Taiwanese Humpback Dolphin (*Sousa chinensis taiwanensis*) 2018-2023

Bibliography

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Background & Scope

The goal of this bibliography is to provide a comprehensive review of the scientific literature published between the timeframe of May 2018 through June 2023 about the Taiwanese humpback dolphin, *Sousa chinensis taiwanensis*.

"The Taiwanese humpback dolphin is a subspecies of the Indo-Pacific humpback dolphin that is only found in a small, narrow stretch of estuarine water off the western coast of Taiwan. This subspecies was first described in 2002 but did not receive formal recognition until 2016. The population is small with fewer than 100 individuals remaining. It also has late maturity, slow reproductive rate, long calving intervals, and long periods of female-calf association.

The main threats to the Taiwanese humpback dolphin include entanglement in fishing gear and habitat destruction, degradation, and modification due to coastal development. In 2018, NOAA Fisheries listed the Taiwanese humpback dolphin as endangered under the Endangered Species Act." -NMFS

Section I – Biology

Section one is intended to provide an overview of new information since May 2018 on the biology of the Taiwanese humpback dolphin. The research in this area includes a compilation of literature on genetics, body size, reproduction, metabolism, growth, taxonomy, and lifespan.

Section II – Ecology

Section two is intended to provide an overview of ecology for the Taiwanese humpback dolphin. The research in this area includes habitat, acoustics, communication, migration, feeding, behavior, and social ecology.

Section III – Population Abundance & Trends

Section three is intended to provide an overview of the population estimates and abundance of the Taiwanese humpback dolphin. Articles focus on observations in the waters around the Taiwan region, as well as trends affecting population size.

Section IV – Threats

A threat is defined as any factor that could represent an impediment to a species' recovery. Thus, section four is intended to provide an overview of any existing threats to the Taiwanese humpback dolphin. This may include habitat loss, noise pollution, entanglements, bycatch, vessel strikes, disease, pollution, climate change, and predation.

Section V – Conservation Efforts

Section five is intended to provide an overview of current conservation efforts related to the Taiwanese humpback dolphin. Literature focuses on local and international conservation efforts, monitoring, regulatory mechanisms, and coastal zone management.

Section VI – General

Section six contains literature about the larger species, Indo-Pacific humpback dolphins, in waters off of the coasts of Taiwan and China.

Sources Reviewed

The following databases were used to identify sources: Clarivate Analytics' Web of Science – Science Citation Index Expanded and Social Science Index; Digital Science's Dimensions.ai; Lens.org; ProQuest's Science and Technology collections, including the Earth, Atmospheric & Aquatic Science Collection, Ebook Central, and Oceanic Abstracts; Elsevier's Science Direct; EBSCO's Academic Search Complete, Academic Search Premier, Environment Complete, and GreenFILE; Wiley Online Library; NOAA's Institutional Repository; Google Scholar, Animal Welfare Institute, UCN Red List of Threatened Species, International Whaling Commission, Center for Biological Diversity, and WildEarth Guardians. Only English language materials were considered.

Section I: Biology

Chen, B., Jefferson, T. A., Wang, L., Gao, H., Zhang, H., Zhou, Y., . . . Yang, G. (2018). Geographic Variation in Pigmentation Patterns of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Chinese Waters. *Journal of Mammalogy, 99*(4), 915-922. https://doi.org/10.1093/jmammal/gyy068

The pigmentation patterns of Indo-Pacific humpback dolphins have not been well studied throughout most of the species' range. In the present study, both the subjective scoring method and a newly developed quantified scoring method were employed to evaluate the spotting intensity of 137 humpback dolphin individuals from the Xiamen and Beibu Gulf putative populations, including the Dafengjiang-Nanliujiang River Estuary (DRE) and Shatian-Caotan (SC) communities. Both scoring methods indicated that spotting intensity on the dorsal fin was lower than that on the body of humpback dolphins in all 3 groups. The SC and DRE humpback dolphins had significantly greater dorsal fin, body spotting intensity, and greater differences between spotting on the dorsal fin and body than Xiamen dolphins, while no differences were found between SC and DRE. The pigmentation variation is related to age class, young dolphins have more spotting density than adults, and young and adults showed similar geographical variation as above. The present paper, in combination with previous research, clarifies the general pattern of pigmentation for Chinese humpback dolphins. Eastern Taiwan Strait and Pearl River Estuary populations represent 2 extreme patterns of pigmentation, while the Xiamen population, SC community, and DRE community seem to be intermediate. The results suggest that these groups should be viewed as demographically distinct forms.

Jia, K., Bian, C., Yi, Y., Li, Y., Jia, P., Gui, D., . . . Wu, Y. (2019). Whole Genome Sequencing of Chinese White Dolphin (*Sousa chinensis*) for High-Throughput Screening of Antihypertensive Peptides. *Marine Drugs, 17*(9). https://doi.org/10.3390/md17090504

Chinese white dolphin (*Sousa chinensis*), also known as the Indo-Pacific humpback dolphin, has been classified as "Vulnerable" on the IUCN Red List of Threatened Species. It is a special cetacean species that lives in tropical and subtropical nearshore waters, with significant differences from other cetaceans. Here, we sequenced and assembled a draft genome of the Chinese white dolphin with a total length of 2.3 Gb and annotation of 18,387 protein-coding genes. Genes from certain expanded families are potentially involved in DNA replication and repairing, suggesting that they may be related to adaptation of this marine mammal to nearshore environments. We also discovered that its historical population had undergone a remarkable bottleneck incident before the Mindel glaciation. In addition, a comparative genomic survey on antihypertensive peptides (AHTPs) among five representative mammals with various residential habitats (such as remarkable differences in exogenous ion concentrations and sea depth) revealed that these small bioactive peptides were highly conserved among these examined mammals, and they had the most abundant hits in collagen subunit proteins, especially for two putative AHTP peptides Gly-Leu-Pro (GLP) and Leu-Gly-Pro (LGP). Our genome assembly will be a valuable resource for further genetic researches on adaptive ecology and conservation biology of cetaceans, and for in-depth investigations into bioactive peptides in aquatic and terrestrial mammals for development of peptide-based drugs to treat various human cardiovascular diseases.

Ming, Y., Jian, J., Yu, X., Wang, J., & Liu, W. (2019). The Genome Resources for Conservation of Indo-Pacific Humpback Dolphin, *Sousa chinensis*. *Scientific Data, 6*(1), 68. https://doi.org/10.1038/s41597-019-0078-6

The Indo-Pacific humpback dolphin (*Sousa chinensis*), is a threatened marine mammal and belongs to the First Order of the National Key Protected Wild Aquatic Animals List in China. However, limited genomic information is available for studies of its population genetics and biological conservation. Here, we have assembled a genomic sequence of this species using a whole genome shotgun (WGS) sequencing strategy after a pilot low coverage genome survey. The total assembled genome size was 2.34 Gb: with a contig N50 of 67 kb and a scaffold N50 of 9 Mb (107.6-fold sequencing coverage). The *S. chinensis* genome contained 24,640 predicted protein-coding genes and had approximately 37% repeated sequences. The completeness of the genome assembly was evaluated by benchmarking universal single copy orthologous genes (BUSCOs): 94.3% of a total 4,104 expected mammalian genes were identified as complete, and 2.3% were identified as fragmented. This newly produced high-quality assembly and annotation of the genome will greatly promote the future studies of the genetic diversity, conservation and evolution.

Tang, X., Lin, W., Karczmarski, L., Lin, M., Chan, S. C. Y., Liu, M., . . . Li, S. (2021). Photo-Identification Comparison of Four Indo-Pacific Humpback Dolphin Populations Off Southeast China. *Integrative Zoology, 16*(4), 586-593. https://doi.org/10.1111/1749-4877.12537

Indo-Pacific humpback dolphins (*Sousa chinensis*) inhabit shallow coastal waters of the Indo-Pacific region including southeast China, with at least 6 putative populations identified to date in Chinese waters. However, the connectivity among these populations has not yet been fully investigated. In the present study, we compared and cross-matched photographic catalogs of individual dolphins collected to date in the Pearl River Delta region, Leizhou Bay, Sanniang Bay, and waters southwest of Hainan Island, a total of 3158 individuals, and found no re-sighting of individual dolphins among the 4 study areas. Furthermore, there was a notable difference in the pigmentation pattern displayed by individuals from these 4 regions. We suggest that this may be a phenotypical expression of fine-scale regional differentiation among humpback dolphin groups, possibly distinct populations. Given the considerable conservation management implications it may carry (e.g. definition of management units), further research is much needed.

Zeng, Q., Wang, X., & Zhu, Q. (2021). Preliminary Study on the Reproductive Ecology of a Threatened Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Population in Xiamen Bay, China. *Aquatic Mammals, 47*(1), 43-52. https://doi.org/10.1578/am.47.1.2021.43

Reproductive data can provide important information for the conservation and management of threatened animals. The small resident Indo-Pacific humpback dolphin (*Sousa chinensis*) population in Xiamen Bay is threatened by frequent exposure to anthropogenic activities, and its reproductive ecology is still unknown. Based on photo-identification data collected from August 2010 to August 2015, the present study tracked 13 reproductive females and 19 of their calves and estimated the reproductive data. Births occurred all year round but were mainly concentrated in spring and summer; the annual crude birth rate was 0.053 +/- 0.025, and the annual recruitment rate was 0.028 +/- 0.024; the calf survival rate to 1 year old was 0.600 +/- 0.392; and females had a long inter-birth interval (4.27 +/- 1.06 y). All these factors may be due to intense extrinsic anthropogenic disturbances (such as busy vessel

traffic and coastal construction). In addition to these substantial extrinsic pressures, the low birth rate, low calf survival rate, and long inter-birth interval of humpback dolphins would further intrinsically preclude the sustainable survival of this population.

Zhang, P., Zhao, Y., Li, C., Lin, M., Dong, L., Zhang, R., . . . Li, S. (2020). An Indo-Pacific Humpback Dolphin Genome Reveals Insights into Chromosome Evolution and the Demography of a Vulnerable Species. *Iscience, 23*(10), 101640. https://doi.org/10.1016/j.isci.2020.101640

The Indo-Pacific humpback dolphin (*Sousa chinensis*) is a small inshore species of odontocete cetacean listed as Vulnerable on the IUCN Red List. Here, we report on the evolution of *S. chinensis* chromosomes from its cetruminant ancestor and elucidate the evolutionary history and population genetics of two neighboring *S. chinensis* populations. We found that breakpoints in ancestral chromosomes leading to *S. chinensis* could have affected the function of genes related to kidney filtration, body development, and immunity. Resequencing of individuals from two neighboring populations in the northwestern South China Sea, Leizhou Bay and Sanniang Bay, revealed genetic differentiation, low diversity, and small contemporary effective population sizes. Demographic analyses showed a marked decrease in the population size of the two investigated populations over the last ~4,000 years, possibly related to climatic oscillations. This study implies a high risk of extinction and strong conservation requirement for the Indo-Pacific humpback dolphin.

Section II: Ecology

Bao, M., Wang, X., Liu, W., Chen, H. L., Li, Y., Wu, F., . . . Huang, S.-L. (2019). Habitat Protection Actions for Coastal Delphinids in a Disturbed Environment with Explicit Information Gaps. *Ocean & Coastal Management, 169*, 147-156. https://doi.org/10.1016/j.ocecoaman.2018.12.017

Bridging information gaps in an animal's habitat configuration is an explicit challenge in planning habitat protection actions (HPAs) for marine megafauna species near sites of intense anthropogenic activity. This challenge is further complicated by inadequate field survey designs and data manipulation that likely bias habitat configuration baselines. In this study, the likely habitat configuration of Indo-Pacific humpback dolphins, *Sousa chinensis*, in the Chinese provinces of Fujian and Guangdong was projected using species distribution modeling (SDM). The influence of inadequate survey design and data manipulation of the baseline presentation was explored by comparing the SDM results from different datasets with current knowledge of humpback dolphin distributions in Chinese waters. Only the SDM based on data from systematically designed surveys projected a habitat configuration matching the current humpback dolphin distribution in China. The likely habitat configuration of humpback dolphins was characterized by high primary productivity and a shallow water depth. This study showed that ecosystem service losses, indexed by CO2 absorption, due to coastal alteration activities need to be factored into environmental impact assessments. Sound HPA practices include sharing information between research teams, mitigating the adverse impacts of anthropogenic activities, associating protected area networking with regional maritime spatial planning, monitoring coastal landscapes and seascape baselines, reducing land-based pollution, restoring degraded habitats for aquatic biota, and recovering land-to-sea connectivity. These measures require comprehensive coordination and collaboration between scientific research teams, policy representatives, NGOs/NPOs and stakeholder groups.

Chan, S. C. Y., Karczmarski, L., Lin, W., Zheng, R., Ho, Y.-W., Guo, L., . . . Wu, Y. (2023). An Unknown Component of a Well-Known Population: Socio-Demographic Parameters of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) at the Western Reaches of the Pearl River Delta Region. *Mammalian Biology, 102*(4), 1149-1171. https://doi.org/10.1007/s42991-022-00335-2

Quantifying demographic parameters and patterns of social dynamics is fundamental to understanding the population ecology of group-living animals and carries considerable conservation implications. In the Pearl River Delta (PRD) region, one of the world's largest, most urbanised and industrialised estuarine systems located on the southeast coast of China, Indo-Pacific humpback dolphins are under a multitude of anthropogenic pressures. While in Hong Kong, at the eastern perimeter of the region, these dolphins have been studied for many years, at the western reaches of the PRD they have received little research and conservation attention. In this study, with the application of mark-recapture and socio-demographic modelling techniques, we quantify population parameters, group dynamics and social structure, establishing socio-demographic baselines for this little known component of the longest-studied population of the genus *Sousa*. These dolphins live in a fluid fission-fusion society with markedly weak inter-individual affiliations. Individual ranging patterns and spatial preferences (e.g., foraging areas) appear to be among the key factors determining their grouping pattern and socio-spatial structure across the region, with several social clusters which, although discernible, especially at the peripheries of the region, frequently interact socially and overlap spatially. Currently, 914 dolphins inhabit waters of western PRD, but their estimated survival rates are below the previously estimated threshold needed for long-term survival as a viable demographic unit. These findings indicate high levels of environmental

stress and raise conservation concerns, especially in the face of manifold and growing anthropogenic pressure. This study calls for comprehensive assessments of cumulative anthropogenic impacts and for a critical revision of present conservation measures.

Dares, L. E. (2019). *Habitat Characteristics, Density Patterns and Environmental Niches of Indo-Pacific Humpback Dolphins (Sousa chinensis) of the Pearl River Estuary and Eastern Taiwan Strait.* (Doctor of Philosophy Ph.D.), Trent University Ontario, Canada. Retrieved from https://digitalcollections.trentu.ca/objects/etd-671

The purpose of this thesis is to quantify the habitat characteristics, density patterns and environmental niches of two groups of Indo-Pacific humpback dolphins: Chinese white dolphins (CWD) of the Pearl River estuary (PRE), and Taiwanese white dolphins (TWD, =Taiwanese humpback dolphin, THD) found in the eastern Taiwan Strait (ETS). Much work has already been done on the habitat use of CWDs in parts of the PRE, so the purpose of my first two chapters was to advance knowledge of the TWD to a comparable level. Chapter 2 contains the first published description of the relatively shallow, inshore, estuarine habitat of the TWD. General environmental characteristics and observed group sizes were consistent with other populations of humpback dolphins, and group sizes were not correlated with the environmental variables measured during surveys. Chapter 3 investigated density patterns of TWDs, finding spatiotemporal heterogeneity across the study area. Humpback dolphin densities fluctuated from year to year, but some parts of the study area were consistently used more than others. Environmental characteristics again did not influence dolphin densities, though more dolphins than expected were sighted in waters adjacent to major land reclamations, which may be related to the location of these areas close to major rivers. In Chapter 4, niches of the TWD and CWDs found in the PRE were compared using species distribution models, which indicated significant niche overlap. This may be due to niche conservatism maintaining similar fundamental niches between the two groups since their historical split >10,000 years ago, or a result of the intrinsic biotic factors that influence occurrence data affecting the hypervolume dimensions of each realized niche in similar ways. Geographic predictions indicate that most of the TWD's range has likely been surveyed, and that there may be connectivity between PRE humpback dolphins and at least one neighbouring putative population due to continuous predicted suitable habitat in waters that remain poorly surveyed. Overall, my thesis demonstrates that density patterns may vary over time, but on a broad temporal scale, these two allopatric groups of Indo-Pacific humpback dolphins have similar habitat requirements in geographically isolated, but environmentally similar locations.

do Amaral, K. B., Amaral, A. R., Ewan Fordyce, R., & Moreno, I. B. (2018). Historical Biogeography of Delphininae Dolphins and Related Taxa (Artiodactyla: Delphinidae). *Journal of Mammalian Evolution, 25*(2), 241-259. https://doi.org/10.1007/s10914-016-9376-3

Delphinine dolphins arose via a recent, rapid radiation, probably within the last four million years. Although molecular phylogenies are increasingly well resolved, patterns of morphology-ecology-geography are hard to link to phylogeny or to translate into taxonomy. Such problems might be tackled through understanding the drivers of the delphinine radiation. Here, we examine delphinine historical biogeography using the phylogeny of McGowen et al. (Mol Phylogenet Evol 53:891–906, 2009) as our working hypothesis. We used the "Spatial Analysis of Vicariance" method to delimit modern distribution patterns, including disjunctions involving sister nodes in the Delphininae. The analysis identified disjunct sister nodes, allowing some interpretation of Delphininae biogeography. The Central American Seaway

was probably an important gateway for early delphinids, but the succeeding "hard" barrier of the Panama Isthmus had little influence. Southern African waters form the Atlantic-Indo-Pacific gateway, which is sometimes considered a "soft" barrier because of the variation in the Benguela and Agulhas currents, in turn driven by tectonic changes and/or Pleistocene glacial and interglacial cycles. The latter cycles probably fragmented coastal habitats, allowing allopatric speciation. Geological patterns of turnover in Southern Ocean diatoms, which link to physical oceanic change, closely match the main cluster of delphinine divergences. The Eastern Pacific Barrier, and perhaps the associated Humboldt Current and equatorial "cold tongue," affect modern distributions, but cause and effect are poorly understood. Future research should involve molecular-morphological phylogenetics for all species, subspecies, and ecomorphs. Complete distributions must be known for all taxa to understand how vicariance and dispersal shaped the distribution of delphinines.

Dong, L., Caruso, F., Dong, J., Liu, M., Lin, M., & Li, S. (2021). Whistle Characteristics of a Newly Recorded Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Population in Waters Southwest of Hainan Island, China, Differ from Other Humpback Dolphin Populations. *Marine Mammal Science, 37*(4), 1341-1362. https://doi.org/10.1111/mms.12816

Indo-Pacific humpback dolphins (*Sousa chinensis*) use whistles to communicate with their conspecifics. Little is known about the acoustic repertoire of Indo-Pacific humpback dolphins in waters southwest of Hainan Island, a newly recorded population in 2014. In this study, whistles of Hainan humpback dolphin population were collected by using autonomous acoustic recorders. The fundamental frequencies and durations of whistles were in ranges of 0.71-21.35 kHz and 0.06-2.22 s, respectively. Significant intraspecific differences in duration and frequency of whistles were found between the Hainan population and the other geographically neighboring populations (in Chinese waters) or the population in Malaysia waters. Compared with other *Sousa* species, significant interspecific differences were also observed. Based on clustering analysis, the whistle parameters of neighboring populations were likely similar to each other. Significant differences were found between humpback dolphins in waters southwest of Hainan Island and those dolphins in the neighboring areas, supporting the hypothesis that this population may be independent. Ambient noise measurements in waters of Hainan Island, Zhanjiang, and Sanniang Bay showed that humpback dolphin populations may use whistles with longer duration, lower frequency, and fewer inflection points for more effective communication to adapt to a noisier environment.

Dong, L., Caruso, F., Lin, M., Liu, M., Gong, Z., Dong, J., . . . Li, S. (2019). Whistles Emitted by Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Zhanjiang Waters, China. *The Journal of the Acoustical Society of America, 145*(6), 3289-3298. https://doi.org/10.1121/1.5110304

Whistles emitted by Indo-Pacific humpback dolphins in Zhanjiang waters, China, were collected by using autonomous acoustic recorders. A total of 529 whistles with clear contours and signal-to-noise ratio higher than 10 dB were extracted for analysis. The fundamental frequencies and durations of analyzed whistles were in ranges of 1785–21 675 Hz and 30–1973 ms, respectively. Six tonal types were identified: constant, downsweep, upsweep, concave, convex, and sine whistles. Constant type was the most dominant tonal type, accounting for 32.51% of all whistles, followed by sine type, accounting for 19.66% of all whistles. This paper examined 17 whistle parameters, which showed significant differences among the six tonal types. Whistles without inflections, gaps, and stairs accounted for 62.6%, 80.6%, and 68.6% of all whistles, respectively. Significant intraspecific differences in all duration and frequency

parameters of dolphin whistles were found between this study and the study in Malaysia. Except for start frequency, maximum frequency and the number of harmonics, all whistle parameters showed significant differences between this study and the study conducted in Sanniang Bay, China. The intraspecific differences in vocalizations for this species may be related to macro-geographic and/or environmental variations among waters, suggesting a potential geographic isolation among populations of Indo-Pacific humpback dolphins.

Dong, L., Dong, J., Caruso, F., Zhao, L., & Li, S. (2021). Temporal Variation of the Underwater Soundscape in Jiaotou Bay, an Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Habitat Off Hainan Island, China. *Integrative Zoology, 16*(4), 477-498. https://doi.org/10.1111/1749-4877.12530

The underwater soundscape is an important ecological element affecting numerous aquatic animals, in particular dolphins, which must identify salient cues from ambient ocean noise. In this study, temporal variations in the soundscape of Jiaotou Bay were monitored from February 2016 to January 2017, where a population of Indo-Pacific humpback dolphins (*Sousa chinensis*) has recently been a regular sighting. An autonomous acoustic recorder was deployed in shallow waters, and 1/3-octave band sound pressure levels (SPLs) were calculated with central frequencies ranging from 25 Hz to 40 kHz, then were grouped into 3 subdivided bands via cluster analysis. SPLs at each major band showed significant differences on a diel, fishing-related period, seasonal, and tidal phase scale. Anthropogenic noise generated by passing ships and underwater explosions were recorded in the study area. The fish and dolphin acoustic activities both exhibited diel and seasonal variations, but no tidal cycle patterns. A negative significant relationship between anthropogenic sound detection rates and dolphin detection rates were observed, and fish detection rates showed no effect on dolphin detection rates, indicating anthropogenic activity avoidance and no forced foraging in dolphins in the study area. The results provide fundamental insight into the acoustic dynamics of an important Indo-Pacific humpback dolphin habitat within a coastal area affected by a rapid increase in human activity, and demonstrate the need to protect animal habitat from anthropogenic noises.

Hu, W.-C., Chen, C.-F., & Chou, L.-S. (2020). Acoustic Ecological Investigation of Estuary Habitat on Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in Yunlin, Taiwan. *The Journal of the Acoustical Society of America, 148*(4), 2773-2773. https://doi.org/10.1121/1.5147719

A sunspecies/population of Indo-Pacific humpback dolphins (IPHD, *Sousa chinensis*) lives in the shallow waters of Eastern Taiwan Strait. Their habitat is very close to the coast and suffering from the impact of human activities and marine pollution; the survival of this vulnerable group is at high risk. The long-term visual survey result shows that the Xinhuwei estuary has been an IPHD hot spot. Two Passive acoustic monitoring (PAM) stations with temperature sensors were deployed to detect IPHD sounds in the estuary habitat. During the past four seasons, underwater marine recorders and temperature-depth data loggers were deployed at two locations in the estuary of Xinhuwei creek, Yunlin, Taiwan. The total duration of valid data for each station is at least 19 consecutive days during each season. IPHD's click-trains and whistles were counted by a supervised detection method. The results show that the trend of click-trains (echolocation and foraging sounds) is positively correlated with sea temperature. The most active foraging behavior occurs during the daytime of summer. Whistles (social and communication sounds) are most common during spring. Except in winter, the number of click-trains and whistles are larger at the deeper measuring station (water depth of 11 m). This research was funded by Formosa Petrochemical Corporation.

Huang, S.-L., Wang, C.-C., & Yao, C.-J. (2018). Habitat Protection Actions for the Indo-Pacific Humpback Dolphin: Baseline Gaps, Scopes, and Resolutions for the Taiwanese Subspecies. *Aquatic Conservation: Marine and Freshwater Ecosystems, 28*(3), 733-743. https://doi.org/10.1002/aqc.2875

Information gaps resulting from incomplete data used to describe habitat configuration frequently hinder the efficacy of habitat protection action (HPA) for an animal with a wide distribution range. Such concerns are particularly important for the Indo-Pacific humpback dolphin, inhabiting disturbed coastal and estuarine habitats. This study inspected the likely habitat use of the Taiwanese humpback dolphin, an endemic subspecies that inhabits a highly disturbed habitat. Habitat use was evaluated using species distribution modelling with occurrence data from field surveys and remotely sensed oceanographic layers. Likely core habitats of the Taiwanese humpback dolphin were predicted near estuaries. The chlorophyll-a concentration was the primary factor affecting the distribution of the Taiwanese humpback dolphin. Bathymetry influenced the humpback dolphin distribution in the early 1980s, but became less important in the early 2010s. Significant sea surface temperature increases in the estuarine and coastal waters and chlorophyll- a concentration decreases in the inshore waters were observed from the 1980s to the 2010s, indicating declining ecosystem productivity and shifting ecosystem functions. These oceanographic changes may be associated with adverse consequences of coastal alterations in western Taiwan. 5. We propose revising the current HPA scope by refining the HPA zoning, integrating coastal and watershed management, implementing regulatory fishery management, and designing and conducting restoration measures in compromised habitats and watershed landscapes. The need to reassess the current baselines of habitat use and HPA complex for the humpback dolphin across its natural range has been addressed.

Hung, C.-T., Chu, W.-Y., Li, W.-L., Huang, Y.-H., Hu, W.-C., & Chen, C.-F. (2021). A Case Study of Whistle Detection and Localization for Humpback Dolphins in Taiwan. *Journal of Marine Science and Engineering, 9*(7). https://doi.org/10.3390/jmse9070725

In recent years, Taiwan's government has focused on policies regarding offshore wind farming near the Indo-Pacific humpback dolphin habitat, where marine mammal observation is a critical consideration. The present research developed an algorithm called National Taiwan University Passive Acoustic Monitoring (NTU_PAM) to assist marine mammal observers (MMOs). The algorithm performs whistle detection processing and whistle localization. Whistle detection processing is based on image processing and whistle feature extraction; whistle localization is based on the time difference of arrival (TDOA) method. To test the whistle detection performance, we used the same data to compare NTU_PAM and the widely used software PAMGuard. To test whistle localization, we designed a real field experiment where a sound source projected simulated whistles, which were then recorded by several hydrophone stations. The data were analyzed to locate the moving path of the source. The results show that localization accuracy was higher when the sound source position was in the detection region composed of hydrophone stations. This paper provides a method for MMOs to conveniently observe the migration path and population dynamics of cetaceans without ecological disturbance.

Li, S., Gao, H., Hao, X., Zhu, L., Li, T., Zhang, H., . . . Chen, B. (2018). Seasonal, Lunar and Tidal Influences on Habitat Use of Indo-Pacific Humpback Dolphins in Beibu Gulf, China. *Zoological Studies, 57*, e1. https://doi.org/10.6620/ZS.2018.57-01

Cetacean habitat use based on different environmental phases varies between species and geographies, and little is known about Pacific humpback dolphin habitat use in the Beibu Gulf. Here we aimed to identify seasonal, lunar and tidal influences on the spatial use of Beibu humpback dolphins based on two parameters: water depth and distance to an estuary. The ANOVA test indicated that habitat use was influenced by seasons and tidal phases, but not lunar phases. The humpback dolphins utilized shallow areas near an estuary throughout the wet season and high tides, and moved toward deeper water during the dry season and low tides. This habitat preference is likely synchronized with prey seasonal and tidal movements. The wet season and high tides bring abundant prey resources and increase accessibility to inshore shallow waters for humpback dolphins. The present study provides new information on regular habitat use by Indo- Pacific humpback dolphins, which is crucial for developing effective conservation strategies.

Lin, C. H., Lin, H. J., Suen, J. P., & Chou, L. S. (2021). Association between Estuary Characteristics and Activities of the Critically Endangered Indo-Pacific Humpback Dolphin (*Sousa chinensis*). *Frontiers in Marine Science, 8*. https://doi.org/10.3389/fmars.2021.577976

The Indo-Pacific humpback dolphin (*Sousa chinensis*) has been reported to prefer estuary habitats. This study explored the environmental factors affecting a critically endangered population off the coast of Yunlin, Taiwan. We measured dolphin sighting rates and estuary characteristics affected by the watershed, including seven physical factors (watershed rainfall, watershed runoff, estuarine turbidity, pH, salinity, temperature, and dissolved oxygen) and two biological factors (estuarine net primary production and chlorophyll a concentration), at the Hsinhuwei River estuary in Taiwan. Dolphin activity was measured by sighting rate and behavioral indices for feeding and traveling between 2017 and 2018. We observed that when the maximum net production increased alongside rising temperatures in spring, both the dolphin sighting rate and foraging activity increased. This trend was maintained until heavy rainfall or increased river runoff occurred during late summer, which resulted in high turbidity in autumn and winter. Turbidity was significantly negatively correlated with dolphin activity (sighting rate and foraging). Furthermore, we found that dolphin traveling positively correlated with the chlorophyll a concentration and maximum net production factors, which could attract dolphins expecting more abundant prey fish in the estuary supported by the high primary production. This study provides empirical evidence on how estuary characteristics affected by the watershed can affect the sighting rate and behavioral activities of Indo-Pacific humpback dolphins.

Lin, M., Liu, M., Dong, L., Caruso, F., & Li, S. (2022). Modeling Intraspecific Variation in Habitat Utilization of the Indo-Pacific Humpback Dolphin Using Self-Organizing Map. *Ecological Indicators, 144*. https://doi.org/10.1016/j.ecolind.2022.109466

Coastal cetaceans are recognized as ecologically important species and have been the target for environmental monitoring programs and conservation strategies. Although supervised models have increasingly been used to better monitor complexity relationships between cetaceans and their habitats, the development of unsupervised learning techniques that have significant advantages in visualizing, grouping and reducing the dimensionality of data has been overlooked. Here, using the unsupervised

artificial neural network of self-organizing map (SOM), we examined the intraspecific variation of habitat utilization among three geographically neighboring populations (waters southwest of Hainan Island abbreviated as WS Hainan, Sanniang Bay, and Zhanjiang waters) of the Indo-Pacific humpback dolphin (*Sousa chinensis*) in the northern South China Sea. The results showed that the population inhabiting in WS Hainan occupied a largest area with scattered patterns comparing to the other two in Sanniang Bay and Zhanjiang waters. The SOM analysis further showed that the examined populations in different waters have distinct habitat characteristics. *S. chinensis* in WS Hainan was sighted in deeper water with higher salinity, whereas the population in Sanniang Bay inhabited in estuary with lower pH and salinity. More complicated distributed patterns and environmental heterogeneity were observed in Zhanjiang waters, where the dolphins distributed contractively in a small area at the entrance of Zhanjiang Port and dispersed in another large area in Leizhou Bay. Correspondently, part of the sightings in Zhanjiang waters had similar habitat with those in WS Hainan, while others were reported in more inshore, deeper and muddied waters. Based on these findings, we hypothesized that *S. chinensis* can be divided into two ecotypes: estuarine and non-estuarine. Here, we confirmed that the SOM can well identify the habitat differentiation in *S. chinensis*, and therefore suggested it is a powerful modeling tool for cetacean monitoring program. Our findings contribute to a specific habitat conservation strategy that one integrated protected area would be better for *S. chinensis* in Sanniang Bay and Zhanjiang waters, while several small protected areas with connecting corridors were more suitable for population in WS Hainan.

Schormans, E. K. (2021). *Temporal and Spatial Characterization of Acoustic Activity Patterns of Indo-Pacific Humpback Dolphins (Sousa chinensis Chinensis) in Hong Kong Waters.* (Master of Science), Saint Mary's University, Halifax, Nova Scotia. Retrieved from https://library2.smu.ca/handle/01/29506.

Indo-Pacific humpback dolphins face a number of serious anthropogenic pressures in Hong Kong waters. Since the late 1990's, data has shown both a decline in their abundance and shift in their distribution, therefore obtaining a better understanding of their habitat use through passive acoustic monitoring is important. Twelve C-PODs deployed throughout their habitat from June 2018-July 2019 were able to provide data on diel, seasonal and geographical patterns in their acoustic activity; and location had the largest effect on the probability of detections. When acoustic and visual data were compared to characterize the ability of the C-PODs to detect dolphins and assess the relative efficacy of each detection method, little overlap was found between methods. Despite these limitations, the C-PODs are able to survey continuously and simultaneously over many areas and represent a valuable tool for long-term monitoring.

Section III: Population Abundance & Trends

Araújo-Wang, C., Wang, J. Y., Draghici, A. M., Ross, P. S., & Bonner, S. J. (2022). New Abundance and Survival Estimates for the Critically Endangered Taiwanese White Dolphin Indicate No Signs of Recovery. *Aquatic Conservation: Marine and Freshwater Ecosystems, 32*(8), 1341-1350. https://doi.org/10.1002/aqc.3831

Small populations of cetaceans with restricted ranges are particularly vulnerable to anthropogenic disturbances. The assessment of demographic parameters for these populations can provide meaningful insight into the ways in which they are being impacted by different threats. The Taiwanese white dolphin (TWD), *Sousa chinensis taiwanensis*, is a subspecies endemic to Taiwan and is classified as Critically Endangered. Multistate robust design mark–recapture models were 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 and the dolphins' use of their habitat were also explored. Abundance estimates varied from a maximum of 72 in 2010 (95% credible interval (CI) [65, 78]) to a minimum of 61 (95% CI [58, 64]) in 2017. In the oldest age category, abundance estimates varied from 10 (95% CI [10, 11]) in 2013 to 13 (95% CI [10, 13]) in 2016. Modelling showed that, over time, the abundance of dolphins in the oldest age group remained stable, while the remainder of the population, which includes reproductive individuals, experienced a steady decline. This decline is bound to affect the demographic recovery of TWD. Spatial heterogeneity indicated that some areas (i.e. with consistent high occurrences) likely represent important areas for biological functions of the TWD. This suggests that the recovery of the population may be enhanced with immediate and focused actions (such as the ban of gillnet fisheries) in these areas. However, with a small and declining population, reducing threats throughout their entire range is needed, including the new offshore windfarm development being constructed in and adjacent to the dolphin's range. Concerted actions to address known threats, continued monitoring of the population, and education of stakeholders are needed to prevent the extinction of the TWDs.

Chen, B., Gao, H., Jefferson, T. A., Lu, Y., Wang, L., Li, S., . . . Yang, G. (2018). Survival Rate and Population Size of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Xiamen Bay, China. *Marine Mammal Science, 34*(4), 1018-1033. https://doi.org/10.1111/mms.12510

The survival rate and population size of Indo-Pacific humpback dolphins (*Sousa chinensis*) in Xiamen, China, were estimated from vessel-based surveys during 2007-2010. Over the course of 202 d (881.1 observation hours), 76 groups were observed, and 52 dolphins were successfully identified. The Cormack-Jolly-Seber model estimated a constant apparent survival of 0.948 (95% CI: 0.922-0.966). Based on the open/POPAN model, the population size was estimated at 70 individuals (95% CI: 63-88). To explore the effect of uneven yearly survey effort, we pooled the data with seven sampling occasions with similar effort. This data set generated similar results of a constant survival of 0.957 (95% CI: 0.918-0.978) and population size of 72 (95% CI: 65-88). The small population size of the Xiamen humpback dolphins satisfies the Critically Endangered criterion of IUCN (D), and emphasizes urgency of the need for protection of the population. Improved monitoring efforts should be focused on enhancing our understanding of current status and evaluating impacts of all anthropogenic activities. A conservation plan for the population should also be drawn up.

Guo, L., Lin, W., Zeng, C., Luo, D., & Wu, Y. (2020). Investigating the Age Composition of Indo-Pacific Humpback Dolphins in the Pearl River Estuary Based on Their Pigmentation Pattern. *Marine Biology, 167*(4). https://doi.org/10.1007/s00227-020-3650-x

Age composition is an important population parameter for understanding and managing endangered species. There are very few studies involving cetaceans in estimating the age of individuals in the wild. In this study, we rigorously quantified the body color pattern of 37 stranded Indo-Pacific humpback dolphins (*Sousa chinensis*) of the Pearl River Estuary (PRE), which showed a significant, albeit with variability between individuals, correlation with age for both the males (between age 1 and 35, r2 = 0.84) and females (between age 1 and 25, r2 = 0.85). The population-averaged correlation (r2 = 0.85) was then applied to a large volume of photo-identification data (2011–2015) to estimate the age composition of the population occurring in the greater deltaic region, which further suggested a spatial difference in age composition and, therefore, a complex demographic process of the humpback dolphin across the region. In particular, the age composition of humpback dolphins in the east PRE (Lingding Bay) is severely aged. Finally, a population viability analysis with the consideration of observed age structure and the simulated age-specific fecundity suggested that 95.75% of the Lingding Bay humpback dolphins are projected to be lost after three generations. Given the sophisticated anthropogenic landscape in the PRE, we suggest that management units of the humpback dolphins should be clearly defined and the regional-specific conservation measures are much needed.

Javdan, S. (2022). *Combining Line Transect Sampling and Photographic-Identification Surveys to Investigate the Abundance and Distribution of Cetaceans.* (Doctor of Philosophy), Trent University, Peterborough, Canada. Retrieved from https://digitalcollections.trentu.ca/objects/etd-978

Line transect sampling and photographic-identification (photo-ID) are common survey techniques for estimating the abundance and distribution of cetaceans. Combining these approaches in the field ('combined LTPI' surveys) and using data from both components has the potential for generating comprehensive ecological knowledge that can be far more valuable than when these techniques and their data are used independently. In this thesis, I evaluated the results and conclusions from these two methods, used singly and in tandem, by investigating the population dynamics of two humpback dolphin (*Sousa chinensis* spp.) populations: the large and widely distributed Chinese white dolphin (*S. chinensis*) of the Pearl River estuary (PRE), and the small and geographically isolated subspecies of Taiwanese white dolphin (S. c. taiwanensis) in the eastern Taiwan Strait. Data from combined LTPI surveys in Hong Kong waters, at the eastern edge of the PRE, revealed a shift in space use with individuals spending less time in these waters than at the start of surveys. Data from combined LTPI surveys in Taiwan provided further support for a subspecies restricted to the central western waters, and identified a commonly used area at the northern part of their limited range. These two case studies demonstrated an overall efficacy of combined LTPI surveys in ecological studies of cetaceans. However, a multi-criteria analysis revealed that combined LTPI surveys with a line transect focus (e.g., Hong Kong) performed better than a LTPI survey with a photo-ID focus (e.g., Taiwan) when considering ecological aspects of the study populations, labour and data requirements, and ecological output. Even so, the photo-ID focus of Taiwan's monitoring program led to better assessments of individual space use patterns, likely helped by the Taiwanese white dolphin population's smaller size and intensive photographic effort. In both cases, the ecological output of combined LTPI surveys could be improved by expanding the study area or extending the field season or frequency of surveys. Overall, I showed that by following a set of general

guidelines, different iterations of the combined LTPI approach (i.e., photo-ID focus or LT focus) can serve as powerful tools for uncovering multi-dimensional ecological information on cetaceans.

Lin, W., Wu, L., Zeng, Q., Leng, X., Mo, Y., Serres, A., & Li, S. (2022). First Live Sighting of an Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in the Yellow Sea, the Northern-Most Record of the Species Range. *Journal of the Marine Biological Association of the United Kingdom, 102*(5), 333-337. https://doi.org/10.1017/s0025315422000534

An opportunistic sighting of an Indo-Pacific humpback dolphin (*Sousa chinensis*) was reported in the nearshore waters off the east Liaodong Peninsula, China. This is the first at-sea sighting in this area, and the northern-most sighting record of this species with a distance >3000 km away from the nearest described conspecific population located in the mid-China. The present sighting occurred in close proximity to the location at which another Indo-Pacific humpback dolphin was found by-caught in 2003. The sighted individual could not be identified through the existing photo-identification catalogues of this species in China (>3500 individuals). Therefore, we suggest that a population of Indo-Pacific humpback dolphins that was never reported might exist in the north of the Yellow Sea.

Liu, M., Lin, M., Dong, L., Xue, T., Zhang, P., Tang, X., & Li, S. (2020). Group Sizes of Indo-Pacific Humpback Dolphins in Waters Southwest of Hainan Island, China: Insights into Rare Records of Large Groups. *Aquatic Mammals, 46*(3), 259-265. https://doi.org/10.1578/AM.46.3.2020.259

Group size is important to both communication and social dynamics for manv marine mammal species. Thus, group size estimation is essential to the research of marine mammal behavior. Humpback dolphins (Soma spp.) are small odontocetes widely distributed in the western Pacific, Indian, and eastern Atlantic Oceans. Recent taxonomic revision shows the existence of at least four species in the genus Soma: Indo-Pacific humpback dolphin (S chinensis), Australian humpback dolphin (S sahulensis), Indian Ocean humpback dolphin (S plumbea), and Atlantic humpback dolphin (S teuszji). Here, Liu et al present baseline data on group size estimates of humpback dolphins around the SW Hainan Island and potential factors that might influence the group size estimation of these animals.

Liu, M., Lin, M., & Li, S. (2023). Population Distribution, Connectivity and Differentiation of Indo-Pacific Humpback Dolphins in Chinese Waters: Key Baselines for Improving Conservation Management. *Aquatic Conservation: Marine and Freshwater Ecosystems, 33*(4), 409-422. https://doi.org/10.1002/aqc.3930

Humpback dolphins (*Sousa* spp.), throughout their distribution ranges, are often designated as flagship species for coastal ecosystem conservation. Most of the early research on humpback dolphins was carried out in Chinese waters, and in the last two decades, numerous studies have provided abundant conservation-valuable findings.In this study, a systematic review was conducted to gain a comprehensive understanding of the distributional ecology of humpback dolphins in Chinese waters, to establish an updated national knowledge base about key conservation baselines on this flagship species.Currently, there are at least eight main distribution areas of humpback dolphins along the coast of southern China, representing a clear picture of place-based conservation units. However, the overall biogeographical distribution pattern is discontinuous, and existing marine protected areas are far from sufficient to protect these key areas for the survival of humpback dolphins.Based on the photo-

identification technique, cross-matching of humpback dolphin individuals revealed extremely low inter-population connectivity among most of the known populations. Genetic studies suggested that several examined populations have low haplotype diversity levels, with limited inter-population gene flow. Morphological and behavioural evidence also supports population differentiation among geographical locations.These findings provide key baselines for the promotion of conservation management initiatives for humpback dolphins in Chinese waters. All recognizable geographical populations, together with each key habitat, should be considered as independent conservation units. With small distribution areas, low genetic diversity and unfavourable geographical isolation, several populations may be at a high risk of regional extinction.A country-led scheme with cross-regional collaboration is required for science-based, action-focused and timely conservation efforts. Future conservation management initiatives should aim to increase or at least maintain key habitats, inter-population connectivity, population-level genetic diversity and effective population size.

Peng, C., Wu, H., Wang, X., Zhu, Q., Jefferson, T. A., Wang, C. C., . . . Huang, S. L. (2019). Abundance and Residency Dynamics of the Indo-Pacific Humpback Dolphin, *Sousa chinensis*, in the Dafengjiang River Estuary, China. *Marine Mammal Science, 36*(2), 623-637. https://doi.org/10.1111/mms.12663

Robust population size estimates are essential for informing population conservation status. Residency dynamics show population habitat use through time. Population size of Indo-Pacific humpback dolphins (*Sousa chinensis*) has been extensively investigated in Chinese waters, but their residency dynamics are rarely known. Mark-recapture analysis based on photo-identification records was applied to humpback dolphins in the Dafengjiang River Estuary habitat, one of the key habitats in the northern Beibu Gulf, China. Movement analyses based on lagged identification rate indicated the humpback dolphins spent, on average, 78.5 days inside and 46.9 days outside the survey area. Within the study area, the humpback dolphin abundance was 83 identifiable dolphins. A total of 353-430 humpback dolphins, estimated by POPAN modeling, were involved in this fluid habitat-use dynamic. Robust Design analysis showed strong seasonality in humpback dolphin abundance and emigration probability, implying a movement- and habitat-use pattern likely associated with spatiotemporal distribution of oceanographic characteristics and prey occurrences. Population surveys and conservation measures currently conducted in Chinese waters seldom consider seasonality in movements between habitat patches, which can be addressed by genetic analyses across habitats and cross-matching photo-identification records among neighboring habitats.

Wang, C.-C., Xu, Y., Li, N., Peng, C., Wu, H., & Huang, S.-L. (2021). Seasonal Distribution of the Indo-Pacific Humpback Dolphins: Implications for Coastal Habitat Management. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(3), 696-707. https://doi.org/10.1002/aqc.3479

Organisms utilize suitable habitat patches wherein they optimize fitness. For marine megafauna such as cetaceans, foraging is generally the explanation for their utilization distribution. However, an explicit link between cetaceans' distribution and spatio-temporal pattern of food resource is usually lacking. The Indo-Pacific humpback dolphin (*Sousa chinensis*; VU listed in the IUCN Red List) inhabits the coastal waters from south-east China to eastern India. Seasonal distribution of the humpback dolphin was explored in the northern Beibu Gulf, China. Sightings of the humpback dolphin were systematically collected at monthly intervals from 2012 winter till 2018 spring and used to derive distribution patterns

from kernel density estimates. Satellite remotely sensed net primary productivity (NPP) and bathymetry were used to present oceanographic characteristics in the study region. Seasonal variations were observed in oceanographic characteristics and spatial distribution of the humpback dolphin. Although the core distribution area of the humpback dolphin showed seasonal expansion and contraction, it had consistently higher NPP and shallower depth than the survey range throughout the seasons. Our findings indicate a clear profile of these two oceanographic characteristics (i.e. NPP and bathymetry) in the humpback dolphin's core distribution area. Food resource utilization could play an important role in the humpback dolphin's distribution within the study site. The seasonal dynamics imply that not only food abundance, but also efficiency in accessing/capturing the prey may affect distribution of the humpback dolphin. In the study site, human activities that can change regional topography and productivity of the coastal water through land reclamation, dredging, sand mining and bottom trawling, should be mitigated, regulated or avoided. Proactive conservation should incorporate catchment management of the main rivers to address potential sediment and nutrient load into the estuary to protect local habitat configuration in terms of NPP and bathymetry.

Section IV: Threats

Animal Welfare Institute. (2023). Expanded Port Portends Doom for Taiwanese White Dolphin. *AWI Quarterly*. Retrieved from https://awionline.org/awi-quarterly/spring-2023/expanded-port-portends-doom-taiwanese-white-dolphin

In 2002, a subspecies of Indo-Pacific humpback dolphin was identified in the coastal waters of western Taiwan: *Sousa chinensis taiwanensis*, now known as the Taiwanese white dolphin (TWD). Their skin, gray at birth, loses pigmentation as they age and turns white, but flushes bright pink from exertion. Their entire world is a narrow strip of water—only 3 kilometers wide—that hugs Taiwan's west coast, one of the most highly industrialized in the world. Scientists and policy experts have outlined management steps needed to recover these imperiled dolphins, but to date, the government and industries have done little, if anything, to save them.

Brownell Jr, R. L., Reeves, R. R., Read, A. J., Smith, B. D., Thomas, P. O., Ralls, K., . . . Wang, J. Y. (2019). Bycatch in Gillnet Fisheries Threatens Critically Endangered Small Cetaceans and Other Aquatic Megafauna. *Endangered Species Research, 40*, 285-296. https://doi.org/10.3354/esr00994

The conservation status of small cetaceans has significantly worsened since the 1980s, when the baiji was the only species of small cetacean listed as Endangered by IUCN. Now the baiji is almost certainly extinct and 13 other species, subspecies, or populations (hereafter units-to-conserve or units) of small cetaceans are listed as Critically Endangered (CR) on the IUCN Red List. Bycatch is the main threat to 11 of the CR units. Entanglement in gillnets contributed to the extinction of the baiji and is responsible for the imminent extinction of the vaquita. Unfortunately, there is no simple technical solution to the problem of bycatch of small cetaceans. If the 8 CR units with 100 or fewer remaining individuals are to be saved, conservation zones must be established where gillnets are eliminated and bans on their use are strictly enforced. Recent experience with the vaquita in Mexico demonstrates that enforcement of such conservation zones can be very difficult. Ineffective enforcement is also a problem for at least 4 of the other CR units. Time is very short and, unless major efforts are made now to address the bycatch problem, the prospects for CR small cetaceans and other at-risk aquatic megafauna are grim. The ultimate long-term solution to the bycatch problem is the development of efficient, inexpensive, alternative fishing gear that can replace gillnets without jeopardizing the livelihoods of fishermen. Good fishery governance and the direct involvement of fishing communities are also essential to the successful conservation of most threatened populations of small cetaceans.

Chan, S. C. Y., & Karczmarski, L. (2019). Epidermal Lesions and Injuries of Coastal Dolphins as Indicators of Ecological Health. *Ecohealth, 16*(3), 576-582. https://doi.org/10.1007/s10393-019-01428-0

Humpback dolphins (genus *Sousa*), obligatory inshore delphinids, are frequently exposed to adverse effects of many human activities. In Hong Kong, one of the world's most urbanised coastal regions, ~ 50% of the dolphins suffer from at least one type of epidermal lesions, likely related to anthropogenically degraded habitat. Furthermore, one in every ten dolphins has physical injuries indicative of vessel collisions, propeller cuts and fishing-gear entanglements. As top predators with long lifespan, dolphins are good "barometers" of marine environment and their compromised health conditions are symptomatic of increasingly degraded ecological conditions of coastal seas, especially in rapidly developing regions of fast-growing economies.

Dearden, A. (2020). When 'Clean Energy' Comes up Short: Wind Farms Threaten Taiwanese White Dolphins. Retrieved from https://ocean.org/blog/when-clean-energy-comes-up-short-wind-farms-threaten-taiwanese-white-dolphins/

In the Eastern Taiwan Strait, between China and Taiwan, 22 large wind turbines stand tall above the waters. Now in operation, these giants generate 128 MW of “green” energy, of which Taiwan is desperate for, to replace coal, oil and nuclear power generation. Hundreds more turbines (5,700 MW) are planned for installation offshore by 2025[1], and another 1,000 MW will be added annually thereafter, which will make this location one of the world’s largest wind farms. But this “green energy” may exact a toll on the environment. The continued windfarm construction could result in the extinction of Taiwan’s only endemic marine mammal, the Taiwanese white dolphin. The harsh reality is that the construction of windfarms that create fishery exclusion zones will push gillnet fishers inshore into prime dolphin habitat. This will exacerbate the existing threat from fisheries interactions thereby resulting in a significantly increased risk of entanglement and death.

Guo, L., Zhang, X., Luo, D., Yu, R. Q., Xie, Q., & Wu, Y. (2021). Population-Level Effects of Polychlorinated Biphenyl (Pcb) Exposure on Highly Vulnerable Indo-Pacific Humpback Dolphins from Their Largest Habitat. *Environmental Pollution, 286*, 117544. https://doi.org/10.1016/j.envpol.2021.117544

While polychlorinated biphenyl (PCB)-related risks have been reported at the cellular, organ, and individual levels in some marine mammals, studies quantifying the PCB-associated population-level effects are limited. Here, we combined chemical analysis and individual-based model simulation to investigate the impact of PCBs on the Indo-Pacific humpback dolphin (sub)population from the Pearl River Estuary (PRE). An annual PCB accumulation rate of 0.29 +/- 0.07 mg/kg lipid per year was estimated based on the measured age-specific male data as males continue to accumulate PCBs throughout their lifetime, without depurating contaminant loads. Using the Taiwan Strait dolphin population with low PCBs as a baseline, we compare our model simulations in PRE population to estimate relative population impacts of PCBs and other stressors. When using the current vital rates of the PRE dolphins which have been affected by PCBs and other stressors (e.g., underwater noise, prey limitation, etc.), our simulations revealed a substantial decline (8.1%) in the annual population growth rate (lambda) of PRE metapopulation compared to baseline over the next 100 years. At the estimated PCB accumulation rate, the PCB-mediated effects on calf survival and immunity would cause a slight decline (0.9%) in lambda relative to baseline. Our findings suggest a relatively limited impact of PCBs on the long-term survival of PRE dolphins among all stressors. However, it should be noted that even under model simulations where dietary PCBs were eliminated, humpback dolphins would still need a long time to reduce their PCB burdens to a relatively "safe" level through biological cycling. Considering that the baseline vital rates might also have been affected by PCBs and other stressors, our results are considered relative rather than absolute. This study provides a starting point for quantifying population-level consequences of contaminant exposure on humpback dolphins, although more efforts are needed to perfect this type of analysis.

Ho, Y., Wu, P. Y., Chou, L. S., & Yang, W. C. (2023). Skin Marks in Critically Endangered Taiwanese Humpback Dolphins (*Sousa chinensis taiwanensis*). *Animals, 13*(4). https://doi.org/10.3390/ani13040608

As long-lived apex predators, Indo-Pacific humpback dolphins (*Sousa chinensis*) are key indicators of marine coastal environmental health. Skin marks can be observed on dorsal body surfaces that are visible during mark-recapture studies that rely on photo-identification (photo-ID) methods. Skin mark prevalence may be an indicator of environmental or anthropogenic stressors in the ecosystem, which may lead to individual and/or population-level health concerns. The prevalence of marks of anthropogenic origin was assessed in the Critically Endangered *S. chinensis taiwanensis* population along the coasts of central Taiwan. Fifty, twenty-eight, and thirty-four individuals were identified in 2018, 2019, and 2021, respectively. At least one category of injuries was observed in 47 of 57 distinctive individuals (82%), and adults showed a higher prevalence of deep injuries than the other coloration stages. At least one category of skin lesion was observed in 33 of 57 distinctive individuals (58%), and high prevalence of skin lesions was found in mature individuals. Given the difficulty in taking direct observations, skin mark prevalence is proposed as a proxy for estimating habitat health and anthropogenic stressors upon *S. chinensis taiwanensis*. The moderate-to-high prevalence of skin marks in this study was designated as a warning of risks. This study provides important updated information for the assessment of the health and survival of this population. More effective management measures are urgently needed to reverse the observed population decline.

Hu, W.-C., Siddagangaiah, S., Chen, C.-F., & Pieretti, N. (2022). Impact of Vessel Transit on Vocalizations of the Taiwanese Humpback Dolphin. *Diversity, 14*(6). https://doi.org/10.3390/d14060426

Recent offshore windfarm development has led to increased vessel traffic in the Eastern Taiwan Strait, which is part of the habitat of the critically endangered Taiwanese humpback dolphin (*Sousa chinensis taiwanensis*). However, data on possible effects on the behavior of this endemic subspecies are lacking to date. In this study, we observed Taiwanese humpback dolphins' acoustic behavior associated with shipping noise and analyzed their whistles and clicks before, during, and after vessel transit. Before vessel transit, the median rate of dolphin whistles and clicks was 100 and 1550 counts per minute, which significantly reduced to less than 8 and 170 counts per minute during and after vessel transit. Dolphins produced significantly shorter whistles during (0.07 s) and after (0.15 s) vessel transit. The vocalizing behavior of the Taiwanese humpback dolphin may be affected by vessel transit, which, if sustained, could possibly influence the individual communication and feeding success of the population. Implementing measures such as re-routing of the vessel lanes and regulating the speed of the vessel traffic in the habitat are proposed to overcome the influence of vessel noise on Taiwanese humpback dolphins.

Huang, S. L. (2022). Unstated Impacts of the Green Energy Industry on the Habitat of a Coastal Delphinid: Turbid-Turbulent Wakes Induced by Offshore Wind Turbine Foundations. *Aquatic Conservation: Marine and Freshwater Ecosystems, 32*(11), 1787-1796. https://doi.org/10.1002/aqc.3888

Offshore wind farms (OWFs) are a green energy solution to reducing CO2 emissions, but often encroach on major habitats of coastal delphinids. Clustered OWF construction in shallow waters may have cumulative negative impacts on coastal delphinids and marine ecosystems. Although the impacts of

piling noise have been discussed extensively, the potential impacts of oceanographic alterations induced by wind turbine foundations are rarely discussed. Two OWFs were constructed near the core habitat of a critically endangered subspecies of humpback dolphin (*Sousa chinensis taiwanensis*) in the eastern Taiwan Strait. Turbid-turbulent wakes induced by wind turbine foundations were inspected using Landsat images. Sighting rates of the humpback dolphin that were obtained from boat-based line-transect surveys near the northern OWF (OWFn) since the late 2000s were examined. Indicators of surface turbidity were used to highlight turbid-turbulent wakes extending in the direction of the main current. Sighting rates of the humpback dolphins near the OWFn have been declining since the 2000s, but decreased significantly after the OWFn was constructed and began operating. The long-term decline in sighting rates implies an alarming decline in the population size of humpback dolphins. Decreased sighting rates after the OWFn installation indicate the reduced utilization of a once-important habitat. Offshore wind farm construction may influence prey abundance and composition and cause acute stress from piling noise; operational noise may mask the chorus of prey fish and turbid-turbulent wakes may disturb the benthic ecosystem. Site selection committees for future OWFs should avoid the habitats of coastal delphinids and areas subject to strong ocean currents. Ecological impact assessments for OWF projects should examine the impacts of turbulent wakes on benthic ecosystems and of acoustic disturbance on marine mammals. Long-term environmental monitoring programmes are recommended, which can be funded by wind energy companies as a compensatory measure.

Huang, Y. H., Hung-Hsu, Y., Su, I. Y., Zhang, Y. C., Hung, C. T., Chen, C. F., & IEEE. (2019). *Autonomous Mobile Acoustic Monitoring System Simulation and Implementation*. Paper presented at the 2019 OCEANS Marseille, Marseille, France. https://IEEExplore.IEEE.org/abstract/document/8867088

Due to the potential of the offshore wind energy in the Taiwan Strait, the development of the offshore wind farm is cost-effective. However, the expected develop area for potential offshore wind farms has overlapped with the habitat of the *Sousa chinensis* (also called Indo-Pacific Humpback Dolphin or Chinese White Dolphin). Therefore, to know if there are dolphins in the construction area is the most important. This paper provides a process for checking if there are dolphins in the specific area and using an unmanned surface vehicle to track the source and find the area they are. This process has four main topics, including real-time dolphin whistle detection, underwater acoustic source direction calculate, source tracking behavior (STB) and real-time shoreside monitoring system of the surface vehicle. The whole system was developed using the open source middleware MOOS-IvP and testing in the embedded system (NVIDIA Jetson TX1). The whole system was implemented and successfully tested in the field experiment using artificial dolphin sound.

Hung, P.-Y. (2020). Placing Green Energy in the Sea: Offshore Wind Farms, Dolphins, Oysters, and the Territorial Politics of the Intertidal Zone in Taiwan. *Annals of the American Association of Geographers, 110*(1), 56-77. https://doi.org/10.1080/24694452.2019.1625749

The development of offshore wind farms has been a way for the state to repackage national development projects using green energy discourses. In Taiwan, where the further development of nuclear power is suspended due to public antinuclear sentiment, offshore wind farms have been heavily promoted as a way of meeting electricity demand. The planned site for offshore wind farms, mainly the intertidal zone along the coast of Changhua County, overlaps with both oyster farms and the habitat of Taiwanese humpbacked dolphins, categorized as a critically endangered species by the International

Union for Conservation of Nature. This has resulted in a clash between conserving the oyster farming landscape, protecting an endangered species, and developing green energy. Facing this dilemma, pro-wind farm discourses that highlight concerns about global climate change have gradually supplanted those stressing the welfare of oysters and dolphins, even though the latter have been used successfully as local icons by movements opposing previous development projects on the intertidal zone. This article reconsiders the politics of territorialization implied by the "green" label affixed to offshore wind farm projects and other forms of green energy in general. As such, the meaning of offshore wind farms, as a newly discovered energy resource, is intertwined with the changing meanings of both dolphins and oyster farms, as rival nonhuman objects of resource exploitation and natural conservation. The territorialization of such resources in the emerging discursive space of green energy has proceeded via relational placemaking with nonlinear connections among multiple human and nonhuman elements. Key Words: conservation, intertidal zone, landscape, renewable resources, resource frontier.

Ko, Y., Coffman, M., Mulvaney, D., Copping, A., Wang, H.-W., & Barrett, B. (2022). 'Conflicts of Greens' in Renewable Energy Landscapes. In *The Routledge Handbook of Sustainable Cities and Landscapes in the Pacific Rim.* Y. Yang & A. Taufen (Eds.), Retrieved from https://www.taylorfrancis.com/chapters/edit/10.4324/9781003033530-38/conflicts-greens-renewable-energy-landscapes-yekang-ko-makena-coffman-dustin-mulvaney-andrea-copping-hsiao-wen-wang-brendan-barrett

The magnitude of renewable energy deployment needed to meet the challenges of climate change means localities are pursuing large-scale projects – often in more remote and rural areas, and in oceans and waterways. Although these facilities produce much 'greener' energy sources than fossil fuel power plants, their siting often poses conflicts with wildlife habitat, other local environmental impacts, as well as social and cultural resources in communities. Poorly sited projects can lead to concerns for 'energy justice', where negative impacts fall more heavily upon marginalized communities. Given this challenge, this chapter presents a comprehensive framework to address and mitigate this emerging 'conflicts of greens'. It drew upon lessons from large-scale renewable energy projects across the Pacific Rim, including California, Hawai'i, Japan, Taiwan, and Korea. Case studies illustrate a range of renewable energy types as well as highlight considerations for impacts to vulnerable communities. We examine the cases successes and failures related to spatial and community planning, to identify criteria for a generalizable renewable energy planning framework. It encompasses having a robust public process to shape renewable energy siting, including ample pre-construction data collection and analysis of impacted species and communities, as well as measures for adaptive management.

Lin, C.-H., & Chou, L.-S. (2021). Rapid Changes in Environmental Factors Could Affect the Distribution of Taiwanese Humpback Dolphins (*Sousa chinensis taiwanensis*) Off the Coast of Yunlin, Taiwan. *Taiwania, 66*(2), 184-192. https://doi.org/10.6165/tai.2021.66.184

A small population of fewer than 80 *Sousa chinensis taiwanensis* inhabits the western coast of Taiwan. To explore the relationship between environmental factors (water depth, temperature, salinity, turbidity, and pH) and distribution patterns of dolphins, this study was conducted in Yunlin, which has been one of the population's core areas despite being subject to heavy industrial development. 242 day-surveys were conducted along four parallel transect lines between 2008 to 2018, during which sightings of 274 dolphin groups of this species were recorded. The standardized dolphin sighting rate (groups/100km) was used as an index for comparison. Contrasting to the roughly steady distribution in

east-west gradient, the north-south gradient exhibited substantial and varied temporospatial changes among three sections (north, middle, and south) off the coast of Yunlin and among three periods. Dolphin sighting rate during spring-summer was significantly higher than that during autumn-winter. Taking data from inshore surveys for long term comparison, we found that sighting rates at the middle section remained high and relatively stable (around 2-4.6), whereas the rates in the other two sections exhibited opposite trend with high fluctuations, e.g. drastically fluctuated between 0-3.4 in the northern section, while from 3.36 declined to 0.35 in the southern section. We further discovered that rapid changes in three environmental factors, including turbidity, pH, water depth and construction disturbance, could play key roles on dolphin distribution patterns, and can serve as good indicators for habitat suitability for this vulnerable subspecies.

Lu, Y., Liu, G., Cheung, W. W. L., Xian, Y., Chen, W., & Yu, D. (2023). Anthropogenic Footprints Are Invading Global Habitats of Indo-Pacific Humpback Dolphins. *Geography and Sustainability, 4*(1), 58-69. https://doi.org/10.1016/j.geosus.2022.12.001

As ecologically fragile areas, coastal zones are affected by both anthropogenic activities and climate change. However, the impacts of these factors on large nearshore mammals, such as Indo-Pacific humpback dolphins (IPHDs, *Sousa chinensis*), are poorly understood. Here, modeling revealed that the suitable habitats of IPHDs are affected mainly by the sea surface temperature (SST), and the habitat suitability decreases as the distance to the nearest coastline increases. In addition, anthropogenic activities involving demersal fishing, contamination and shipping have narrowed IPHD habitats and reduced the habitat suitability. We found that climate change will further narrow suitable habitats located farther than 7 km from coastlines and trigger habitat losses in the eastern Taiwan Strait by 2090–2100 under the Representative Concentration Pathway (RCP) 8.5 scenario. The projected decreases in habitat suitability and area emphasize the urgency of establishing connected marine protected areas (MPAs) while considering climate change, intergovernmental cooperation, and public involvement.

Ross, P. S., Araujo-Wang, C., Barrett-Lennard, L., Chen, B., Dares, L., Dungan, S., . . . Rose, N. A. (2018). *Mitigating the Impacts of Offshore Windfarms on the Taiwanese White Dolphin (Sousa chinensis taiwanensis).* Taipei, Taiwan. Retrieved from https://awionline.org/sites/default/files/uploads/documents/TWD-Windfarm-Workshop-Report-2018.pdf

Large-scale offshore windfarms are planned for the eastern Taiwan Strait, an area adjacent to, or in, the priority habitat for the Critically Endangered Taiwanese white dolphin (*Sousa chinensis taiwanensis*). Noise disturbance has been described as one of the five major threats to the recovery of this isolated population, which has a restricted range along the west coast of Taiwan. Since sound transmits readily over large distances underwater, the construction and operation of 600 to 1000 wind turbines may have severe impacts on the remaining dolphins (which number fewer than 75) and may lead to their extinction. The Eastern Taiwan Strait *Sousa* Technical Advisory Workoing Group (ETSSTAWG) was asked by the Taiwanese conservation group, Wild at Heart, to convene an applied international workshop to characterise the nature and extent of this additional threat and to describe potential solution-oriented practices that would mitigate this threat. Experts from around the world met in Taipei, Taiwan, on 17-20 April 2017. The group shared the latest findings from their disciplines, including from the relevant scientific literature; reviewed and discussed the threats posed by the proposed windfarm projects to

the very small population of Taiwanese white dolphins in their restricted range; and devised a toolbox for local 'best practices' for industry and government managers to apply to project plans, reviews, and operations. Central among the principles developed for consideration were: 1)Locate the greatest threats resulting from the turbines away from areas where dolphins are found; 2) Design engineering practices that are specific to the Taiwanese white dolphin, its habitat, and its specific vulnerabilities, to reduce noise disturbance during construction, operation, and decommissioning; 3) Work with commercial fishers to reduce the threats of fisheries interactions now and during windfarm construction and operation, since these activities may exacerbate the current impacts of fisheries. The group concluded that it will be necessary to directly assess and monitor the impacts from windfarm construction and operation on the Taiwanese white dolphin, in the context of its specific vulnerabilities as a small population with a restricted range. Taiwan should develop its own set of best practices for windfarm development because following textbook examples for abundant, widely-ranging species (such as the harbour porpoise, Phocoena phocoena, in the North Sea) will not be effective. The group converged on a win-win solution to mitigate the impacts of fisheries, the most pressing threat facing the Taiwanese white dolphin. Should windfarm proponents embark on a partnership with fishers so as to protect dolphins wherever they be encountered, there exists the potential for this sector to contribute to the long term rcovery of the Taiwanese white dolphin population. If construction and operation of offshore windfarms are done properly, in ways that effectively mitigate their impacts, as well as the impacts of exisiting threats, these developments offer the promise of clean energy and increased domestic energy security in Taiwan, as well as hop for the Taiwanese white dolphin.

Serres, A., Lin, W., Clua, E. E. G., Lin, M., Liu, M., & Li, S. (2021). Evidence of Interactions between Sharks and Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in the Northern South China Sea. *Marine Mammal Science, 38*(3), 1262-1271. https://doi.org/10.1111/mms.12902

Understanding the factors that impact animal behavior, distribution, habitat selection, and use is essential to increase knowledge of population dynamics. Among factors shaping these dynamics, predation pressure plays a preponderant role by influencing the group structure and composition (Kiszka et al., 2011; Norris & Dohl, 1980), habitat use (Gowans et al., 2007; Heithaus & Dill, 2002, 2006; Srinivasan et al., 2010; Wrangham & Rubenstein, 1986), reproductive strategies (Fearnbach et al., 2011), and social structures (Kiszka et al., 2015) of animals. The relative importance of predation pressure, however, may vary between species or populations depending on the probability of interacting with predators (Heithaus & Dill, 2006; Kiszka et al., 2011; MacLeod et al., 2007), and should therefore be evaluated on a case-by-case basis. Six populations of Indo-Pacific humpback dolphins have been identified in Chinese waters with little interpopulation exchanges, if any (Jefferson & Smith, 2016; Tang et al., 2021). These dolphins live in shallow coastal, sometimes estuarine environments and exhibit high site fidelity (Xu et al., 2015). Several widely distributed species including bull sharks (Carcharhinus leucas), tiger sharks (Galedocerdo cuvier), sixgill sharks (Hexanchus griseus), and white sharks (Carcharodon carcharias) have been documented in the South China Sea (Arai & Azri, 2019; Compagno, 1997; Lam & Sadovy de Mitcheson, 2011; Talaue-McManus, 2000). These species have been suggested to be responsible for most shark-inflicted injuries on dolphins in other locations (Castelblanco-Martínez et al., 2021, Corkeron et al., 1987; Heithaus et al., 2001a, 2006; Smith et al., 2018), but except for the Taiwan population, sharkdolphin interactions in the South China Sea have not yet been assessed. In the present study, we investigated the occurrence of shark-inflicted injuries on Indo-Pacific humpback dolphins from three locations in the northern South China Sea, based on a long-term photo-identification (photo-ID) survey effort, to evaluate the potential interactions between dolphins and sharks in these areas.

Wang, C.-M., & Chien, K.-H. (2020). Mapping the Subaquatic Animals in the Aquatocene: Offshore Wind Power, the Materialities of the Sea and Animal Soundscapes. *Political Geography, 83*. https://doi.org/10.1016/j.polgeo.2020.102285

This paper examines the controversy around marine animal management in Taiwan Strait, where the sea has been territorialized by offshore wind power developers. Concerns have been focused on the impacts of pile driving noise on the Taiwanese white dolphin which is on the IUCN list of extremely endangered species. To deal with the problem, both state and developers have been involved in volumetric practices which attempt to render the marine mammals knowable, and in turn, governable. While recent work on volumetric thinking has revealed that power is exercised through volume, we contend that insufficient attention has been given to those lively 'non-human' subjects living in the volumetric spaces. Inspired by recent scholarship on animal atmospheres and the wet ontologies, we argue that marine animals are sentient beings that cannot be known, or mapped, by the state-corporate volumetric practices which are mainly based on scientific experiments, conducted in isolated social contexts. To illustrate this, we draw on assemblage thinking and develop the idea of marine animal soundscapes. We suggest that marine animal soundscapes exist only through the embodied experience of a sensory, marine animal body, which is able to affect, and learn to be affected by, others, through non-linguistic 'signs', such as sound. We maintain that animal soundscapes are shaped by social, ecological and material circumstances, of which, the materialities of the sea, such as its liquidity, rapidity and fluidity, are of great importance. With an emphasis on the subaquatic animal soundscapes, our approach intends to extend social relationality to non-humans and calls for an ontology, distinct from the one with which existing volumetric analysts work.

Wang, X., Jutapruet, S., Huang, S.-l., Turvey, S., Wu, F., & Zhu, Q. (2018). External Injuries of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Xiamen, China, and Its Adjacent Waters as an Indicator of Potential Fishery Interactions. *Aquatic Mammals, 44*(3), 285-292. https://doi.org/10.1578/am.44.3.2018.285

Interactions between marine mammals and fisheries have been reported worldwide and are probably the greatest conservation concern for cetaceans. The International Whaling Commission has recognized that mortality in fisheries will likely continue to pose a threat to marine mammal populations in the future, as these interactions are increasing in frequency and intensity, especially to species living in coastal and estuarine habitats. Although entanglements in fishing gear often result in fatality for marine mammals, many individuals survive these interactions but are often left with non-fatal, though potentially severe, wounds or scars. Entanglement in fishing gear is one of four major sources of such scars and wounds, which include completely or partially collapsed dorsal fins, missing dorsal fins, missing flukes, various scar markings, and skin ulcerations. Other sources of scars include teeth marks from inter-/intraspecific interactions, biting wounds from predators such as sharks and killer whales (*Orcinus orca*), and vessel collisions or propeller strikes.

Winkler, R. (2020). When “Green” Energy Meets Biodiversity: How Taiwan’s Iconic White Dolphins Face Possible Extinction. *Taiwan Insight*. Retrieved from https://taiwaninsight.org/2020/11/13/when-green-energy-meets-biodiversity-how-taiwans-iconic-white-dolphins-face-possible-extinction/

In terms of biodiversity, Taiwan ranks near the top of all countries with past natural historians referring to Taiwan as “the Galapagos of Asia.” For nearly forty years of martial law, most of the general

population other than fishers and soldiers were kept away from the oceans for purported security concerns. However, as the Taiwan government becomes more mature in its self-discovery, particularly during the past two and a half decades, it has rediscovered that we are an island nation. Many policy initiatives reflect this, significantly the creation of a cabinet-level Ocean Affairs Council in 2018, a 4 June 2020 white paper and Premier Su Tseng-chang's "pledge to respect the sea."

Wright, A. J., Araujo-Wang, C., Wang, J. Y., Ross, P. S., Tougaard, J., Winkler, R., . . . Reeves, R. R. (2020). How 'Blue' Is 'Green' Energy? *Trends in ecology & evolution, 35*(3), 235-244. https://doi.org/10.1016/j.tree.2019.11.002

Often perceived as environmentally benign, 'green' renewable energy technologies have ecological costs that are often overlooked, especially those occurring below the waterline. After briefly discussing the impacts of hydropower on freshwater and marine organisms, we focus this review on the impacts of marine renewable energy devices (MREDs) on underwater marine organisms, particularly offshore wind farms and marine energy converters (e.g., tidal turbines). We consider both cumulative impacts and synergistic interactions with other anthropogenic pressures, using offshore wind farms and the Taiwanese white dolphin (*Sousa chinensis taiwanensis*) as an example. While MREDs undoubtedly can help mitigate climate change, variability in the sensitivity of different species and ecosystems means that rigorous case-by-case assessments are needed to fully comprehend the consequences of MRED use.

Wu, H., Li, Q., Wang, C., Wu, Q., Peng, C., Jefferson, T. A., . . . Huang, S.-L. (2022). Bycatch Mitigation Requires Livelihood Solutions, Not Just Fishing Bans: A Case Study of the Trammel-Net Fishery in the Northern Beibu Gulf, China. *Marine Policy, 139*. https://doi.org/10.1016/j.marpol.2022.105018

Fishery bycatch is an acute threat endangering survival of coastal delphinids. While mitigation measures aim at restricting fishing activities by spatial, temporal and gear management, these measures undoubtedly decrease fishery production and trigger conservation-livelihood conflicts, particularly in artisanal fisheries associating with 'poverty traps'. This study surveyed spatio-temporal activities of trammel-net fisheries and fishers' education-household livelihood background in a rural fishing village in the northern Beibu Gulf, China to investigate dolphin-fishing interactions and the willingness of fishers to exit fishing and their ability to engage in alternative livelihoods with regard to fishers' household livelihood baselines. Within the survey region, overlap between humpback dolphins and trammel-net fishing was high (at least 43.35%). Spatial closures through MPAs would help reduce 46.9% of trammel-net fishing. While labor force aging and low education levels were observed in fishing, farming and casual labor livelihoods, fishers showed an unwillingness to exit fishing and inability to engage in alternative livelihoods. The suspended MPA plan should be enacted immediately to reduce fishing-gear entanglements. Implementation of a permanent trammel-net ban or 'exit-fishing' policy, however, should address the household livelihood consequences to fishers. Though ecotourism is often recommended to fishers as an alternative livelihood, low education level hinders fishers' ability to engage in dolphin-watching tourism in a sustainable manner. Fishing-gear modification, an ad hoc training program focusing on sustainable ecotourism, motivating and mobilizing local people in MPA monitoring and management, and integration of traditional ecological knowledge into livelihood diversification programs are critical components to deal with the complexity of this issue.

Zhang, X., Xie, Q., Yu, R. Q., & Wu, Y. (2022). Temporal Trends of Alternative Halogenated Flame Retardants in Humpback Dolphins from the South China Sea. *Environmental Science & Technology, 56*(8), 5037-5048. https://doi.org/10.1021/acs.est.1c08636

Increasing human activities are altering marine ecosystems, which may have ramifications for predator feeding ecology and, thus, the degree of contaminant exposure. We conducted the first investigation of spatiotemporal trends for nine alternative halogenated flame retardants (AHFRs) and their relations with dietary variations in 128 humpback dolphins that were stranded along the northern South China Sea during 2003-2020. We detected the highest levels of seven major AHFRs in humpback dolphins compared with the results reported in cetaceans globally, indicating high AHFR contamination in coastal regions of South China. Dolphins that were stranded near urban regions generally contained higher AHFR concentrations than those that were stranded near rural areas, mirroring the environmental trends of AHFRs occurring in this area. Model-generated diet estimates suggested that humpback dolphins have reduced their consumption of high trophic-level prey in recent years, likely attributable to overfishing-induced prey decline in this region. After adjusting AHFR concentrations due to diet changes, the temporal trends of AHFR contamination in humpback dolphins were only slightly altered. Our results suggest that increasing discharges of AHFRs into the South China Sea during the 2000s and 2010s may have had a greater influence on AHFR trends in humpback dolphins than dietary shifts.

Section V: Conservation Efforts

Animal Welfare Institute. (2018). Taiwanese Humpback Dolphin Protected under U.S. Endangered Species Act [Press release]. Retrieved from https://awionline.org/press-releases/taiwanese-humpback-dolphin-protected-under-us-endangered-species-act

The National Marine Fisheries Service today protected rare Taiwanese humpback dolphins, listing the species as "endangered" under the Endangered Species Act. The decision comes in response to a March 2016 petition from the Animal Welfare Institute, Center for Biological Diversity and WildEarth Guardians seeking US protections to help prevent the extinction of a population that now numbers fewer than 100 individuals. "These rare dolphins deserve every possible chance to escape extinction, and we are thrilled that the National Marine Fisheries Service has stepped up and given them the protections of the Endangered Species Act," said Taylor Jones, endangered species advocate for WildEarth Guardians. "A myriad of dolphin species are at risk due to human activities, and we owe these intelligent creatures the best protections we can give them."

Animal Welfare Institute. (2019). Experts Outline Needed Steps to Save Taiwanese White Dolphin. *AWI Quarterly*. Retrieved from https://awionline.org/awi-quarterly/winter-2019/experts-outline-needed-steps-save-taiwanese-white-dolphin

Scientists identified a distinct population of Indo-Pacific humpback dolphins in 2002, off the west coast of Taiwan. Locals knew dolphins were there, but were unaware that they were unique to Taiwan, rather than migrants from the coast of China. In 2015, this population was confirmed as a subspecies, now known as the Taiwanese white dolphin. The Eastern Taiwan Strait is a geographic barrier to these dolphins, who prefer shallower water, and therefore this population had evolved separately from those along the Chinese coast for thousands of years.

Animal Welfare Institute. (2019). New Recovery Plan Seeks to Ward Off Extinction of Taiwanese White Dolphin. *AWI Quarterly*. Retrieved from https://awionline.org/press-releases/new-recovery-plan-seeks-ward-extinction-taiwanese-white-dolphin

The Taiwanese government must act quickly to ban gill and trammel nets and stop development from further degrading the habitat of the critically endangered Taiwanese white dolphin, according to a new recovery plan drafted by an international team of marine mammal and policy experts. Dr. Naomi Rose, marine mammal scientist for the Animal Welfare Institute (AWI), joined more than a dozen experts in cetacean biology and ecology, bioacoustics, and conservation and wildlife policy in urging the Taiwanese government to work with industry, scientists, and other stakeholders to mitigate the threats facing the disappearing dolphin. The most serious threat is bycatch (entanglement and drowning) in fisheries, followed by habitat destruction and degradation, pollution of coastal and riverine waters, boat traffic, noise, and, more recently, offshore wind farms.

Chien, T.-Y., Chen, C.-F., Chen, Z.-Y., & IEEE. (2022). *Study of Taiwanese White Dolphins Detection and Tracking Techniques by Utilizing Autonomous Unmanned Aerial Vehicles*. Paper presented at the 2022 OCEANS Hampton Roads, Virginia Beach, VA. Proceedings Paper Retrieved from https://IEEExplore.IEEE.org/document/9977246/

The paper describes the autonomous virtual UAV (Unmanned Aerial Vehicle) using a visual detection model to track the Taiwanese white dolphins. In this research, the SITL simulator (Software in the Loop) runs ArduPilot on the machine. ArduPilot is an autopilot system for autonomous vehicles, which is installed on the virtual drone. The simulation helps evaluate the detection model and the tracking system prior we launch the drone out over the ocean where the consequences of mistakes can be very expensive. The customized YOLO v4 model has been trained on the Taiwanese White Dolphin Image dataset 2018 owned by Cetacean Lab in NTU. The model has the ability to detect the side view of the white dolphin under 702 pixels @0.5AP (Average Precision) in the real-sea footage. The model's proper detection condition such as the distance between the white dolphin and the drone, the height above the horizon, and the pitching angle of the camera, is estimated by the simulation in the paper as well. A white dolphin 3D model is sculpted and textured based on the real white dolphin called Doufu with Blender software. In the Gazebo Simulator, the 3D dolphin model moves in the shapes of a rectangle, circle, and figure-eight with a constant velocity of 10 knots on the water. With the frame caught on the virtual drone camera and the detection model, the virtual drone can track the dolphin without losing it under certain conditions. The Taiwanese White dolphin (subspecies of *Sousa chinensis*) is listed as critically endangered. And the population is decreasing year by year. The real-time monitoring of the Taiwanese White dolphin is still unlikely to be realized unless we launch the drones, send the hydrophones to the sea, and establish the individual PHOTO ID and AUDIO ID. It is hoped that people can take advantage of this system, run different varieties of simulations, and figure out a better algorithm running through those possibilities to help monitor and conserve the white dolphins.

Chung, H.-S. E., & Jao, J.-C. (2022). Improving Marine Protected Area Governance: Concerns and Possible Solutions from Taiwan's Practice. *Marine Policy, 140*. https://doi.org/10.1016/j.marpol.2022.105078

Taiwan is surrounded by oceans with rich marine biodiversity. Thus, marine ecosystem services play a crucial role in sustaining the society. Key to conserving the marine environment and resources has been the designation of marine protected areas (MPAs). As of February 2022, Taiwan had 46 MPAs. While improving governance of these MPAs has long been under discussion in Taiwan, little progress has been made. Therefore, this study reviews all Taiwanese MPAs to identify management concerns and possible solutions from a perspective of governance. It provides findings on the background of MPAs, pertinent issues regarding the current governance system, and methods for improvement of MPA governance based on benchmark models. Also, this study proposes that integration approaches and sustainable mechanisms are essential components for improving MPA governance. Furthermore, the Taiwanese MPA experience could be a valuable reference to inform marine practices and academics worldwide.

Fang, L., Lin, W., Guo, L., Cai, H., Pine, M. K., & Wu, Y. (2020). Monitoring Indo-Pacific Humpback Dolphin Occurrences in a Highly Urbanized Estuary for Informing Conservation and Management. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(3), 685-695. https://doi.org/10.1002/aqc.3475

The estuaries within the Pearl River Delta are sites for large-scale urban development and offshore construction. These projects have conservation stakeholders calling for more protection for the Indo-Pacific humpback dolphins whose habitat overlaps with current and proposed construction sites. Efforts to improve impact assessments are hindered by the lack of baseline data and comprehensive understanding of how often the dolphins are present in areas near or within locations targeted for further development. The Modaomen Estuary within the Pearl River Delta is a good example of this, with little consideration for the dolphins as no data on their diurnal and seasonal occurrences within the estuary exist. A passive acoustic monitoring system was deployed over a calendar year from October 2016 to September 2017 to monitor the presence of humpback dolphins in the Modaomen Estuary. Results indicated that the estuary is an important area for humpback dolphins, with regular diel rhythms and seasonality in detection rates. For example, higher detections were seen during the wet season than during the dry season. However, there was no significant difference in detection rates between the flood and ebb tides, or between high and low tidal phases. Since the Modaomen Estuary is targeted for further development in the near future, these data provide the rationale for resource management and consent processes to consider potential impacts on the dolphins, as well as to aid marine spatial planning and conservation measures.

IUCN-SSC Cetacean Specialist Group. (2021). *Taiwanese White Dolphin (Sousa chinensis taiwanensis).* https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T133710A122515524.en

Taiwanese Humpback Dolphin, *Sousa chinensis* ssp*. Taiwanensis,* has most recently been assessed for The IUCN Red List of Threatened Species in 2017. *Sousa chinensis* ssp. *taiwanensis* is listed as Critically Endangered under criteria C2a(i,ii). The total population (all ages) was estimated at about 100 individuals in the mid-2000s. More recent mark-recapture analysis of photo-identification data collected from 2007 to 2010 resulted in the largest annual estimate being 74 individuals in 2010 (CV=4%) (Wang et al. 2012). The extent of occurrence (EOO) is only a small stretch of coastal waters off western Taiwan (estimated to be ca 750 km²) with the core area being about 515 km². Given the number of development projects that are underway or proposed, and the fact that only minimal or no conservation measures are in place to reduce the probable impacts of the various threats (i.e., bycatch in net fisheries, severe reduction of freshwater flow to estuaries, land reclamation, noise and chemical pollution), a continuing decline in the subspecies' abundance is projected. Although there is no prospect of obtaining a long enough time series of data to show a decline over the last three generations (about 60 years), a decline almost certainly has occurred (at least since the beginning of Taiwan's rapid industrialization about 30-40 years ago) and there is no reason to believe that the causes have stopped, or even slowed as recent PVA studies have shown. Therefore, it is reasonable to project a continuing decline so this subspecies meets criterion C2a(i,ii) for Critically Endangered (total of fewer than 250 mature individuals, projected continuing decline, and at least 90% of mature individuals in a single subpopulation with fewer than 50 mature individuals in each subpopulation). With the most recent annual abundance estimates, this subspecies also meets criterion D for CR because the total number of mature individuals is fewer than 50 (regardless of the value used to estimate percent mature: 60% from Jefferson or 50% from Taylor).

Huang, S. L., Wang, X., Wu, H., Peng, C., & Jefferson, T. A. (2021). Habitat Protection Planning for Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Deteriorating Environments: Knowledge Gaps and Recommendations for Action. *Aquatic Conservation: Marine and Freshwater Ecosystems, 32*(1), 171-185. https://doi.org/10.1002/aqc.3740

In Chinese and South-east Asian waters, the coastal and estuarine environments are important habitats for the Indo-Pacific humpback dolphin (*Sousa chinensis*). Coastal and estuarine maritime engineering (CEME), including land reclamation, embankment or shoreline armouring, harbour construction and marine farming, permanently changes coastal environments and threatens the long-term persistence of marine biota and ecosystems. Such impacts on humpback dolphin viability, however, are rarely discussed. Likely core habitat of the humpback dolphin was extrapolated based on present understanding of habitat characteristics, which is much narrower than present data describing the species' range. Some uninvestigated habitats near densely populated landscapes may be prone to intense CEME impacts. CEME impacts compromise humpback dolphin survival through habitat loss, population fragmentation, alteration of ecological regimes and deterioration of ecosystem functionality. A 30% loss of core habitat can catastrophically reduce the population viability of this species. The best strategy to avoid CEME impacts on humpback dolphin viability is to adopt a conservative planning regime from the outset. To inform habitat protection planning, current and past habitat configuration and habitat characteristics of the humpback dolphin can be clarified by systematically designed surveys, local ecological knowledge investigation, long-term satellite remote-sensing data and species distribution modelling exercises. Sound habitat protection planning includes mapping hierarchical marine protected area (MPA) networks using spatial planning algorithms and carefully examining CEME impacts from an ecosystem perspective. To prevent inappropriate CEME planning, the inclusion of citizen science, local community participation, marine environmental education and effective information delivery is proposed. Questions relating to the proposed areas of habitat loss, the extent of environmental change and the status of population-habitat viability under the scenario of CEME impacts are proposed in order to examine and re-examine the environmental impacts of any CEME project.

Huang, S. L., Wu, H., Wang, X., Peng, C., & Wang, C. C. (2020). Beware of Changes: Conservation of Indo-Pacific Humpback Dolphins in Disturbed Habitats. *Aquatic Conservation: Marine and Freshwater Ecosystems, 30*(9), 1775-1782. https://doi.org/10.1002/aqc.3417

Protecting critical habitats of the Indo-Pacific humpback dolphin, *Sousa chinensis*, is a hot topic of discussion for marine biodiversity conservation in China and many Southeast Asian countries. In practice, sound habitat protection action (HPA) planning often suffers from information gaps in macroscopic habitat configurations and changes in the habitat conditions of humpback dolphins. Recent publications in the journalAquatic Conservation: Marine and Freshwater Ecosystems(AQC) have served to advance humpback dolphin conservation in Chinese waters by resolving such habitat configurations and indicating significant changes in distribution patterns and habitat characteristics under intense coastal anthropogenic activity. We highlight an integrative research framework to investigate habitat configuration and long-term habitat changes when planning a holistic HPA programme for humpback dolphins. When constructing habitat configuration baselines, field surveys should be designed and conducted in a systematic manner to ensure survey efforts cover diverse environments equally, in either a spatially stratified or gridded pattern, to minimize potential spatial sampling biases. Long-term habitat changes can be revealed by comparing satellite images from different decades. Changes in habitat preferences and habitat characteristics can be explored through questionnaire surveys on local ecological knowledge, associating historical occurrences with coastline features and projecting historical

habitat configuration by species distribution modelling exercises. A lack of good communication and sharing of information between research and management sectors can still be an obstacle to the implementation of sound conservation practices, however, even though there is robust scientific evidence to fill knowledge gaps in distribution and habitat baselines. We have addressed the need to establish a mechanism to improve and streamline information sharing between research teams, management sectors, and stakeholder groups.

Jefferson, T. A. (2019). Endangered Odontocetes and the Social Connection: Selected Examples of Species at Risk. In *Ethology and Behavioral Ecology of Odontocetes.* B. Wursig (Ed.), (pp. 465-481): Springer https://doi.org/10.1007/978-3-030-16663-2_22

Despite centuries of whaling focused mostly on mysticete species, eight of the ten most endangered species of cetaceans in the world today are odontocetes. These species have certain features of their ecology in common, such as coastal habitats and usually ranges in developing countries, but also have some shared behavioral and social traits, such as strong susceptibility to entanglement in fishing nets and acoustic disturbance. I use four species of small cetaceans as case studies to examine the elements that have caused their predicaments. It is likely that the vaquita (*Phocoena sinus*) will soon become the second species of cetacean to go extinct in modern times, and the Atlantic humpback dolphin (*Sousa teuszii*) appears to be the next most endangered species. Several other cetacean species are facing similar levels of risk—despite some having misleading status assessments. There is a need to learn from our past mistakes to provide better protection to those species at risk and thereby avoid future extinctions.

Jhan, H. T., Lee, H. T., & Ting, K. H. (2022). The Potential Compatibility of Designating Offshore Wind Farms within Wider Marine Protected Areas-Conservation of the Chinese White Dolphin Regarding Fishers' Perception. *Fishes, 7*(4). https://doi.org/10.3390/fishes7040195

The population of the Chinese white dolphin along Taiwan's west coast is under a range of threats. The designation of marine protected areas (MPA) is urgently required for their protection. However, conflicts between specific species conservation and fishing rights mean that the success of such a designation relies on the fishers' perceptions and awareness of an MPA. Designating offshore wind farms within MPAs can be a mechanism for minimizing conflicts between fisheries and conservation. The purpose of this study is to examine the potential for designating an offshore wind farm within an MPA for Chinese white dolphin conservation by exploring the attitudes of local fishers. This study used face-to-face questionnaires. The results show that the main challenges are conflicts of interest, insufficient science-based information, and inadequate law enforcement. Offshore wind farms could be a way to maximize the benefits for different stakeholders and positively impact the marine environment and ecosystem. This study makes feasible recommendations on how to improve conservation, promote renewable energy, and encourage sustainable fisheries.

Lien, W. W. (2021). *A Landscape Approach to the Conflicts of Greens: Planning for Energy and Wetland Land-Use Growth in Southwestern Taiwan's Coastal Landscape in a Climate-Changing Era.* (Master of Landscape Architecture), University of Oregon, Eugene, OR. Retrieved from https://scholarsbank.uoregon.edu/xmlui/handle/1794/26129.

Taiwan's national plan to expand solar energy by 2025, including rooftop photovoltaics and ground-level photovoltaics, triggered numerous public debate and land-use conflicts since Taiwan's 2016 presidential election. In particular, the wetlands along the southwest coast have been attracting many solar farms because of their excellent solar radiation potentials as former saltpans; however, this abundant wetland ecosystem also supports many endangered migratory bird species, which has been leading to the conflicts of "Greens" between solar energy and critical habitats. This project developed alternative future scenarios to assess the solar generation potential and other land uses of the southwest coastal landscape for the 40 years' timeframe from now to 2060. Based on the scenario guide input from the experts, solar zoning overlay and developmental rights, plans for two different future scenarios that give priority on climate adaptation and photovoltaic expansion, respectively. These scenarios project areas for solar energy development considering their priority in relation to flooding conditions, ecological conservation, and land-use developmental strategies. Future scenarios are evaluated according to its land area and associated performance of flood mitigation, ecological conservation, energy generation, and land-use efficiency. Findings show that the total solar developmental rights of the expansion scenarios grow slightly (13.57GWc in 2040 and 15.03GWc in 2060), while the CO2e emission avoided dropped from 4424 kilo-ton to 3796 kilo-ton CO2e. Adaptation plans have a constant growth of solar developmental rights (7.97 GWc in 2040 and 15.42 GWc in 2060), while CO2e emission avoided grows 2486 kilo-ton to 4464 kilo-ton. Although the expansion plan saves more carbon emission in 2040, the adaptation plans are more efficient in land-use, impacting less agricultural land and wetland than expansion scenarios in both 2040 and 2060 while saving compatible carbon emission. This indicates that adaptation planning is more a systematic approach that brings multiple benefits over photovoltaic expansion planning in the southwest coastal Taiwan context.

Lin, M., Liu, M., Lek, S., Dong, L., Zhang, P., Gozlan, R. E., & Li, S. (2021). Modelling Habitat Suitability of the Indo-Pacific Humpback Dolphin Using Artificial Neural Network: The Influence of Shipping. *Ecological Informatics, 62*. https://doi.org/10.1016/j.ecoinf.2021.101274

The distribution of cetaceans is generally studied on the basis of their visual locations. However, the absence of observations does not exclude the presence of dolphins and not allow to distinguish habitats favourable to the species but where it would be currently absent due to anthropic disturbances. The modelling of ecological niches represents a powerful alternative choice and intensive computer modelling has been increasingly used to reveal the complexity of the relationships between cetaceans and their habitat. Here, we predicted the presence/ absence of the Indo-Pacific humpback dolphin (*Sousa chinensis*), an endangered species, using the artificial neural network model of back-propagation (BP-ANN) with eight environmental variables. The BP-ANN model had a higher success rate for correct prediction (74%) compared to linear discriminant analysis (67%), especially for the prediction of the presence of *S. chinensis* (63% to 31%), indicating its potential application in cetacean habitat research. In the model output map, three suitable habitats were predicted without *S. chinensis* sightings identified. However, only one was confirmed by subsequent field surveys, the other two being located in a strong shipping area. Therefore, we suggest that the traditional assessment of the baseline habitat based on visual sighting may miss the identification of some suitable habitats due to anthropogenic disturbance. We have also highlighted the importance of ecological modelling research for cetacean conservation. In

addition, among the eight environmental variables studied, distance from shore, fish abundance and salinity proved to be the most important factors for the distribution of *S. chinensis*, indicating that coastal construction, sea recovery and overfishing would be key constraints for its conservation.

Peng, Q. M., Hui, L., Wang, K. M., & Chang, L. C. (2020). Effectiveness Analysis of an Iot Mechanism in Support of Monitoring Chinese White Dolphins by Simulation Model. *Journal of Supercomputing 76*(5), 3847-3865. https://doi.org/10.1007/s11227-018-2529-9

The population of the Chinese white dolphin is claimed to be critically endangered and is on the International Union for Conservation of Nature (IUCN) Red list. It is estimated that there are fewer than 100 individuals in the East Taiwan Strait, and the number is falling. The dolphin's habitat has been seriously impacted by man-made pollution, such as industry contamination, fishing, and noise. To prevent extinction of the species, conservative action is vital. Prior to any such action, data on the dolphin are essential for decision makers. The current method of observing dolphins is the man-on-boat-watch approach, which is heavily dependent on manpower. Its performance is seriously affected by the weather, fatigue of those on board, and it is also risky and costly. An Internet of things (IoT) data collection mechanism concept is proposed for the purpose of observing dolphins with close watch. It consists of off-the-shelf products such as hydrophones, unmanned aerial vehicles (UAVs) and a specific command and control in search/detection for carrying out the observation task. A Monte Carlo simulation model was developed to analyze the effectiveness of the feasible alternatives, in which some factors are considered and analyzed for their significance. The simulation result showed that the IoT mechanism has an 8.5 times greater chance of availability in operation and at least 2 times more contact than the man-on-boat-watch method. The significant factor affecting the IoT mechanism's effectiveness is the number of hydrophones and UAVs in the scenario. The great contribution made by this study is that it is the first analytical paper to reveal the effectiveness of an IoT mechanism in benefitting the observation of Chinese white dolphin. The limitation is that it uses off-the shelf products for the IoT mechanism instead of high-end products which could be more effective.

Shih, Y.-C., Chen, W. C., Chen, T.-A. P., & Chang, C.-w. (2023). The Development of Ocean Governance for Marine Environment Protection: Current Legal System in Taiwan. *Frontiers in Marine Science, 10*. https://doi.org/10.3389/fmars.2023.1106813

Taiwan establishes Ocean Affairs Council (OAC) in 2018. Ocean governance has reached a new milestone. In 2019, the Ocean Basic Act was enacted. In 2020, the National Ocean Policy White Paper was published, meaning that Taiwan has specialized ocean authorities, regulations, enforcement units, and relevant mechanisms and policies. The Ocean Conservation Administration (OCA) is also responsible for marine environmental protection and conservation. To ensure good ocean governance, maintain marine resources, and protect the environment, the OCA has recently drafted the Marine Conservation Act for sustainable development. This article mainly reviews, analyzes, and compares Taiwan’s current marine-related laws and regulations and refers to the laws, policies, and mechanisms of other countries to provide suggestions on marine governance and the ongoing draft of the Marine Conservation Act.

Taylor, B. L., Araujo-Wang, C., Pei, K., Gerrodette, T., Rose, N. A., Bejder, L., . . . Reeves, R. R. (2019). *Recovery Plan for the Taiwanese White Dolphin (Sousa chinensis taiwanensis).* London, Ontario, Canada. Retrieved from https://iucn-csg.org/wp-content/uploads/2019/11/Taiwanese-White-Dolphin-Recovery-Plan-FINAL-14Oct19.pdf

The goal of this recovery plan is to specify actions needed to stop the decline of Taiwanese white dolphins (TWDs), promote their recovery and ensure the long-term viability of these dolphins in their natural environment. TWDs are a subspecies of Indo-Pacific humpback dolphin endemic to a narrow strip of coastal waters along western Taiwan. Population size is currently estimated to be fewer than 75 dolphins and declining. TWDs are recognised as seriously endangered both nationally and internationally. Available knowledge is sufficient to justify moving forward with six immediate actions: 1. Establish a ban on gill and trammel nets in TWD habitat. 2. Locate any new development and related impacts away from TWD habitat. 3. Establish mandatory routes and speed limits for vessels to reduce both noise and the risk of vessel strikes in TWD habitat. 4. Reduce pollution (air, water, soil). 5. Increase natural river flows. 6. Establish regulations to limit human-caused underwater noise levels in TWD habitat. The ban on gill and trammel nets is the single most urgent action needed. If effectively enforced, it would immediately halt the decline in TWD population size. The other five actions may not have immediate effects, but are essential for sustained TWD recovery. Precisely because they require longer times to show effects, it is important to initiate the other five actions without delay. A long-term view of TWD conservation is essential because TWDs have a low natural rate of increase. For example, even if all human-related mortality stopped immediately, it would take at least a decade for the population to increase from 75 to 100 animals. In addition to immediate government actions for TWD recovery, several research topics were identified as high priority, including monitoring trends in abundance and estimating survival and reproduction rates. Results from TWD research should be transparent and accessible to both local and international audiences. Implementation of the priority actions are the responsibility of Taiwanese government agencies, but implementation steps could be detailed by a group of local and international stakeholders to be convened by the government. However, the current development of offshore windfarms provides an opportunity for a creative solution to the most urgent threat, bycatch in fisheries. Companies and financial institutions involved with windfarm development could contribute to government programmes to eliminate gill and trammel nets from TWD habitat by compensating fishers for a transition to other fishing methods. Such an innovative solution would be a win for windfarms and green energy, a win for fishers, and, most importantly, a win for Taiwanese white dolphins.

Whittaker, K., & Young, C. N. (2018). Status Review Report of the Taiwanese Humpback Dolphin *Sousa chinensis taiwanensis*. In *National Oceanic and Atmospheric Administration.* National Marine Fisheries Service (Ed.). Silver Spring, MD: National Oceanic and Atmospheric Administration Retrieved from https://repository.library.noaa.gov/view/noaa/18694

Taiwanese humpback dolphin (*Sousa chinensis taiwanensis*), a subspecies of the Indo-Pacific humpback dolphin (*Sousa chinensis*), as either threatened or endangered under the U.S. Endangered Species Act (ESA). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). NMFS determined the petition presented substantial information for consideration and that a status review was warranted for the subspecies (see following link for the Federal Register notices for the Taiwanese humpback dolphin: https://federalregister.gov/a/2016-11014). Thus, this document is a status review of the Taiwanese humpback dolphin. The ESA stipulates that listing determinations

should be based on the best scientific and commercial information available. NMFS appointed an employee in the Office of Protected Resources Endangered Species Conservation Division to undertake the scientific review of the biology, population status and trends, threats, and future outlook for the species. Using this scientific review, NMFS then conducted an extinction risk analysis for the Taiwanese humpback dolphin.

Section VI: General

Altherr, S., & Hodgins, N. (2018). *Small Cetaceans, Big Problems: A Global Review of the Impacts of Hunting on Small Whales, Dolphins and Porpoises.* Retrieved from https://www.prowildlife.de/wp-content/uploads/2022/01/small-cetaceans-report.pdf

The hunting of small cetaceans (i.e., all toothed whales, except the sperm whale) for food or fishing bait is far more widespread than most people realise. Overall, approximately 100,000 small whales, dolphins, and porpoises are intentionally killed each year worldwide. In most cases, these are unregulated, or even illegal, hunts. Typically, they are unsustainable and poorly documented and their impact on populations is unknown. Where legislation is in place, appropriate control and rigorous enforcement measures are often lacking. This report aims to give a global overview of the scale of small cetacean hunts, the number of individuals and species targeted, and their ecological impact. By far, the world's largest kill of small cetaceans is in Peru, where up to 15,000 dolphins are killed annually to be used as bait in shark fisheries. Other countries where direct takes of more than 1,000 individuals annually occur are Brazil, Canada, Greenland, Ghana, Guatemala, India, Indonesia, Japan, Madagascar, Malaysia, Nigeria, Republic of Korea, Solomon Islands, Sri Lanka, Venezuela, and Taiwan, Province of China/Chinese Taipei (henceforth Taiwan (PRC)). Up to several hundred small cetaceans are hunted each year in the United States (Alaska), Cameroon, Colombia, Faroe Islands, Guinea Bissau, Kiribati, Myanmar, Pakistan, Philippines, Papua New Guinea, Senegal, St. Lucia, St. Vincent and the Grenadines, Vietnam, and Tanzania. An increasingly common trend is the evolution from opportunistic use of dolphins entangled in fishing nets ('bycatch'), to the growth of a market for their meat as food or fishing bait and the development of a targeted hunt to meet the ensuing demand. Some species are killed because they are perceived as competitors for commercial fish species. In many areas, small cetacean hunting is unselective—no specific species, size, or sex is targeted; instead, the most easily accessible— individuals are hunted, making river and coastal dolphins especially vulnerable to over-exploitation. Given the high levels of contaminants that accumulate in the tissues of small cetaceans, the precarious conservation status of many populations, and their slow rate of reproduction, they are not a safe and sustainable choice to provide food security. However, as fish stocks decline globally due to commercial over-exploitation, small cetacean hunts are likely to further increase unless concerted international and domestic efforts are taken to protect both cetacean and fish stocks. To facilitate such efforts, we include recommendations to range states and relevant international organisations, such as the International Whaling Commission (IWC), on how to stop the escalation of small cetacean hunts.

Bezamat, C., Hammond, P. S., Castilho, P. V., Simões-Lopes, P. C., & Daura-Jorge, F. G. (2021). Dolphin Population Specialized in Foraging with Artisanal Fishers Requires Zero-Bycatch Management to Persist. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(11), 3133-3145. https://doi.org/10.1002/aqc.3694

The small population paradigm assumes that populations with low numbers of individuals intrinsically have a high probability of extinction. The small population of Lahille?s bottlenose dolphins Tursiops truncatus gephyreus that specializes in foraging with artisanal fishers in Laguna, southern Brazil, faces human pressures including bycatch in fishing gear. The viability of this population was modelled over 30 and 100 years under different levels of bycatch, including the current scenario of two bycatches every year, two scenarios with higher incidence of bycatches and three management scenarios. The sensitivity of predicted growth rates to fixed-proportion and observed-variation changes in life history parameters was explored. The current scenario predicted a declining population ($r = 0.014$; $\lambda = 0.986$) with a high

probability of extinction in the long term (PE = 0.71). A small increase in bycatches would result in a marked increase in the probability of extinction. Management scenarios seem promising, but only the zero-bycatch management scenario would make the difference between a declining and an increasing population. As expected for slow-growing species, population growth rate was most sensitive to proportional changes in adult female and juvenile survival. However, considering observed variation in vital rates, population dynamics were most influenced by variation in reproductive rates. To determine the highest priority for management action, another simulation was made of how additional threat scenarios of recognized human activities (i.e. bycatch influencing adult survival and increased underwater noise or pollution influencing calf survival) would affect population dynamics. Population growth rate was very sensitive to changes in adult bycatch (especially females), as expected, and only subtly sensitive to a reduction in calf survival. The current level of bycatch is unsustainable. Bycatch needs to be eliminated to maximize the probability of long-term persistence of this dolphin population. However, this populations persistence could be threatened by natural variation in reproductive rates.

Bohorquez, J. J., Xue, G., Frankstone, T., Grima, M. M., Kleinhaus, K., Zhao, Y., & Pikitch, E. K. (2021). China's Little-Known Efforts to Protect Its Marine Ecosystems Safeguard Some Habitats but Omit Others. *Science Advances, 7*(46), eabj1569. https://doi.org/10.1126/sciadv.abj1569

China has made substantial progress towards global targets for conserving coastal habitats but less headway for deeper waters. China's stature as the world's major producer and consumer of seafood is legendary, but its long-standing tradition of protecting marine life domestically is virtually unknown. We present the most comprehensive database on area-based marine conservation in China including 326 sites that conserve 12.98% of China's seas and address 142 conservation objectives. Twenty-two percent of shallow habitats (<10 meters) were fully or highly protected and 20% of waters 10 to 50 meters deep were conserved to some degree. Ecosystems in deeper waters (>50 meters) are critical to protect, yet <5% of these waters in China were conserved, primarily in areas with the highest chlorophyll-α concentrations. Habitats such as underwater canyons and seamounts beyond the continental shelf had no area-based protection. While China has made progress in marine protection within its boundaries, there is more work to be done to ensure that the full suite of marine life is safeguarded.

Caruso, F., Dong, L., Lin, M., Liu, M., Xu, W., & Li, S. (2020). Influence of Acoustic Habitat Variation on Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in Shallow Waters of Hainan Island, China). *The Journal of the Acoustical Society of America, 147*(6), 3871-3882. https://doi.org/10.1121/10.0001384

The Indo-Pacific humpback dolphin (IPHD, *Sousa chinensis*) is a coastal species inhabiting tropical and warm-temperate waters. The presence of this vulnerable dolphin was recently discovered in shallow waters southwest of Hainan Island, China. The influence of the acoustic habitat on the distribution and behavior of IPHD was investigated using an array of passive acoustic platforms (n = 6) that spanned more than 100 km of coastline during a 75-day monitoring period. Its presence was assessed within 19 215 five-min recordings by classifying echolocation clicks using machine learning techniques. Spectrogram analysis was applied to further investigate the acoustic behavior of IPHD and to identify other prominent sound sources. The variation in the ambient noise levels was also measured to describe the spatiotemporal patterns of the acoustic habitat among the different sampling sites. Social and feeding sounds of IPHD (whistles and click-series of pulsed sounds) were identified together with other biological sources (finless porpoise, soniferous fishes, and snapping shrimps) and anthropogenic

activities (ship noise, explosions, and sonars). Distribution, acoustic behavior, and habitat use of this nearshore dolphin species were strongly influenced by the abundance of soniferous fishes, and under similar conditions, the species was more acoustically active in locations with lower noise levels.

Cheung, L. T. O., Ma, A. T. H., Chow, A. S. Y., Lee, J. C. K., Fok, L., Cheng, I. N. Y., & Cheang, F. C. C. (2019). Contingent Valuation of Dolphin Watching Activities in South China: The Difference between Local and Non-Local Participants. *Science of the Total Environment, 684*, 340-350. https://doi.org/10.1016/j.scitotenv.2019.05.276

Ecotourism has seen both demand and attention increase globally and locally. Dolphin watching tours, as a type of nature-based activity, have become popular in Tai O of Hong Kong. However, little attention has been paid to the quality and pricing of the tour operators in relation to the expectations of visitors. This study seeks to understand the willingness to pay (WTP) of local and non-local visitors and the relationship between WTP and environmentally responsible behavioural intentions (ERBI) and satisfaction. The key findings include a positive correlation between WTP and ERBI for local visitors and a positive correlation between WTP and satisfaction for non-local visitors. These differences between local and non-local visitors are the result of the affective connection of local visitors to the environment, as such connection is not found among non-local visitors. These findings provide important clues to help improve pricing strategies and service quality towards achieving a sustainable ecotourism industry in Hong Kong, and they offer implications for ecotourism elsewhere.

Hawkins, E. R., Gustavsson, M., Pogson-Manning, L., Pheloung, H., & Jaehnichen, C. (2022). Prevalence of Skin Lesions and Injuries in Australian Humpback Dolphins (*Sousa sahulensis*) and Indo-Pacific Bottlenose Dolphins (*Tursiops aduncus*) in Moreton Bay, Queensland. *Aquatic Mammals, 48*(4), 297-313. https://doi.org/https://doi.org/10.1578/AM.48.4.2022.297

Coastal dolphin populations are highly vulnerable due to their proximity to major urban centres and exposure to cumulative threats from anthropogenic activities. As bioindicators of environmental condition, it is crucial to understand and monitor the health of these coastal dolphin populations. Visual assessments of skin lesions on dolphins can provide useful insights into the health of these populations and exposure to environmental stressors. We examined the prevalence of skin lesions in Australian humpback dolphins (Sousa sahulensis) and IndoPacific bottlenose dolphins *(Tursiops aduncus*) of different age classes inhabiting the near-urban embayment of Moreton Bay, Queensland. The prevalence and extent of nontraumatic and traumatic skin lesions on individual dolphins were assessed using photographs taken during 103 boatbased surveys completed between 2014 and 2016. A total of 15 primary skin lesion categories were identified from 126 humpback and 100 bottlenose dolphins. Differences in the prevalence of skin lesions were evident between age classes and species. Nontraumatic skin lesions were prevalent in 48.4% of the humpback and 61.0% of the bottlenose dolphins. Comparatively, traumatic lesions were evident in almost all humpback (92.3%) and bottlenose (99.0%) dolphins. Anthropogenicrelated injuries from entanglement in fishing gear and vessel strikes were substantial and significantly differed between species ($p < 0.05$). Injuries from fishing and vessel activities affected 11.0% of humpback dolphins and 30.0% of bottlenose dolphins, suggesting that these activities pose a major threat to these populations. Findings from this study provide an important baseline to inform ongoing health monitoring and conservation efforts of these vulnerable dolphin populations inhabiting a near-urban embayment.

Hou, Y., Xue, X., Liu, C., Xin, F., Lin, Y., & Wang, S. (2022). Marine Spatial Planning Scheme Evaluation Based on the Conflict Analysis System - a Case Study in Xiamen, China. *Ocean & Coastal Management, 221*, 106119. https://doi.org/10.1016/j.ocecoaman.2022.106119

To achieve the ultimate goal of the coordination of the three elements: sea use activities, ecological environment, and marine economy, a Marine Spatial Planning (MSP) scheme requires regular evaluation and adjustments, given that one particular scheme may not take all elements into account. However, concrete evaluation methods were rarely studied, and there are few practical cases. In this study, a conflict analysis system consisting of three matrices was established to quantitatively evaluate the conflicts between the three elements. Combined with the assessment of the current status of certain sea area through the application of ArcGIS functions and tools, the major issues that certain scheme needs to address could be summarized. The conflict analysis system could also be applied to evaluate and compare different adjusted schemes under different scenarios, with the aim to determine one that can better promote coordination. The proposed method was applied in the Marine Functional Zoning (MFZ) of Xiamen, China, a precursor of MSP. The results showed that under the current MFZ scheme, conflicts among different sea use activities and conflicts between sea use activities and ecological environment were caused by the dense and diverse setting of functional zones, some overlaps, and the unsatisfying water quality, biological quality, and biodiversity. Also, the current MFZ scheme is too economically oriented to adequately balance the three elements. Based on the setting of different scenarios and evaluation of different adjusted schemes, the syncretic Scenario 4 can better meet the goal of coordination by avoiding overlaps and reducing the over-dense sea use activities, setting reserved areas and establishing restoration zones, as well as adjusting functional zones with greater economic stimulation to areas with lower pressure, etc. The application prospects and study limitations of the method were discussed in the last part. This study can provide great policy implications for Xiamen's future MFZ revision as well as a workable method for MSP scheme evaluation, adjustment, and development in other regions, which is of great significance and innovation to the sustainable management of coastal and marine areas.

Hsu, H. W., Lee, Y. C., Ding, J. J., & Chang, R. Y. (2018, 26-30 Oct. 2018). *Dolphin Recognition with Adaptive Hybrid Saliency Detection for Deep Learning Based on Densenet Recognition.* Paper presented at the 2018 IEEE Asia Pacific Conference on Circuits and Systems (APCCAS). https://doi.org/10.1109/APCCAS.2018.8605718

Dolphin identification is important for wildlife conservation. Since identifying dolphins from thousands of images manually takes tremendous time, it is important to develop an automatic dolphin identification algorithm. In this paper, a high accurate deep learning based dolphin identification algorithm is proposed. We presented an advanced approach, called hybrid saliency method, for feature extraction and efficiently integrate several wellknown techniques to make dolphins distinguishable. With the proposed techniques, we can avoid the background part (e.g. the sea water) to affect the identification results, which is usually a problem of most convolutional neural network based methods. Simulations show that the proposed algorithm can well identify a dolphin in most cases and it can achieve the accuracy rate of 85% even if there are 40 dolphins to be distinguished.

Huang, S.-L., Peng, C., Chen, M., Wang, X., Jefferson, T. A., Xu, Y., . . . Wu, H. (2019). Habitat Configuration for an Obligate Shallow-Water Delphinid: The Indo-Pacific Humpback Dolphin, *Sousa chinensis*, in the Beibu Gulf (Gulf of Tonkin). *Aquatic Conservation: Marine and Freshwater Ecosystems, 29*(3), 472-485. https://doi.org/10.1002/aqc.3000

Habitat configuration is an important baseline to delineate protected area design, refine impact mitigation measures and define habitat protection plans for threatened species. For coastal delphinids, outlining their habitat configuration becomes a real challenge when faced with large distribution ranges that straddle international borders, leaving broad information gaps in uninvestigated areas. This study projected likely habitats of Indo-Pacific humpback dolphins, *Sousa chinensis*, in the Beibu Gulf (Gulf of Tonkin) based on occurrence data and remotely sensed oceanographic characteristics. Net primary productivity was derived to measure the ecosystem service of humpback dolphin habitats. Bathymetry and chlorophyll-a concentration are major variables contributing to humpback dolphin habitat configuration, which is characterized by shallow water depth and high primary productivity. Three major, likely habitats were identified in the northern Beibu Gulf from western Leizhou Peninsula to the China?Vietnam border, western Gulf of Tonkin from the Red River estuary to the central coast of Vietnam, and south-western Hainan Island. Less than 9% of likely habitats are currently protected by marine protected areas. Affinity to high primary productivity and shallow depths implies that prey abundance and foraging efficiency influence habitat selection by Indo-Pacific humpback dolphins. Anthropogenic activities potentially altering oceanographic characteristics may impact regional marine ecosystem functions, and hence habitat configuration. Habitat protection actions for Indo-Pacific humpback dolphins include implementing coordinated and systematic surveys in major habitats, associating core habitat protection with protected area networks and maritime function zoning, ensuring ecosystem function integrity within major habitats, and reducing both explicit lethal impacts and implicit anthropogenic impacts from activities that change oceanographic features. The habitat protection plan should not only consider marine habitats, but also adjacent coastal landscapes and river catchments. This requires coordination, collaboration and information sharing between scientific research teams, government policy representatives, non-governmental organizations, local communities and other interested stakeholders.

Kimura, S. S., Sagara, T., Yoda, K., & Ponnampalam, L. S. (2022). Habitat Preference of Two Sympatric Coastal Cetaceans in Langkawi, Malaysia, as Determined by Passive Acoustic Monitoring. *Endangered Species Research, 48*, 199-209. https://doi.org/10.3354/esr01194

Little is known about the ecology of the Indo-Pacific finless porpoise *Neophocaena phocaenoides* or the Indo-Pacific humpback dolphin *Sousa chinensis* in Southeast Asia. The present study describes the distribution and habitat preferences of these species around the Langkawi Archipelago of Malaysia. Vessel-based passive acoustic monitoring surveys were conducted 5 times between 2012 and 2013. Both species mainly preferred relatively shallow waters, especially on the east sides of the islands at <15 m depth. However, the species differed in number of detections and spatial distribution, preferred distance from shore, chlorophyll a concentration in the water where they resided, and season in which they were detected, indicating that they have different habitat preferences. The best spatial habitat model for the prediction of finless porpoise distribution included bathymetric depth and longitude. The distribution of finless porpoises was relatively stable around the islands and especially in the eastern waters, whereas humpback dolphins may only seasonally visit specific regions of the waters around the islands. Their detection sites were too patchy to enable distribution modeling. The results of this study

provide baseline information that can facilitate conservation planning for these species according to their habitat preferences and core areas.

Li, S., Liu, M., Dong, L., Dong, J., & Wang, D. (2018). Potential Impacts of Shipping Noise on Indo-Pacific Humpback Dolphins and Implications for Regulation and Mitigation: A Review. *Integrative Zoology, 13*(5), 495-506. https://doi.org/10.1111/1749-4877.12304

Shipping noise is a widespread and relatively loud sound source among human-induced underwater sounds. The impacts of shipping noise are of special concern for Indo-Pacific humpback dolphins (*Sousa chinensis*), as they inhabit shallow and nearshore habitats and are highly dependent on sound for survival. This study synthesizes our current understanding of the potential impacts of shipping noise on Indo-Pacific humpback dolphins combined with knowledge on sound production and hearing of these animals and the impacts of noise on other whales and dolphins. For further protection and management of Indo-Pacific humpback dolphins and their habitats, shipping noise should be regulated and mitigated to modify sound from ships, to reduce overall noise levels, and to set more marine protected areas (MPAs) covering most Indo-Pacific humpback dolphin habitats with seasonal and geographical restrictions to avoid ensonification of shipping noise. The emphasis for future research should be on obtaining more baseline information about the population distribution, sound production, hearing capabilities at the population level, behavior, and stress hormones of the humpback dolphins under different noise conditions or under different noise-producing activities, and/or in high-noise areas compared with relatively quiet areas, and the noise characteristics of ships of different types, sizes and speeds.

Li, W. T., Chou, L. S., Chiou, H. Y., Chen, I. H., & Yang, W. C. (2021). Analyzing 13 Years of Cetacean Strandings: Multiple Stressors to Cetaceans in Taiwanese Waters and Their Implications for Conservation and Future Research. *Frontiers in Science, 8*. https://doi.org/10.3389/fmars.2021.606722

This study summarizes the postmortem investigations of 73 cetaceans stranded on the coast of Taiwan between 2001 and 2013, including 51 *Delphinidae*, 17 *Kogiidae*, 3 *Ziphiidae*, 1 *Physeteridae*, and 1 *Balaenopteridae*. Of these, eight (11%) were categorized into direct human-related strandings, including fisheries interaction (bycatch), vessel collision and other anthropogenic-related pathology. Gastrointestinal foreign bodies were found in eight individuals (11%). Most of the bacteria isolated from stranded dolphins were zoonotic pathogens including extended-spectrum beta -lactamases Escherichia coli, which indicates waste pollution from land. Severe parasite infestation was found in 36 of the cases (49%), which suggests that the immune function could be compromised. Thirty-eight cases (52%) were diagnosed with myocardial patchy fibrosis or dilated cardiomyopathy. The evidence shown here indicates that cetaceans around Taiwanese waters may suffer from multiple stressors. This study provides baseline data for the health assessment of cetacean populations in Taiwan, which may ultimately provide recommendations for future cetacean conservation and research throughout the western Pacific.

Lin, M., Xing, L., Fang, L., Huang, S.-L., Yao, C.-J., Turvey, S. T., . . . Li, S. (2019). Can Local Ecological Knowledge Provide Meaningful Information on Coastal Cetacean Diversity? A Case Study from the Northern South China Sea. *Ocean & Coastal Management, 172*, 117-127. https://doi.org/10.1016/j.ocecoaman.2019.02.004

Identifying and evaluating potentially suitable tools to assess the status of cetaceans in coastal waters with high levels of anthropogenic threat represents a first step towards effective conservation management. Local ecological knowledge (LEK) can often provide more extensive information on focal species and biological resources than is available from standard ecological surveys, and is increasingly recognized as an important source of data for conservation research and management, but it has rarely been used as a tool to assess the status of cetaceans. We investigated the efficacy of using LEK from local fishers combined with stranding records to characterise the diversity and distribution of coastal cetaceans in the northern South China Sea, a region with high historical levels of cetacean abundance and diversity but which is experiencing intensifying anthropogenic pressures. Fishers were unable to identify most regionally occurring cetaceans to species level. However, we were able to determine the distributions of eight categories of cetaceans that were observed by fishers, and a previously unknown population of Indo-Pacific humpback dolphin reported from the coastal waters of Hainan that was later confirmed through boat-based surveys. The number of sightings of different cetacean categories reported by fishers has a significant positive linear relationship with independent data on numbers of stranded cetaceans, validating the accuracy of our respondent data and indicating that LEK can provide useful, quantitative information on abundance rankings of different cetacean categories.

Lin, W., Zheng, R., Liu, B., Chen, S., Lin, M., Liu, M., . . . Li, S. (2022). Low Survivals and Rapid Demographic Decline of a Threatened Estuarine Delphinid. *Frontiers in Marine Science, 9*. https://doi.org/10.3389/fmars.2022.782680

Beibu Gulf's (BBG) Indo-Pacific humpback dolphins present both a genetic differentiation and phenotypical differences from conspecifics from other areas of the South China Sea. Given the recent urbanization and industrialization in southern China, humpback dolphins from the BBG warrant conservation attention. However, this population's demographic trend is unclear, making it hard to take conservation measures. To assess the population status of humpback dolphins in the BBG, photo-identification surveys were conducted between 2015 and 2019 in the inshore region surrounding the Dafeng River Estuary, which represents the most urbanized and industrialized coastal area of the BBG region. Robust design modeling suggested a constant survival for the female adults (0.89, 95% CI: 0.83–0.94). In comparison, the survival of the juvenile and sex-undetermined adults dropped from 0.92 (95% CI: 0.75–0.98) in 2015 to 0.86 (95% CI: 0.71–0.94) in 2016 and bounced back to 0.89 (95% CI: 0.80–0.94) in 2018. The low level of survival may justify the rapid decline in the annual population size from 156 (95% CI: 133–184) in 2015 to 102 (95% CI: 98–107) in 2019. We found little impact of emigration on the dolphin demographic process. Instead, the low and fluctuating survivals, although with overlapping confidence intervals, seemingly suggested a presence of strong marine stressor(s). Our study highlighted that obtaining high-resolution data is essential to improving our understanding of the demographic dynamics. Moreover, the anthropogenic stress in the BBG region should be quantitatively studied in both temporal and spatial perspectives, to help depict the ecological response of the dolphins to anthropogenic activities.

Lin, Z., Gao, M., Yu, X., Zhu, Q., Yu, Z., & Wang, X. (2023). Modeling Suitable Habitats of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in a Highly Urbanized Bay. *Aquatic Mammals, 49*(2), 148-159. https://doi.org/10.1578/AM.49.2.2023.148

Indo-Pacific humpback dolphins (*Sousa chinensis*) live in coastal waters that have experienced considerable anthropogenic disturbances. Specifically, along the coasts of highly urbanized regions, available habitats have decreased in both space and scale. This study used Maxent software to simulate the distribution of suitable habitats for *S. chinensis* during the dry and wet seasons in Xiamen Bay. We also aimed to identify key environmental factors influencing habitat distribution, with the goal of using our results to analyze conservation gaps and propose adjustments. We found that during the dry season, *S. chinensis* were mainly distributed in the Western Harbor, Jiulong River Estuary, and the mouth of Tongan Bay. During the wet season, they were distributed in the south of Western Harbor, Jiulong River Estuary, and around the Wuyu and Dadeng-Xiaodeng Islands. Nekton density, chlorophyll-a concentration, sea surface temperature, slope, and salinity are the primary factors affecting *S. chinensis* distribution in Xiamen Bay. To better protect the species, the existing Tongan Bay reserve should be expanded during dry seasons, and suitable habitats in the Jiulong River Estuary should be turned into a seasonal protected region. Similarly, during wet seasons, the original Western Harbor portion of the reserve should increase to include the Jiulong River Estuary, northwest of the Wuyu Islands and south of the Dadeng-Xiaodeng Islands. In addition to this dynamic seasonal management of reserve size, we also recommend developing multiple-use protected areas and establishing a joint protection mechanism between local governments. In conclusion, our model offers important guidance on improving conservation measures of *S. chinensis* in Xiamen Bay.

Liu, M., Lin, M., Dong, L., Caruso, F., & Li, S. (2022). An Integrated Strategy for Monitoring Cetaceans in Data-Poor Regions. *Biological Conservation, 272*, 109648. https://doi.org/10.1016/j.biocon.2022.109648

A fundamental issue in cetacean conservation is determining the occurrence, distribution, and habitat use of target species. However, these baselines are extremely deficient in many poorly investigated regions, making it challenging to inform conservation management initiatives. In this case study, we employed three complementary approaches to generate conservation baselines on a “Vulnerable” near-shore delphinid species, the Indo-Pacific humpback dolphin, *Sousa chinensis*, in the waters southwest of Hainan (SW Hainan), China. First, in late 2013, we conducted large-scale local ecological knowledge (LEK) surveys with 510 Hainanese fishers. Our LEK findings revealed that SW Hainan was a previously underreported area with numerous fishermen encounters of humpback dolphins dating back to the 1970s. Second, from 2014 to 2019, we conducted monthly boat-based visual surveys in SW Hainan. Our sighting data verified the reliability of previous LEK findings and further confirmed the year-round occurrence and species dominance of humpback dolphins in SW Hainan. Third, we applied a supplementary approach (stationary passive acoustic monitoring, PAM) to monitor dolphin biosonar activities in the region. Our 10-site PAM dataset from February 2018 to June 2019 indicated spatiotemporal variations in dolphin click detections. To conclude, our findings, derived from multiple approaches, provide a scientific basis for cetacean conservation management and marine spatial planning on a regional scale. More generally, this study offers an integrated monitoring strategy consisting of three step-by-step approaches, which can help conservationists, especially those who work in data-deficient waters, obtain critical baseline data on cetaceans in an efficient, timely, and reliable way.

Liu, M., Lin, M., Lusseau, D., & Li, S. (2021). Intra-Population Variability in Group Size of Indo-Pacific Humpback Dolphins (*Sousa chinensis*). *Frontiers in Marine Science, 8*. https://doi.org/10.3389/fmars.2021.671568

Group size is a key social trait influencing population dynamics of group-living animals. The Indo-Pacific humpback dolphins (IPHDs), *Sousa chinensis*, a shallow water delphinid species, display a fission-fusion social system. Yet little is known about how social organization of this species vary with temporal scales and behavioral state. In this study, we sampled group size estimates from the world's second largest population of humpback dolphins (*Sousa* spp.), which inhabit the eastern waters of Zhanjiang, China. IPHD group sizes changed seasonally and inter-annually, but not with tidal phases. Group sizes also changed with behavioral state of IPHD groups and with number of mother-calf pairs present. IPHDs formed larger groups in the autumn than in other seasons, which might be related to seasonal changes in food availability and reproductive cycle. Of the groups observed, we recorded the presence of mother-calf pair in 85 groups (i.e., nursery groups: 47 ones with one pair, 25 ones with two pairs, and others with three pairs). Notably, nursery groups were about 2–4 times larger than non-nursery groups. In addition, group sizes greatly increased with the number of mother-calf pairs. Living in relatively large groups, more protection, food, and resources might be available for IPHD mothers and calves, and such social strategy provide higher reproduction efficiency and survival success for this species. During our observations, feeding (45.5%) and traveling (25.2%) represented the majority of IPHD's behavioral budget, while socializing (8.4%) and resting/milling (6.8%) were not frequently observed. Resting/milling groups were approximately 50% smaller than feeding, traveling, or socializing groups, while the latter three types had a similar mean group size. Large groups when IPHDs foraged, traveled, or socialized, might provide more added group benefits. For the first time, our findings clearly revealed intra-population variability in IPHD group sizes across different behavioral and temporal variables, and provided a better understanding of IPHDs' adaptations to various biological processes and ecological constraints.

Liu, M. M., Lin, M. L., & Li, S. H. (2022). Species Diversity and Spatiotemporal Patterns Based on Cetacean Stranding Records in China, 1950-2018. *Science of the Total Environment, 822*. https://doi.org/10.1016/j.scitotenv.2022.153651

Stranding data can provide conservation-valuable information on cetaceans over long time and large space, representing a low-cost but useful approach to monitor these indicator species and their inhabiting environments. Here, we established a national dataset by collating all available records of cetacean strandings (CSs) along >30,000-km coastline of China over seven decades. Between 1950 and 2018, a total of 1763 CSs were recorded across 36 cetacean species from eight families. Importantly, 30.5% of the recorded species are currently recognized as threatened levels on the IUCN Red List. In quantity, Odontocete species accounted for 89.9% of total CSs. In 1763 CSs, 91.8% were events of single individual. Furthermore, 31.9% and 42.4% were events of alive and dead animals, respectively. The number of CSs increased gradually from 1950 to 2018, and more rapidly between 1990 and 2018. CSs occurred in all months, while a seasonal pattern could be observed with 38.5% reports between March and June. The most commonly recorded species were finless porpoises (*Neophocaena* spp., n = 492) and Indo-Pacific humpback dolphin (*Sousa chinensis* , n = 291). The highest number of CSs (n = 478) was documented in Hong Kong, while the greatest species richness (n = 28) and the highest stranding density (24.6 CSs per 100-km coastline) were observed in Taiwan. Several CS hotspots were identified in the southern and eastern China, while hotspots differed among taxonomic categories. To conclude, these findings provided a comprehensive understanding of cetacean communities in the coastal waters of

China, which are beneficial for improving further research, conservation, and management on cetaceans.

Marine Ecology Enhancement Fund. (2019). *Conservation Ecology of Chinese White Dolphins across the Pearl River Estuary Phase 2: Population Parameters, Demographic Structure and Habitat Requirements.* Marine Ecology Enhancement Fund, MEEF2017015A. Retrieved from https://env.threerunwaysystem.com/en/meef/Completion-Report/MEEF2017015A_Completion-Report.pdf

The project reported here represents a continuation of Phase 2 of a multi-year undertaking, initiated with a pilot study in 2015. The multi-year undertaking aims at developing a sound ecological framework for the conservation of Chinese White Dolphins (CWD) across the greater Pearl River Delta (PRD) region, southeast China. The western reaches of the PRD region (referred here as Western Pearl River Estuary, W-PRE) appear to harbour substantial numbers of CWD, seemingly larger than those in Eastern PRE. The dolphins in Western PRE may in fact be critically important to the continuous long-term survival of CWD anywhere in the greater PRD region. However, with no in-depth research ever done in Western PRE (other than our pilot Phase 1 of this multi-year project), literally nothing is known about these dolphins and all aspects of their ecology and socio-demography investigated in our project represent first ever scientific account of this population. All work and project-related activities intended to take place during the time period reported here progressed as planned, timely and on schedule, following closely the originally envisioned framework of the project. The photo-ID data collected across the PRD contributed a very substantial new component to the long-term markrecapture database that is the backbone for the entire multi-year undertaking. Even though there are obvious limits to how much field-collected data can a 1-year project (which is the time-duration of the project reported here) possibly generate, in our case, in conjunction with the earlier phase of this study and the ongoing MEEFfunded Phase-3, the work reported here represents an important building block within the framework of the larger multi-year undertaking. A total of 105 surveys were conducted during the project period reported here, which resulted with 519 encounters of dolphin groups and a cumulative number of 2836 dolphin sightingrecords. Our current analyses, albeit not yet anything final in the context of the multi-year project, have preliminarily quantified individual movement patterns across the PRD, mapped the habitat use pattern and computed the temporal social dynamics of the CWDs in the eastern part of the PRD region, and quantified the population parameters and socio-demographic structure of CWD in the westernmost part of the PRD. Early-stage movement analyses across the region, albeit still preliminary, indicate moderate-to-considerable long-term site fidelity of Chinese white dolphins n all three sectors of the Pearl River Delta region. Although some individuals may leave their respective sectors of the PRD, re-immigration is frequent and in the longterm the dolphins exhibit considerable affinity to relatively restricted geographic ranges. These early findings suggest that the movement between different sectors of the PRD may be limited, but this can only be confirmed with more in-depth modelling approach after sufficiently beefed-up dataset (which should be achieved after additional 2-years of field work) is fully synthesized and cross-matched across the entire PRD region. At the eastern reaches of the PRD, areas frequented by CWDs were mapped by constructing advanced habitat utilization models. High-definition "heat-maps" illustrating the area utilization patterns clearly indicate that CWDs have very restricted core areas, centred in inshore shallow waters, especially along the coastlines that remain relatively 'unspoiled' by anthropogenic impacts and with relatively low levels of human disturbance (lower levels than in other sectors of the area); e.g. as Southwest Lantau and Green Island/Sam Kok Shan Island). The foraging core areas are even more restricted, yet closely resemble the overall area use pattern, which reaffirms our earlier observations that the dolphins' nutritional needs and foraging locations determine

their overall habitat use pattern in the PRD. Moreover, the current evidence suggests that Hong Kong waters, particularly off west and southwest Lantau Island, represent one of the most important dolphin foraging ground, with the largest continuous patch of relatively unaltered coastal foraging habitat in the entire Eastern PRE. Based on the latest spatial projection of the area use pattern, finer-scale movement analyses were performed to compute individual site fidelity and movement pattern between foraging core areas across the Eastern PRE waters. The early-stage findings suggest low short-term fidelity of CWDs at the same core areas with frequent movements between areas, but moderate long-term site fidelity with considerable re-immigrations of dolphins back to the same foraging locations. Social dynamics analyses were also performed to examine the temporal stability of associations among individuals in the Eastern PRE. Although their social affiliation was stronger than by chance alone, in other words non-random, inter-individual associations were generally weak and fluid as in a typical fission-fusion mammalian society. On the other side of the Pearl River Deltaic region, mark-recapture analyses suggest that there are at least 914 dolphins inhabiting the coastal waters of Western PRE, corresponding to our initial supposition that this part of the PRD harbours a substantial number of dolphins, and is therefore of critical importance to the overall persistence of CWD in the PRD. However, the survival rates of the dolphins in the western reaches of the PRD seem surprisingly low, likely below the threshold of longterm persistence. This is a highly unexpected finding, but the estimates are still very much preliminary at this stage and ringing the alarm bell would be premature. However, if this figure is supported by further analyses of a larger sample size, it would indicate that although the coastal waters of Western PRE are vast and seemingly still productive, the dolphins are likely under considerable environmental stress; probably stress of a different type and magnitude compared to that in the eastern part of the region, but larger than one would have expected in the relatively less-impacted western reaches of the PRD, and the population trajectory may be on a downward slope. More data and further analyses are still needed though, before conclusions can be reached. This work is currently underway within the framework of the ongoing MEEF-supported Phase 3 of this project, and this part of our current efforts is of the highest urgency. Agglomerative cluster analyses identified five hierarchical social clusters in the Western PRE. Although individual affiliations are generally fluid and dynamic, the dolphin social structure is heterogeneous with stronger and more frequent associations among individuals in the same cluster than from other clusters, yet not sufficiently discrete to be considered as separate communities. Individuals attributed to different clusters exhibited different, but not completely dissimilar, distribution pattern, and with considerable overlapping in their ranges. While this is indicative of a discernible social structure among the dolphins, the hierarchy of association modelled using the agglomerative approach may correspond primarily to the spatial segregation of individuals, likely driven by spatial preferences and individual fidelity to foraging areas. As such, non-hierarchical clustering methods will be explored in future analyses to further examine the social structure and interindividual / inter-group connectivity, and the current findings and interpretations presented in this report should be viewed as preliminary. In overall, the findings summarized in this report, although still far from final or conclusive, are all first of its kind even after decades of former research effort in the region, underlining the urgent need of such information for effective CWD conservation strategy. Our current findings and initial analyses affirm the overall framework and direction of this multi-year project, which if continued, will deliver results that are of great interest to marine science in general, and of paramount importance locally/regionally due to their major management implications, benefiting the conservation efforts of CWD across the entire PRD region. Further continuous flow of incoming data is therefore much needed (and currently underway thanks to the MEEF-funded Phase-3 of this project). Once sufficiently robust dataset is in place (as intended by the end of this multi-year project), the results of our efforts will carry important implications in advising local authorities on management recommendations based on empirical scientific evidence.

Mo, H., Zhang, Y., Su, C., & Zheng, Y. (2021, 29-31 July 2021). *Research on the Detection Algorithm of Dorsal Fin of Chinese White Dolphin Based on Yolov4.* Paper presented at the 2021 IEEE International Conference on Power, Intelligent Computing and Systems (ICPICS). https://doi.org/10.1109/ICPICS52425.2021.9524293

Sousa chinensis is the only marine dolphin named by Chinese name, and it is also a key protected wild endangered animal at the national level. It has important ecological, cultural and social values, and it is of great significant to carry out real time detection research. Therefore, in this dissertation, a real-time dorsal fin detection modal of *Sousa chinensis* based on YOLO-4 algorithm is constructed based on more than 3000 images taken in Leizhou Bay. The recognition of the modal can reach 90.98%, which can achieve the effect of real-time detection and provide an effective method for real-time detection of dorsal fin of *Sousa chinensis*.

Pine, M. K., Wang, D., Porter, L., & Wang, K. (2018). Investigating the Spatiotemporal Variation of Fish Choruses to Help Identify Important Foraging Habitat for Indo-Pacific Humpback Dolphins, *Sousa chinensis*. *Ices Journal of Marine Science, 75*(2), 510-518. https://doi.org/10.1093/icesjms/fsx197

Given the common physical overlapping between coastal developments and important marine mammal habitats, there is a need to identify potentially important foraging grounds for dolphins when informing marine spatial planning and management of underwater noise. Hydrophones were deployed at four locations either side of the mainland China–Hong Kong Special Administrative Region border to monitor the presence of soniferous fishes; a key prey item for Indo-Pacific humpback dolphins. Five distinct chorus-types were identified; each showing spatiotemporal variability. Each chorus-type was assumed to represent a separate species. Chorus-type diversity also differed between sites, with SP4 and SP5 types only being detected within Hong Kong waters where bottom trawling is illegal. Chorus-type SP1 was only detected at the recording sites in mainland Chinese waters. Call rates and chorus duration were highest during the spring and summer months. Given these dolphins show a predator-prey relationship, these data provide new information on the local fish communities at a much finer-scale than fish landing records and a baseline of fish activity in an environment that is challenging to explore. Overlaid with acoustic detections of foraging dolphins, these data form a basis for identifying potentially important foraging habitats that should be afforded the highest priority for protection.

Raudino, H. C., Tyne, J. A., Smith, A., Ottewell, K., McArthur, S., Kopps, A. M., . . . Waples, K. (2019). Challenges of Collecting Blow from Small Cetaceans. *Ecosphere, 10*(10), e02901. https://doi.org/10.1002/ecs2.2901

We trialed the collection of blow samples using a waterproof electric multirotor (quadcopter) drone from two free-ranging dolphin species, the abundant and approachable bottlenose dolphin (*Tursiops aduncus*) and the less common and boat shy humpback dolphin (*Sousa sahulensis*). This drone was fast, maneuverable, and quiet compared to other drones commonly used in studies of cetaceans and relative to their hearing thresholds. We were successful in collecting blow samples from four individual dolphins (three bottlenose dolphins and one humpback dolphin) in two groups. The success of obtaining samples was dependent on the individual dolphin's activity. We were successful in sampling when dolphins were resting and socializing but found that socializing dolphins were not predictable in their surfacing and direction and therefore do not recommend drone sampling socializing dolphins. The suitability and

preference of the sampling technique over biopsy sampling is highly dependent on the dolphin activity. We also attempted to extract DNA from the blow samples with the aim of assessing the feasibility of using blow sampling by drone for population genetic studies. We were unsuccessful in extracting DNA and recommend that others attempting to sample dolphin blow with a drone should prioritize collecting a larger volume of blow that may yield adequate concentrations of DNA to be amplified. Blow sample volume could potentially be increased by sampling with more absorbent materials.

Sanganyado, E., Rajput, I. R., & Liu, W. (2018). Bioaccumulation of Organic Pollutants in Indo-Pacific Humpback Dolphin: A Review on Current Knowledge and Future Prospects. *Environmental Pollution, 237*, 111-125. https://doi.org/10.1016/j.envpol.2018.01.055

Indo-Pacific humpback dolphin (*Sousa chinensis*) are chronically exposed to organic pollutants since they inhabit shallow coastal waters that are often impacted by anthropogenic activities. The aim of this review was to evaluate existing knowledge on the occurrence of organic pollutants in Indo-Pacific humpback dolphins, identify knowledge gaps, and offer recommendations for future research directions. We discussed the trends in the bioaccumulation of organic pollutants in Indo-Pacific humpback dolphins focusing on sources, physicochemical properties, and usage patterns. Furthermore, we examined factors that influence bioaccumulation such as gender, age, dietary intake and tissue-specific distribution. Studies on bioaccumulation in Indo-Pacific humpback dolphin remain scarce, despite high concentrations above 13,000 ng/g lw we previously detected for PFOS, ∑PBDE and chlorinated paraffins. The maximum concentration of organochlorines detected was 157,000 ng/g wt. Furthermore, variations in bioaccumulation were shown to be caused by factors such as usage patterns and physicochemical properties of the pollutant. However, restrictions in sampling inhibit investigations on exposure pathway and toxicity of organic pollutants in Indo-Pacific humpback dolphin. We proposed the use of biopsy sampling, predictive bioaccumulation and toxicity modeling, and monitoring other emerging contaminants such as microplastics and pharmaceuticals for future health risk assessment on this critically endangered marine mammal species.

Siddagangaiah, S., Chen, C. F., Hu, W. C., Akamatsu, T., McElligott, M., Lammers, M. O., & Pieretti, N. (2020). Automatic Detection of Dolphin Whistles and Clicks Based on Entropy Approach. *Ecological Indicators, 117*. https://doi.org/10.1016/j.ecolind.2020.106559

Long-term monitoring of cetacean vocalizations allows for the exploration of their occurrence, seasonality and abundance. However, accurate automatic detection of vocalizations from vast acoustic datasets containing diverse sound sources remains a challenge. In this study, we propose the permutation entropy (H) and the sample entropy (SE) as metrics for the unattended detection of whistles and clicks. We tested the detection performance of whistles and clicks in various scenarios commonly occurring in marine habitats, including dense snapping shrimps, vessel engine noise and overlapping whistles and clicks. The use of the entropy metrics resulted in detection accuracy of over 95%. In particular, H outcomes correctly detected whistles even if associated with snapping shrimps or engine noise, while SE was a reliable indicator for clicks and robust to vessel noise. These algorithms do not require prior training in vocalization and are computationally fast. The advancement of metrics such as those presented here, will enable non-invasive and cost-effective assessment of cetacean population dynamics and health and may inform future conservation management.

Sun, X., Guo, L., Luo, D., Yu, R.-Q., Yu, X., Liang, Y., . . . Wu, Y. (2022). Long-Term Increase in Mortality of Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in the Pearl River Estuary Following Anthropic Activities: Evidence from the Stranded Dolphin Mortality Analysis from 2003 to 2017. *Environmental Pollution, 307*, 119526. https://doi.org/10.1016/j.envpol.2022.119526

With the dramatic increase in anthropogenic threats to the Pearl River Estuary (PRE), the population size of the Indo-Pacific humpback dolphins (*Sousa chinensis*) has significantly decreased over the past decade. To understand the impact and potential risks of intense human activities on these dolphins, factors related to the mortality of humpback dolphins in the PRE were investigated by a detailed examination of 343 dolphin specimens stranded during 2003–2017. There was a significant ($p < 0.01$) increasing trend for humpback dolphin stranding, reflecting the accelerating rate of the population decline. A large proportion of strandings (35.88%) were neonates. A low recruitment rate implies slow population growth, and hence, limited capacity to resist anthropogenic stress. The most commonly diagnosed causes of death were vessel collision and net entanglement. The concentrations of trace metals, polychlorinated biphenyl (PCB) congeners, dichlorodiphenyltrichloroethane, polycyclic aromatic hydrocarbons, and most of per- and polyfluoroalkyl substances (PFASs) in the dolphin samples were greater than those previously reported in cetaceans globally. Furthermore, Cu, PCB77, PCB169, PCB81, PCB37, and PFASs (excluding PFBA, PFPeA, PFHxA, PFHxDA, and PFODA) were the major pollutants accumulated in neonates. 67% of PCB, 78% of Cu, and 100% of perfluorooctane sulfonate concentrations in the neonates exceeded the threshold for toxicological effects in marine mammals, suggesting that these compounds could be important factors contributing to the low survival rate of calves in this area. This study revealed that vessel transportation, fishing activities, and pollutant bioaccumulation are the three major causes of humpback dolphin mortality in the PRE. These results highlight the need for more efforts to restrict anthropogenic activities, especially vessel traffic, the catching of these marine animals and fishing, and pollutant discharge, in order to prevent vulnerable species from continuous population decline and further extinction.

Tseng, P.-H., & Ng, M. (2022). *SWOT Analysis of Offshore Wind Power Development in Taiwan.* Paper presented at the IFSPA 2022, Hong Kong. Retrieved from https://www.researchgate.net/profile/Muhittin-Orhan/publication/364308256_An_Overview_through_Start-up_Initiatives_on_HRTech_in_Maritime_and_Offshore_Industries/links/634532ef9cb4fe44f31be7d7/An-Overview-through-Start-up-Initiatives-on-HRTech-in-Maritime-and-Offshore-Industries.pdf#page=238

This paper aims to explore offshore wind power development and uses Taiwan to illustrate the main challenges involved and provides strategies to mitigate these challenges. Strength, Weakness, Opportunities and Threat (SWOT) is used to analyze the strategic management issues (e.g. feasibility evaluation, construction technique, sailing safety, cost, terminal layout, crew, work ship, etc.) based on comprehensive literature review. Taiwan has abundant advantages with wind resources although offshore wind power is still in the early stages. Taiwan's weakness is that it still relies on international support (e.g. Europe, U.S.) for the core know-how. It needs to make more efforts to develop local production. The opportunity is that Taiwan's geographic location is suitable for being a supply chain center for global materials, logistics distribution, work vessels, crew training center for the industry. Currently the governmental subsidy and administrative resource integration have gradually brought opportunities to promote this industry. The threat is negotiation and collaboration with stakeholders (e.g. shipping, fishing operators, and others) for improving environment and ecological impacts (e.g.

sailing channel safety regulation, noise pollution white dolphin, fishing compensation, etc.). Research limitations/implications – Research findings of SWOT application should be further revised based on other regions' characteristics in the future. This paper provides strategic implications for the stakeholders (e.g. government, investors) who have interests in offshore wind power and help decision-making for feasibility evaluation. This paper studies how to balance the economic (e.g. investment profitability) and environmental (e.g. noise for white dolphin) interests and provides suggestions to mitigate negative effects. Existing studies on offshore wind power has seldom focused on a strategic context. This paper adopts SWOT analysis to contribute original insights to industry development.

Wang, T., Zhang, P., Zhang, S., Liu, Q., Liao, X., Rao, Y., . . . Xie, B. (2022). Acoustic Assessment of Fishery Resources in Jinwan Offshore Wind Farm Area. *Journal of Marine Science and Engineering, 10*(12). https://doi.org/10.3390/jmse10121938

After more than ten years of offshore wind farm (OWF) construction, the total installed capacity of China ranks first in the world. The effect of OWF on fish communities to attract or banish differs among fish species and wind farms. Studies on the effects of OWFs are limited in China and results from other regions may not be transferable due to different environmental and biological conditions. In October 2019, an acoustic survey was conducted in Jinwan OWF, outside the Pearl River Estuary, northern South China Sea, China, to assess the fish resources (biomass and abundance), community diversity, and distribution information of this area. According to the Index of Relative Importance (IRI), Harpadon nehereus and Brionobutis koilomatodon were the dominant fish species in the study area. The mean Shannon–Weiner diversity index was 1.74. The mean Margalef richness index and Pielou uniformity index were 2.51 and 0.84, respectively. The ABC curve indicated that the fish community was undisturbed. The mean acoustically-derived biomass and abundance densities were 195.40 ± 254.32 kg/km2 and 6506.83 ± 11,098.96 individuals/km2, respectively. The fishery resources had evident aggregate distribution patterns, and the southern part of the study area had more biomass than the northern part. Seven environmental factors were selected by canonical correspondence analysis (CCA) analysis to reveal the correlation between fish assemblages and environmental factors, including nitrate (NO3) ammonium (NH4+), dissolved oxygen (DO), water depth, pH, Chlorophyll a (Chl a), and phosphate (PO4+). However, the CCA only accounted for 45.49% of the total variation, indicating that other unexplained stresses affect the fish assemblage in Jinwan OWF. This is the first study to examine the fish distribution patterns and community structures of the Jinwan OWF area. In addition, it will help all sectors of society to more scientifically and objectively understand offshore wind farm projects. In future studies, control areas with more trawl samples can be set up to explore the long-term impact of OWF facilities on local fish communities.

Wang, W., Yin, Y., Xie, Q., Fan, S., Gui, D., & Wang, D. (2020, 30 Sept.-2 Oct. 2020). *Applying Machine Learning Method to Identify Indo-Pacific Humpback Dolphin Click Signals.* Paper presented at the 2020 IEEE/OES Autonomous Underwater Vehicles Symposium (AUV). https://doi.org/10.1109/AUV50043.2020.9267907

Accurate and efficient identification of echolocation click signals of cetaceans plays important role in conservation studies. However, it is challenging to analyze large amounts of acoustic data by traditional manual analysis methods. In this study, two supervised machine learning algorithms (the Alexnet neural network and Libsvm) were trained to automatically identify echolocation clicks of Indo-Pacific humpback dolphins. Wavelet transform was implemented to reflect the characteristics of click signals of Indo-

Pacific humpback dolphins in time-frequency images, and these images were fed into the network for training. The better performance was reported by the Alexnet neural network, the click identification accuracy of which is up to 99.7%. This study shows that the Alexnet neural network method is more efficient and available in Indo-Pacific humpback dolphin clicks identification. When this method is mature enough in the near future, then it can be applied in AUV to identify Indo-Pacific humpack dolphins on line.

Wang, X.-y., Jiang, Y., Liu, Z.-w., Yang, C.-m., Chen, B.-y., & Lü, L.-g. (2022). Three Types of Pulsed Signal Trains Emitted by Indo-Pacific Humpback Dolphins (*Sousa chinensis*) in Beibu Gulf, South China Sea. *Frontiers in Marine Science, 9*. https://doi.org/10.3389/fmars.2022.915668

Pulsed signal trains comprising clicks, buzzes, and burst-pulses play important roles in the life activities of odontocetes, but they have not been distinguished in Indo-Pacific humpback dolphins. Underwater vocalizations of this species were recorded from 27 September to 2 October 2019 in the Beibu Gulf, South China Sea. Pulsed signal trains were detected with variations in the pulsed signal number (range of 6–76), mean inter-pulse interval (IPIs_m: 0.1–315 ms), and mean duration (D ranged from tens to thousands of milliseconds). Principal component analysis and hierarchical cluster analysis based on six acoustic parameters in the pulsed signal trains identified three categories of trains designated as clicks, burst-pulses, and buzzes. Buzzes and burst-pulses (different from those described in previous research) were detected for the first time in Indo-Pacific humpback dolphins in China. The results indicated that the IPIs_m was longest for clicks but shortest for buzzes, and the D values were longer for both clicks and burst-pulses than buzzes. The three train types could be identified based on the IPIs_m, with threshold values of 4.9 and 15.5 ms. The significant variations in the three vocalization types were related to surface behaviors, and buzzes could have a special function in foraging by this species, thereby requiring further research. These findings may facilitate future quantitative evaluations of the echolocation performance in wild Indo-Pacific humpback dolphins and provide important guidance regarding acoustic observations and the identification of this species.

Wang, X. Y., Kittiwattanawong, K., Junchompoo, C., Sakornwimon, W., Chen, M., Wu, F. X., . . . Huang, S. L. (2021). Mapping Habitat Protection Priority over a Marine Ecoregion under Information Gaps. *Diversity and Distributions, 27*(2), 233-248. https://doi.org/10.1111/ddi.13190

Holistic marine biodiversity conservation refers to ecosystem-based management through marine conservation planning (MCP), based on mapping habitat protection priority areas. In practice, MCP is frequently hindered by information gaps in biodiversity distributions, particularly on a marine ecoregion scale. Species distribution modelling (SDM) can help to resolve this gap and provide information essential for MCP scenarios. We constructed habitat configurations for three coastal marine megafauna animals using SDM, then based MCP scenarios on the projected habitat configurations and tested the use of marine megafauna animals as surrogates to protect major ecosystems. Location Gulf of Thailand, Southeast Asia. Methods A MaxEnt model was used to project likely habitats for Indo-Pacific humpback dolphins (*Sousa chinensis*), Irrawaddy dolphins (Orcaella brevirostris) and sea turtles in the Gulf of Thailand. MARXAN software was used to prioritize spatial configurations for habitat protection. The percentage of overlaps between MARXAN delineations and major biodiversity features in the Gulf of Thailand were calculated. Results Habitat configurations of humpback dolphins, Irrawaddy dolphins and sea turtles were projected throughout the coastal and estuarine waters along the Gulf of Thailand. MCP based on the habitat of three marine megafauna animals highlighted five critical habitats for the

protection of major ecosystems in the Gulf of Thailand. Main conclusions Holistic MCP starts with mapping critical habitats for marine protected area (MPA) networks, balances MPA networks with maritime livelihood activities and alleviates conflicts between MPA management and local livelihood needs. A combination of SDM and MARXAN methods provides a cost-effective approach to delineate MPA networks. In this approach, surrogate selection and data preparation should consider niches representative of regional ecosystem features and avoid spatial sampling bias. In coastal and estuarine waters, marine megafauna such as coastal cetaceans and sea turtles may serve as efficient surrogates to protect major ecosystems.

Wang, Z.-T., Akamatsu, T., Nowacek, D. P., Yuan, J., Zhou, L., Lei, P.-Y., . . . Wang, D. (2019). Soundscape of an Indo-Pacific Humpback Dolphin (*Sousa chinensis*) Hotspot before Windfarm Construction in the Pearl River Estuary, China: Do Dolphin Engage in Noise Avoidance and Passive Eavesdropping Behavior? *Marine Pollution Bulletin, 140*, 509-522. https://doi.org/10.1016/j.marpolbul.2019.02.013

Soundscapes are vital to acoustically specialized animals. Using passive acoustic monitoring data, the temporal and spectral variations in the soundscape of a Chinese white dolphin hotspot were analyzed. By cluster analysis, the 1/3 octave band power spectrum can be grouped into three bands with median overall contribution rates of 35.24, 14.14 and 30.61%. Significant diel and tidal soundscape variations were observed with a generalized linear model. Temporal patterns and frequency ranges of middle frequency band sound matched well with those of fish vocalization, indicating that fish might serve as a signal source. Dolphin sounds were mainly detected in periods involving low levels of ambient sound and without fish vocalization, which could reflect noise avoidance and passive eavesdropping behaviors engaged in by the predator. Pre-construction data can be used to assess the effects of offshore windfarms on acoustic environments and aquatic animals by comparing them with the soundscape of postconstruction and/or postmitigation.

Xu, W., Dong, L., Caruso, F., Gong, Z., & Li, S. (2020). Long-Term and Large-Scale Spatiotemporal Patterns of Soundscape in a Tropical Habitat of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*). *PLOS One, 15*(8), e0236938. https://doi.org/10.1371/journal.pone.0236938

Little is known about the characteristics of ambient sound in shallow waters southwest of Hainan Island, China, a tropical habitat of the Indo-Pacific humpback dolphin. The spatiotemporal patterns of soundscape in this area were thus studied and described here. Acoustic data collected from February 2018 to February 2019 at ten monitoring sites, spanning ~200 km of the coastline, were analyzed. The ambient sound characteristics in the investigated area showed significant spatiotemporal variations. Sound levels centered at 0.5 and 1 kHz were higher during dusk and night than other times of the day at all monitoring sites except for one. Higher sound levels at frequencies above 8 kHz were documented during autumn and winter at all sites except for three of them. Biological and anthropogenic sound sources including soniferous fishes, snapping shrimps, dolphins, ships, pile-driving activities, and explosions were identified during spectrogram analyses of a subsample of the dataset. The shipping noise was frequently detected throughout the monitoring sites. Spatiotemporal variations of the soundscape in the investigated waters provided baseline information on the local marine environment, which will be beneficial to the protection of the vulnerable Indo-Pacific humpback dolphin population recently discovered in the investigated waters.

Yuan, J., Wang, Z., Duan, P., Xiao, Y., Zhang, H., Huang, Z., . . . Wang, D. (2021). Whistle Signal Variations among Three Indo-Pacific Humpback Dolphin Populations in the South China Sea: A Combined effect of the Qiongzhou Strait's Geographical Barrier Function and Local Ambient Noise? *Integrative Zoology, 16*(4), 499-511. https://doi.org/10.1111/1749-4877.12531

Geographic variations in the dolphin whistles could be useful in assessing association and isolation among populations. Whistle of free-ranging Indo-Pacific humpback dolphins (*Sousa chinensis*) among the Pearl River Estuary (PRE), Leizhou Bei (LZB) and Sanniang Bay (SNB) populations were investigated. A total of 2850 whistles with legible fundamental contour were extracted and 15 acoustic parameters were measured. Contrary to SNB, PRE and LZB had the same relative proportion of tonal type compositions with flat and sine representing the most frequent types. The generalized linear model analysis showed significant acoustic difference among populations and tonal types. All frequency parameters in SNB were significantly higher than those in PRE and LZB, where no significant variation was observed in most of the parameters either at the population level or within each tonal type. Canonical discriminant functions analysis showed a smaller difference between PRE and LZB than between PRE and SNB and between LZB and SNB. Compared with previous recordings, recent recordings demonstrated a consistent pattern of becoming higher in whistle frequency parameters in both LZB and SNB populations, suggesting that noise pollution in LZB and SNB increasing with time according to the acoustic niche hypothesis. Dolphin whistle's geographic variations could be shaped by the combined function of the geographical barrier function of the Qiongzhou strait and local ambient noise. Considering the isolated condition and the relatively smaller population size of the humpback dolphin in the SNB, more effective and proactive conservation actions should be taken to prevent the extinction of small populations.

Zeng, Q., Lin, W., Dai, Y., Zhong, M., Wang, X., & Zhu, Q. (2020). Modeling Demographic Parameters of an Edge-of-Range Population of Indo-Pacific Humpback Dolphin in Xiamen Bay, China. *Regional Studies in Marine Science, 40*. https://doi.org/10.1016/j.rsma.2020.101462

The Indo-Pacific humpback dolphin (*Sousa chinensis*) is a species vulnerable to extinction. One population of this species, located in Xiamen Bay, China, has been extensively studied so as to estimate its abundance. However, the demographic dynamics of this population are not fully known. To study survival and the size of this population, monthly photo-identification surveys were conducted from August 2010 to July 2015. A total of 157 dolphin sightings were recorded and 60 individuals were successfully photo-identified for use in mark-recapture analysis. The super-population size estimated by POPAN modeling suggested that 64 individuals were present in Xiamen Bay during the study period, and the most recent annual population size was estimated at 58 individuals (using both a Huggins closed capture model and a POPAN model). A Cormack-Jolly-Seber model estimated an annual survival rate of 0.976, which remained constant throughout the study period. However, a low level of birth rate and/or calf survival, which was indicated by the low probabilities of entrance into marked population, may not support the long-term persistence of this population. Based on these findings, we propose that a comprehensive assessment of anthropogenic impacts on this population should be performed and actions should be taken accordingly, to limit mortality and increase the birth rate.

Zhang, X., Luo, D., Yu, R.-Q., & Wu, Y. (2023). Multilocus DNA Metabarcoding Diet Analyses of Small Cetaceans: A Case Study on Highly Vulnerable Humpback Dolphins and Finless Porpoises from the Pearl River Estuary, China. *Integrative Zoology, 18*(1), 183-198. https://doi.org/10.1111/1749-4877.12640

Accurate diet identification of top predators is crucial to fully understand their ecological roles. Compared to terrestrial animals, gathering dietary information from cetaceans is notoriously difficult. Here, we applied a multilocus metabarcoding approach to investigate the diet of vulnerable Indo-Pacific humpback dolphins and Indo-Pacific finless porpoises from the Pearl River Estuary (PRE), China. Our analyses identified 21 prey fish species from the 42 humpback dolphin stomachs, as well as 10 species of fish and 1 species of cephalopod from the 13 finless porpoise stomachs. All of the taxa were assigned to the species level, highlighting that the multimarker approach could facilitate species identification. Most of the prey species were small- and medium-sized fishes that primarily fed on zooplankton. The calculated similarity index revealed a moderated dietary overlap between the 2 cetaceans, presumably due to the feeding of the 2 predators in association with fishing vessels in the PRE. A more diverse diet was observed in humpback dolphins in the closed fishing season compared to the fishing season, implying the influence on the dolphin diet due to the availability of commercial fishery resources. However, according to the results of species rarefaction curves, our findings on the feeding habits of the 2 cetaceans are still limited by insufficient sample size and therefore should be interpreted with caution. This study represents a first attempt to apply the multilocus DNA metabarcoding technique in the diet analysis of small cetaceans, although more efforts are needed to improve this type of analysis.

Zhang, X., Luo, D., Yu, R.-Q., Xie, Z., He, L., & Wu, Y. (2021). Microplastics in the Endangered Indo-Pacific Humpback Dolphins (*Sousa chinensis*) from the Pearl River Estuary, China. *Environmental Pollution, 270*, 116057. https://doi.org/10.1016/j.envpol.2020.116057

Microplastic pollution is a growing concern worldwide. Despite numerous studies showing the occurrence of microplastics in low-trophic level aquatic organisms, microplastic ingestion and contamination in cetaceans, especially those from Asian waters, has been rarely recorded. Here, we investigated stomach microplastic pollution in twelve Indo-Pacific humpback dolphins stranded along the Pearl River Estuary (PRE), China. We also compared microplastic abundances in dolphins stranded near populated urban areas (ZH, n = 6) with those stranded near rural areas (JM, n = 6). Microplastics were detected in all samples, with abundance ranging widely from 11 to 145 items individual−1 (mean ± SD, 53 ± 35.2). Major microplastics were polypropylene and polyethylene fibers, with the size mostly ranging from 1 to 5 mm and the dominant colors of white or transparent. Humpback dolphins from ZH (73 ± 36.8 items individual−1) exhibited a significantly higher average microplastic abundance than those from JM (33 ± 18.3 items individual−1, $p < 0.05$). In particular, the highest microplastic concentration was identified in the dolphin (SC-ZH01) stranded near the mouth of the Pearl River, whereas the dolphin (SC-JM04) collected at the rural site contained the lowest concentration of microplastics, suggesting the important influence of land-based human activities on the accumulation of microplastics in the PRE. The identification of varied microplastic polymers indicated their complex source scenarios. This study suggests that, as one of top predators in the potential microplastic food chains, this cetacean species could likely serve as an endpoint biomonitoring species of microplastic pollution in the PRE or other similar estuarine ecosystems. Our results highlight the need for more studies towards better understanding the potential impacts of microplastics on this endangered species.

Zhang, X., Yu, R.-Q., Lin, W., Gui, D., Sun, X., Yu, X., . . . Wu, Y. (2019). Stable Isotope Analyses Reveal Anthropogenically Driven Spatial and Trophic Changes to Indo-Pacific Humpback Dolphins in the Pearl River Estuary, China. *Science of the Total Environment, 651*, 1029-1037. https://doi.org/10.1016/j.scitotenv.2018.09.256

As long-lived apex predators in the Pearl River Estuary (PRE) of China, Indo-Pacific humpback dolphins (*Sousa chinensis*) are particularly vulnerable to anthropogenic impact and may undergo considerable ecological trait changes. The variability of traits, however, is often difficult to trace back in nature. Here, we analyzed stable isotope ratios of carbon and nitrogen in muscle samples of 88 *S. chinensis* stranded in the PRE from 2004 to 2016 to investigate the ecological changes occurring in the dolphins. Stable isotope analysis revealed the existence of two sub-aggregations of *S. chinensis* in the PRE. Generalized additive models showed significant decreasing trends in both carbon and nitrogen isotopic signatures over time, indicating the habitat changes and dietary shifts, possibly due to the influence of increased coastal developments and fishing activities in the PRE. Diet modeling suggests that the proportional contribution of higher trophic-level prey decreased in the *S. chinensis* diet over time, while increased consumption of lower trophic-level prey was observed. This shift was related to depletion of higher trophic-level prey caused by overfishing. Although *S. chinensis* could temporarily compensate for the lost energy supply through feeding plasticity (revealed by the negligible differences of isotope niche width among different stranding periods), long-term depletion in prey availability may cause long-lasting negative effects on this dolphin population. This study highlights the crucial relationships between fishery management and dolphin conservation, providing scientific evidence for the long-term protection of this threatened species in the PRE region.

Zhang, X., Yu, R., Xie, Y., Yu, R.-Q., & Wu, Y. (2022). Organotins Remain a Serious Threat to the Indo-Pacific Humpback Dolphins in the Pearl River Estuary. *Environmental Science & Technology, 56*(18), 13046-13057. https://doi.org/10.1021/acs.est.2c02780

Marine mammals often accumulate high levels of environmental contaminants, even those that are globally regulated regarding usage, raising concerns about their health status. Here, we conducted the first investigation of tissue distribution, spatiotemporal trends, and potential risks of six organotin compounds (OTs) in Indo-Pacific humpback dolphins (n = 101) from the northern South China Sea during 2003–2021. We detected the highest level of hepatic triphenyltin in these humpback dolphins compared with the results reported in cetaceans globally, and the liver accumulated the highest OT concentrations than other analyzed tissues. Despite the downward trend of butyltins in humpback dolphins after the global ban on the use of OTs as antifouling paints, levels of phenyltins have continued to increase over the past 20 years, suggesting that the other applications of phenyltins in South China remain prevalent. In vitro and in vivo analyses revealed that tissue-relevant doses of OTs could induce agonistic effects on the dolphin peroxisome proliferator-activated receptor γ as a master regulator of lipid homeostasis and altered the dolphin fatty acid profiles. Our results highlight the lipid-disrupting effects of current OT exposure in humpback dolphins and emphasize the need for further efforts to eliminate OT contamination in South China.