are likely to increase in the future with increased concentration of vessel activity and support craft for offshore windfarm development and operational maintenance within the Taiwanese humpback dolphin's habitat (Ross *et al.* 2018; Brownell Jr *et al.* 2019; Taylor *et al.* 2019; Hu *et al.* 2022; Ho *et al.* 2023). Additionally, new information on acoustic disturbance and influences of transiting vessel noise on the subspecies' vocalizations within an existing offshore windfarm off the coast of Taiwan indicates that this threat is likely to increase in the future, with increased boating and industrial activity within the dolphin's habitat (Hu *et al.* 2022). Thus, the best available scientific and commercial data indicate that other natural or manmade factors in the form of bycatch and entanglement by fishing gear, vessel strikes, and acoustic disturbance significantly affect overall population recovery.

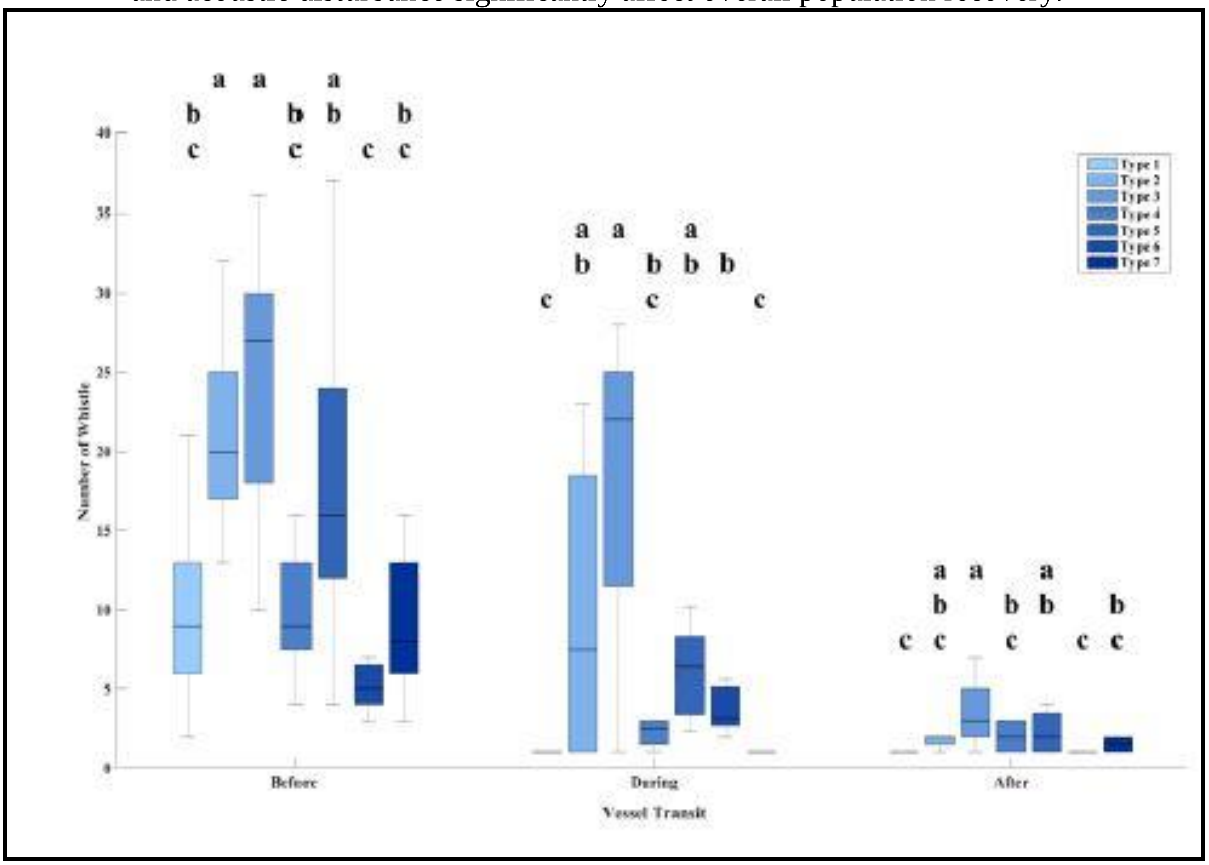


Figure 8. Effect of vessel transit (before, during, and after) on whistle types (1-7). On each box, the central black mark depicts the median, and the top and bottom edges of the box represent the 25th and 75th percentiles. The maximum and minimum values are marked in black at the extreme ends. Each box with a superscript letter represents results from post hoc multiple comparison tests; different superscript letters indicate significant differences ($p<0.05$), with letter 'a' at the top, and subsequent statistical differences are represented at a lower level. *Source:* Hu *et al.* 2022.

2.4 Synthesis

The Taiwanese humpback dolphin (*S. c. taiwanensis*) is an obligatory shallow water inshore subspecies, known for its restricted range, being endemic to a small, narrow band of estuarine water off the western coast of Taiwan (Whittaker and Young 2018; Araújo-Wang *et al.* 2022). The subspecies' population remains geographically isolated and small, with abundance estimates for the entire subspecies numbering fewer than 75 individuals, and declining at an estimated rate of about two individuals per year (Whittaker and Young 2018; Taylor *et al.* 2019; Araújo-Wang *et al.* 2022). This decline likely affects the demographic recovery of the Taiwanese humpback dolphin. Furthermore, two independent PVAs that simulated population dynamics for the Taiwanese humpback dolphin under different scenarios of impacts from bycatch mortality and habitat degradation, suggested that the population is declining due to synergistic effects of habitat degradation and detrimental fishing interactions (Araujo-Wang *et al.* 2014; Taylor *et al.* 2019). Both of these PVAs also indicated a likely continued decline for this subspecies.

The Taiwanese humpback dolphin continues to face a number of threats throughout its restricted range that are increasing in scope and scale, especially in regards to the construction of planned offshore wind farms (Brownell Jr *et al.* 2019; Taylor *et al.* 2019; Hu *et al.* 2022; Ho *et al.* 2023). Coastal development, freshwater diversion, contamination and pollution, bycatch and entanglement by fishing gear, vessel strikes, acoustic disturbance, and possibly potential pathogens identified in the subspecies are threats that affect the dolphin's recovery. While many recommendations have been made to guide the future conservation and recovery of the Taiwanese humpback dolphin (Ross *et al.* 2018; Wang and Araujo-Wang 2018; Taylor *et al.* 2019; Jhan *et al.* 2022; Ho *et al.* 2023), current regulatory mechanisms in place are either ineffective or completely lacking to effectively address the subspecies' primary threats (i.e. bycatch and entanglement in fishing gear, coastal development, and land reclamation activities) and have thus far proven unsuccessful in slowing population decline (see section 2.3.2.4). Additionally, the MWH designated in 2020 by Taiwan's Ocean Affairs Council covers less than 50 percent of confirmed suitable habitat for the subspecies, and gillnet fisheries (a primary threat) continue to be permitted within the MWH (Jhan *et al.* 2022; Araújo-Wang *et al.* 2022). Furthermore, other development has only been minimally restricted in the designated area (Jhan *et al.* 2022). Thus, inadequacy of existing regulatory mechanisms, particularly due to lack of enforcement, implementation, or effectiveness also continues to be a factor affecting overall population recovery. While a recovery plan was drafted in 2019 by international species experts, outlining actions to aid in the recovery of the Taiwanese humpback dolphin, this recovery plan has yet to be adopted or implemented by the Taiwanese government.

In summary, we conclude that the status of the subspecies has not changed since it was listed as endangered in 2018. The Taiwanese humpback dolphin population remains low and continues to decline across its range. Accordingly, with fewer than 75 individuals in the population (which is well below the minimum population size of least 250 individuals required for marine mammals to resist stochastic genetic diversity loss), the gene pool may be experiencing critical bottlenecks (Huang *et al.* 2014; Taylor *et al.* 2019; see section 2.3.1.3). The combination of low diversity, restricted spatial distribution, and small population size likely increases the subspecies' vulnerability to threats of habitat loss and degradation via coastal development projects and other natural or manmade factors via fisheries interactions, vessel strikes, and acoustic disturbance, which have all increased in scope and scale since the subspecies' was listed. For these reasons, we conclude that the Taiwanese humpback dolphin is currently in danger of extinction throughout its range. Consequently, reclassification should not occur, and the status of the Taiwanese humpback dolphin should remain as endangered.

3.0 RESULTS

3.1 Recommended Classification

_____**Downlist to Threatened**
_____**Uplist to Endangered**
_____**Delist** *(Indicate reason for delisting per 50 CFR 424.11):*
_____*The species is extinct*
_____*The species does not meet the definition of an endangered or a threatened species*
_____*The listed entity does not meet the statutory definition of a species*
__X___**No change is needed**

3.2 New Recovery Priority Number

Not Applicable

3.3 Listing and Reclassification Priority Number

Not Applicable

4.0 RECOMMENDATONS FOR FUTURE ACTIONS

This 5-year review indicates that, based on a review of the best available scientific and commercial information, the Taiwanese humpback dolphin should remain classified as endangered. With a number of known threats continuing to increase in scope and scale throughout its range and the emergence of potential new threats, conservation for this subspecies requires immediate action. Recommendations for immediate future actions to mitigate known threats and help recover this subspecies include: (1) banning gillnet/trammel fisheries in coastal and estuarine waters, (2) designating reserves or marine parks in major habitats of this subspecies, (3) restoring disturbed and deteriorated ecosystems, (4) establishing mandatory routes and speed limits for vessels to reduce both noise and risk of vessel strikes in dolphin habitat, (5) reducing pollution (in the air, water, and soil), (6) establishing regulations to limit human-caused underwater noise levels in dolphin habitat, (7) re-planning and re-assessing ongoing offshore wind farm projects near the habitats of humpback dolphins, and (8) increasing natural river flows (Huang *et al.* 2018; Taylor *et al.* 2019; Araújo-Wang *et al.* 2022; Huang 2022).

A complete ban on gillnet activities has been identified by multiple expert panels as the most effective measure to protect the Taiwanese humpback dolphins from continued population decline (Taylor *et al.* 2019; Wright *et al.* 2020). An innovative solution to achieve the ban on gillnet fisheries has been proposed in which companies and financial institutions involved with wind farm development could contribute to government programs to help eliminate gill and trammel nets from Taiwanese humpback dolphin habitat by compensating fishers for a transition to other fishing methods (Taylor *et al.* 2019; Wright *et al.* 2020; Araújo-Wang *et al.* 2022).

In addition to the actions outlined above to mitigate known threats and help recover the Taiwanese humpback dolphin, NMFS recommends gathering information on trends in abundance and estimates of survival and reproduction rates for this subspecies, as it is fundamental to understanding the status of the Taiwanese humpback population. Furthermore, emerging information on potential pathogens, acoustic behavior associated with shipping noise, and contamination and pollution from the cleaning, operation, and maintenance of the wind turbines should continue to be monitored and assessed to determine whether these issues threaten the Taiwanese humpback dolphin.

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Conditions in Critically Endangered Indo-Pacific Humpback Dolphins (Sousa chinensis) from the Waters of Western Taiwan. Pakistan Veterinary Journal 33:505-509.

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Taiwanese humpback dolphin (*Sousa chinensi*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review

- [ ] Downlist to Threatened
- [ ] Uplist to Endangered
- [ ] Delist
- [x] No change is needed

Review Conducted By (Name and Office):

Heather Austin, Office of Protected Resources, Silver Spring, MD.

LEAD OFFICE APPROVAL:

Director, Office of Protected Resources, NOAA Fisheries

Approve DAMON RANDALL.KIMBERLY.BETH.1365821093 Digitally signed by DAMON RANDALL.KIMBERLY.BETH.1365821093 Date: 2024.04.05 11:02:36 -04'00' Date: 4/5/24

Cooperating Regional Administrator, NOAA Fisheries

[ ] Concur [ ] Do Not Concur [x] N/A

Signature____ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.DEAN.1365850948 Digitally signed by RAUCH.SAMUEL.DEAN.1365850948 Date: 2024.04.12 16:31:42 -04'00' Date: _______