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Developing cetacean-friendly guidelines, from whale watching to offshore wind farm operation

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Developing offshore wind farms may impact cetaceans due to vessel collisions and underwater noise. Therefore, it is critical to protect cetaceans while developing offshore wind farms. We first studied the code of conduct/guidelines for whale watching and then interviewed members of the local whale-watching industry to learn about the interaction between cetaceans and vessels. After that, we compared current whale-watching guidelines in Taiwan with 69 published guidelines from other countries and locations, then developed guidelines for the offshore wind farm industry. The results show that rules related to approaching and interacting with cetaceans in Taiwan are similar to those in other countries. However, swimming with cetaceans and approaching calves are prohibited in Taiwan. From the survey of the whale-watching industry, most whale-watching guidelines in Taiwan were found to be feasible, and the guidelines should be described in the premise with different phenotypic traits of various cetaceans. Based on the whale-watching guidelines, we developed a code of conduct for protecting cetaceans from the impact of vessels, specifically in offshore wind farm operations in Taiwan.

KEYWORDS

cetacean, whale watching, offshore wind farm (OWF), vessel guideline, sustainability

Introduction

This study aimed to establish relevant codes of conduct in the operation of the wind farm industry for protecting cetaceans. The purpose is to manage boat activities to minimize the impact on cetaceans and achieve the goal of coexistence with cetaceans. Cetaceans are important in ecosystems and are under protection. According to the Red List of Threatened Species proposed by the International Union for Conservation of Nature (IUCN) in March 2021, there are more than 90 known species of cetaceans. The survival of cetaceans has been considered to play an important role in coping with global change (Sheehy et al., 2022). Cetaceans are high-grade consumers of their habitat ecosystems and are considered important indicators of maintaining ecosystems (Sousa et al., 2019). The life cycle of cetaceans has also been found to contribute to carbon fixation. When cetaceans excrete at the ocean's surface, they provide phytoplankton nutrients, which can increase the fixed carbon (Sheehy et al., 2022). Cetaceans also store large amounts of carbon (Smith and

Baco, 2003). When the cetaceans die and sink to the seafloor, a large amount of carbon stored in their bodies is brought to the seafloor (Sheehy et al., 2022). Therefore, for maintaining the sustainable development of human beings, it is important to maintain the sustainable development of cetaceans.

Cetacean diversity is high in the surrounding seas of Taiwan. According to the Marine Wildlife Conservation Division of the Ocean Conservation Administration (Ocean Conservation Administration, 2022), 33 cetacean species have been recorded around Taiwan (Table 1), approximately one-third of the cetacean species in the world. The underwater topography differs between the east and west of Taiwan, and different cetacean species inhabit it. The continental shelf of the eastern waters of Taiwan is narrow and steep, and the water depth along the coast rapidly drops over 2,000 meters. Many species of cetaceans have been observed, such as Risso's dolphins (*Grampus griseus*), common bottlenose dolphins (*Tursiops truncatus*), pantropical spotted dolphins (*Stenella attenuata*), spinner dolphins (*Stenella longirostris*), and Fraser's dolphins (*Lagenodelphis hosei*) (The Ichthyology Society of Taiwan, 2020), and there are even records of humpback whales (*Megaptera novaeangliae*) (Yu and Hu, 2023). Therefore, whale watching is a popular activity on the eastern coast. The continental shelf in the western water is wide and shallow, and the water depth is mostly within 100 meters. There are few relevant surveys and few records of cetacean species in comparison to the eastern waters. The common cetaceans in the western waters are the widely distributed Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) and Indo-Pacific finless porpoises (*Neophocaena phocaenoides*) in wind farm areas and Indo-Pacific humpback dolphins (*Sousa chinensis* in shallower waters near the coast (Lee, 2006; Yang et al., 2021). Both the diversity and abundance of cetaceans are higher in the East than in the West.

With the diverse population of cetaceans along Taiwan's east coast, whale-watching has become an important human activity in the region (Figure 1). Guidelines for interacting with these marine mammals have also been developed to ensure responsible and respectful interactions. The development of whale-watching tourism in Taiwan started at Shiti Fishing Port, Hualien, in July 1997. The number of tourists increased rapidly in the early years and slowed down around the year 2000 (Ku, 2013). The number of tourists was maintained at approximately 200,000 to 240,000 people annually from 2005 to 2009 (Ku, 2013). Then, it developed into an important tourism project with more than 460,000 visitors annually in 2016 (Chuang et al., 2020). Currently, whale-watching industries are present in several ports along the eastern coast of Taiwan, including Wushi Harbor, Hualien Harbor, Shiti, and Chenggong Harbor (Figure 1). However, while the industry is blooming, it also encountered situations similar to other countries with fast-growing whale-watching industries, i.e., the tourism impact on cetaceans (Pacheco et al., 2022). In order to ensure the coexistence of whale conservation and the whale-watching industry, it is essential to establish high-quality and sustainable whale-watching activities. Therefore, in May 2019, the Ocean Conservation Administration proposed "Whale-Watching Guidelines" for relevant businesses and tourists (Ocean Conservation Administration, 2019).

The offshore wind farm is also one of the human activities in Taiwan that was developed in the west of Taiwan (Figure 1). However, the guidelines for vessels in offshore wind farms are still being developed. There is a high potential for wind energy in the Taiwan Strait, and the government proposes to develop this renewable energy (Cheng et al., 2020). Offshore wind farms in Taiwan have been listed as one of the important development projects of the Ministry of Economic Affairs. The first offshore wind farm was completed and began operating in 2019, and there are more wind farms under construction and planning, mainly around the northeastern part of the Taiwan Strait (Figure 1). The increasing human activities in the ocean may negatively impact marine ecosystems as well as cetaceans, and the major effects of offshore wind farms on cetaceans are ship strikes (Schoeman et al., 2020) and underwater noise (Erbe et al., 2019). According to the records, at least 28 species of cetaceans have been documented to have been struck by vessels, ranging from larger species like baleen whales to smaller ones like toothed whales (reviewed in Schoeman et al., 2020). The impacts of ship strikes on whales and dolphins can be categorized into three types of consequences (Schoeman et al., 2020): (1) the direct consequences, i.e., immediate injuries or even death (Dwyer et al., 2014; Peel et al., 2018); (2) the long-term consequences, i.e., possible reduced fitness of an individual (Moore et al., 2013); and (3) the population consequences, i.e., a higher mortality rate than recruitment rate (Fais et al., 2016). Underwater noise is mainly caused by pile driving at wind turbine construction. This underwater noise may have various impacts on cetaceans, i.e., permanent/temporary hearing loss, masking, habitat displacement, and physiological effects (Thompson et al., 2013; New et al., 2015; Wright et al., 2020; Yang et al., 2021), thereby affecting the survival of individuals and groups (New et al., 2015; Forney et al., 2017). This study focused on preventing ship strikes.

To sum up, this study intends to formulate a guideline to protect cetaceans for vessel activities in Taiwan, especially regarding the impact of vessels on cetaceans. The whale-watching industry has great experience in the interactions between boats and cetaceans. We studied the whale-watching guideline/code of conduct by comparing international guidelines and surveying the whale-watching industry of Taiwan to learn the critical vessel-cetacean interaction, then applied the concept of friendly interaction to the guideline in offshore wind farms.

Materials and methods

Procedures

There are four conducting steps in this study. First, we collected and categorized cetacean-friendly guidelines for the whale-watching industry worldwide. Then, we compared the differences between the Taiwanese guidelines and guidelines from the rest of the world. After that, we surveyed Taiwan's whale-watching industry to understand the practicality of the guidelines. Finally, we compiled a cetacean-friendly guideline for the operating vessels of offshore wind farms.

TABLE 1 Cetaceans known to Taiwan.

Cetacean	The IUCN Red List Categories (Global)	Distribution (Global)	Major Threats (Global)	Protected Species Categories (Taiwan)	Distribution (Taiwan)	Population size (Taiwan)
Balaenopteridae						
Common minke whale (*Balaenoptera acutorostrata*)	LC	From the tropics and subtropics to the ice edges in both hemispheres	Hunting, bycatch, vessel strikes, and habitat disturbance	I	Eastern[67] and centralwestern[7] coast	Unknown
Sei whale (*Balaenoptera borealis*)	EN	From the tropics to polar zones in both hemispheres	Bycatch and vessel strikes	I	Southern coast[8]	Unknown
Bryde's whale (*Balaenoptera edeni*)	LC	In the tropical and subtropical zones in both hemispheres (between 0° and 40°)	Hunting, habitat disturbance, and noise disturbance	I	Taiwan east coast, Penghu and Kinmen[7]	Unknown
Blue whale (*Balaenoptera musculus*)	EN	From the tropics to polar zones in both hemispheres	Bycatch, vessel strikes, noise disturbance, and chemical pollution	I	Eastern[7] and southern[8] coast	Unknown
Omura's whale (*Balaenoptera omurai*)	DD	In the western Pacific and eastern Indian oceans	Bycatch, vessel strikes, and habitat disturbance	I	Eastern and Western coast[7]	Unknown
Fin whale (*Balaenoptera physalus*)	VU	Mainly in the temperate and polar zones of all oceans, rare in tropical seas	Hunting, bycatch, and vessel strikes	I	Western coast[7]	Unknown
Humpback whales (*Megaptera novaeangliae*)[2]	LC	In most seas	Hunting, bycatch, and vessel strikes	I	Eastern[67] and southwestern[7] coast	Unknown
Eschrichtiidae						
Gray whale (*Eschrichtius robustus*)	LC	In the North Pacific Ocean and adjacent sea	Hunting, exploration, and extraction of petroleum	I	Eastern coast[6]	Unknown
Physeteridae						
Sperm whale (*Physeter macrocephalus*)	VU	In all seas	Hunting, bycatch, and vessel strikes	I	Eastern and Southern coast[6]	Several individuals in the summer
Kogiidae						
Pygmy sperm whale (*Kogia breviceps*)	LC	From deep waters in the tropical to warm temperate zones of all oceans	Bycatch, plastic debris ingestion, and vessel strikes	II	Northeastern, eastern and southern coasts[67], and other coasts of Taiwan[7]	Unknown
Dwarf sperm whale (*Kogia sima*)	LC	In the tropical to warm-temperate zones	Hunting and plastic debris ingestion	II	Northeastern, eastern and southern coasts[67], and other coasts[7]	Unknown
Ziphiidae						
Blainville's beaked whale (*Mesoplodon densirostris*)	LC	In the temperate and tropical waters of all oceans	Hunting and bycatch	II	Taiwan's east (including outlying islands), northwest, and southwest coasts, Kinmen and Mazu[7]	Unknown
Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*)	DD	In the temperate and tropical waters of the Indo-Pacific	Hunting and bycatch	II	Taiwan's east (including outlying islands) and southwest coast and Penghu[7]	Unknown

(Continued)

TABLE 1 Continued

Cetacean	The IUCN Red List Categories (Global)	Distribution (Global)	Major Threats (Global)	Protected Species Categories (Taiwan)	Distribution (Taiwan)	Population size (Taiwan)
Longman's beaked whale (*Indopacetus pacificus*)	LC	Mainly in deep waters in the tropical and subtropical Indo-Pacific	Bycatch, garbage pollution, and habitat disturbance	II	Taiwan's northeast and east (including outlying islands) coasts	Unknown
Cuvier's beaked whale (*Ziphius cavirostris pacificus*)	LC	In most seas except the Arctic Ocean	Hunting and bycatch	II	Eastern coast[67]	Unknown
Delphinidae - Globicephalinae						
Pygmy killer whale (*Feresa attenuata*)	LC	In the tropical and subtropical oceans, not ranging north of 40° N or south of 35°	Hunting and bycatch	II	Taiwan northeast and east (including outlying islands)[6] and southwest coasts[7]	Unknown
Melon-headed whale (*Peponocephala electra*)	LC	In the tropical and subtropical oceans, not ranging north of 40° N or south of 35°S	Bycatch, garbage pollution, and habitat disturbance	II	Eastern coast[6]	Unknown
Killer whale, Blackfish (*Orcinus orca*)	DD	In most seas	Hunting, bycatch, noise disturbance, and garbage pollution	II	Eastern and southwestern coasts[6]	Unknown
Short-finned pilot whale, Blackfish (*Globicephala macrorhynchus*)	LC	In the warm temperate to tropical water	Hunting and bycatch	II	Northeastern and eastern coasts[6]	Unknown
False killer whale, Blackfish (*Pseudorca crassidens*)[1]	NT	In the tropical and warm temperate waters in all three major oceans, not generally range poleward of about 50	Bycatch	II	Taiwan's northeastern, eastern, and southwest coasts and Penghu[6]	Unknown
Risso's dolphins (*Grampus griseus*)[2]	LC	From the tropics through the temperate regions in both hemispheres (between 64°N to 46°S)	Hunting and bycatch	II	Eastern coast[6]	400[9]
Delphinidae - Others						
Indo-Pacific humpback dolphins (*Sousa chinensis*)[3]	VU, CR[4]	From central China in the east, through the Indo-Malay Archipelago, and westward around the coastal rim of the Indian Ocean to as far west as the Orissa coast of India	Bycatch, garbage pollution, vessel strikes, and habitat disturbance	I	Taiwan's west coast and Kinmen[6,7]	<100[10]
Pantropical spotted dolphins (*Stenella attenuata*)[2]	LC	Mainly in the Pacific, Atlantic, and Indian oceans	Hunting, bycatch, and garbage pollution	II	Northeastern[6], eastern (including outlying islands)[6], southwestern[6,7], and southern[6,7] coasts	Unknown
Striped dolphin (*Stenella coeruleoalba*)	LC	In the Atlantic, Pacific, and Indian oceans (between 50°N to 40°S)	Hunting, bycatch, and garbage pollution	II	Taiwan northeast[7], east[6], west[6], and south[6] coasts; Penghu;[7] and Kinmen[7]	Unknown
Spinner dolphin, Long-snouted spinner dolphin	LC	In the Atlantic, Pacific, and Indian oceans (between 40°N to 40°S)	Hunting, bycatch, and human recreational activities	II	Northeastern[6], eastern[67] (including outlying islands), and south[6,7] coasts	Unknown

(Continued)

TABLE 1 Continued

Cetacean	The IUCN Red List Categories (Global)	Distribution (Global)	Major Threats (Global)	Protected Species Categories (Taiwan)	Distribution (Taiwan)	Population size (Taiwan)
(*Stenella longirostris*)[2]						
Fraser's dolphins (*Lagenodelphis hosei*)[2]	LC	In the Atlantic, Pacific, and Indian oceans (between 30°N to 30°S)	Hunting, bycatch, and garbage pollution	II	Northeastern[6], eastern[6,7], southwestern[6,7] and southern[6] coasts	Unknown
Rough-toothed dolphin (*Steno bredanensis*)	LC	In the Atlantic, Pacific, and Indian oceans (between 40°N to 35°S)	Hunting, bycatch, and garbage pollution	II	Eastern[6], western[6,7], northern[7], and southern[7] coasts	Unknown
Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)[1,3]	NT	In the warm-temperate to tropical Indo-Pacific	Hunting, bycatch, garbage pollution, and habitat disturbance	II	Eastern[6,7] western[6,7], and southern[6,7] coasts and other coasts[7]	Unknown
Common bottlenose dolphins (*Tursiops truncatus*)[1,2,3]	LC	In the coastal and continental shelf waters of the tropical and temperate regions	Hunting, bycatch, garbage pollution, and habitat disturbance	II	Northeastern[6,7], eastern[6,7] (including outlying islands)[6,7], and northern[6,7] coasts and other coasts[7]	Unknown
Long-beaked common dolphin (*Delphinus capensis*)[3]	DD	In the nearshore of the tropical and subtropical waters (within 180 km of the coast)	Hunting and bycatch	II	Taiwan northeast[6], east (including outlying islands)[6], and north[7] coasts and Kinmen[7]	Unknown
Short-beaked common dolphin (*Delphinus delphis*)[3]	LC	Mainly in the nearshore of the tropical to cool temperate waters of the Atlantic and Pacific oceans	Hunting and bycatch	II	Northern coast[7]	Unknown
Phocoenidae						
Wide-ridged finless porpoise (*Neophocaena phocaenoides*)[1,3]	VU	In the shallow, tropical to warm temperate coastal waters of the Indo-Pacific region	Hunting, bycatch, garbage pollution, and habitat disturbance	I	Taiwan north[7] and west[7] coasts, Kimen[7], and Matsu[6,7]	Unknown
Narrow-ridged finless porpoise (*Neophocaena asiaeorientalis*)[1,3]	EN, CR[5]	In the shallow, tropical to warm temperate coastal waters of the western Pacific Ocean	Hunting, bycatch, garbage pollution, and habitat disturbance	II	Taiwan west[6,7] coast, Kimen[7], and Matsu[6,7]	Unknown

[1]Common species in wind farms in Taiwan.
[2]Common species on the eastern coast of Taiwan.
[3]Common species on the western coast of Taiwan.
[4]Eastern Taiwan Strait population.
[5]Neophocaena asiaeorientalis asiaeorientalis in the Yangtze River of China.
[6]According to the record of visual observation.
[7]According to the record of stranding.
[8]According to the record of catching.
[9]According to the data from Chen (2001) in Yilan and Wang (2000) in Kenting.
[10]According to Wang et al. (2004); Wang et al. (2007); Ross et al. (2010); Slooten et al. (2013); Wang and Araújo-Wang (2018), and Ho et al. (2023).
Summary of the cetaceans known to Taiwan. The adjusted review data from Jefferson et al. (2015), Shao et al. (2020) and IUCN update reports. In the IUCN Red List categories, CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern; DD, data deficient. In the protected species categories of Taiwan, I, endangered species; II, rare and valuable species.

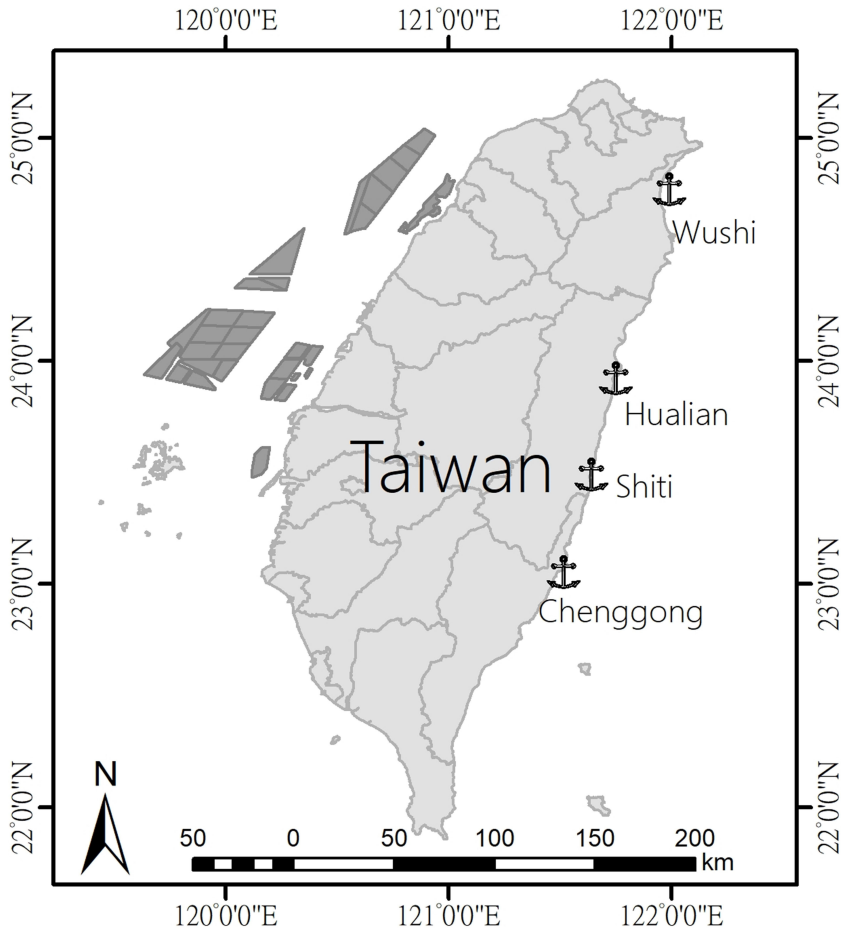

FIGURE 1
Whale-watching harbors and off-shore wind farm areas (gray polygons) in Taiwan.

Guidelines collection and comparison

We searched the internet and solicited the advice of experts to identify guidelines/codes of conduct. The majority of the guidelines were collected from the database on the International Whaling Commission (IWC) website and the review paper of Carlson (2012), while few were from other sources. We followed Garrod and Fennell (2004) and classified terms in the guidelines into four categories: (1) general information (the published year and location of guidelines), (2) approaching characteristics (the way the vessels approach cetaceans), (3) interacting characteristics (the way the vessels and visitors interact with cetaceans), and (4) management orientation characteristics (the restrictions of reducing pollution and the disturbance to calves). Next, we scrutinized these terms by categories.

The cetacean-friendly guideline in Taiwan has been developed by the Ocean Conservation Administration (OCA) since 2018 and is announced on the website of OCA. We compared the terms mentioned in the guideline in Taiwan to other guidelines, focusing on their agreement and disagreement.

Surveys for the whale-watching industry

This study investigated the practicality of whale-watching guidelines, considering the level of acceptability and feasibility of implementing the guidelines. The acceptability is related to whether operators endorse these guidelines (Parsons, 2012). Previous research has shown that during the early stages of guideline development, higher rates are achieved when operators and relevant people are involved in the collaborative agreement and participation process (Parsons and Woods-Ballard, 2003). On the other hand, feasibility is primarily associated with the ease of dissemination (Scarpaci et al., 2004). Requirements that are easier to meet are more likely to be adopted and utilized by operators. When guidelines related to cetacean conservation are readily accepted and feasible to implement, the effectiveness of whale conservation efforts will be enhanced. In Taiwan, the OCA's initial development of the whale-watching guidelines involved soliciting operator feedback. This study seeks to adjust the details of the whale-watching guidelines, and the experiences of relevant operators remain an integral part of this process.

We designed a questionnaire based on terms of Taiwanese guidelines. There were two parts to the questionnaire (Table 2): the first part included 16 terms from the Taiwanese guidelines, and the second part included 14 justified terms based on the Taiwanese guidelines. The questionnaire inquired whether the term is acceptable and feasible to abide by, using a scale of five points. The higher score meant the term was more acceptable and feasible to practice. We surveyed a total of 19 captains and tour guides from 13 whale-watching companies in 2022. There were 13 questionnaires from nine companies from Wushi, four questionnaires from three companies from Hualien, and two questionnaires from one company from Chenggong (Table S1).

Data analyses

In this study, we analyzed survey questionnaires to understand the acceptability and feasibility of the terms in the cetacean-friendly guideline in Taiwan. To assess whether there is a disparity between the level of acceptability and feasibility of whale-watching guidelines, we employed a non-parametric paired test, the Wilcoxon Signed Rank test. If a significant difference is observed, it indicates a disparity between the animal conservation concept and practice. JMP Pro 17 (SAS Institute Inc., Cary, NC, USA) was used for the data analysis in this study.

Results

The current situation of whale-watching guidelines

In addition to the Taiwanese guidelines, 69 cetacean-friendly guidelines for whale-watching were collected worldwide. The general information of these guidelines included the published location and year of the guidelines. We ranked their distribution based on the number of guidelines geographically (Figure 2). Europe ranks highest with 26 guidelines, which accounts for 37.7%. Central and South America ranks second with 17 guidelines, which accounts for 24.6%. Australia/New Zealand/Micronesia ranks third with nine guidelines, which accounts for 13.0%, followed by North America, which provides eight guidelines, accounting for 11.6%. The rest of the world, including Africa, Asia, and Antarctica, provides only nine guidelines.

There were 43 guidelines with the published year as known. The number of guidelines increases through years of whale-watching development (Figure 3). The increment is approximately doubled every ten years. It reached 25 guidelines, accounting for 36.2% in the period 2010-2019.

The characteristics of a vessel approaching may define an observing distance, i.e., the minimal distance between cetaceans and vessels. More than half of the guidelines, i.e., 36 guidelines, accounting for 52.2%, agree that the distance should be 50 to 99 meters (Table 3A). Again, more than half, i.e., 38 guidelines, accounting for 55.1% of the guidelines do not declare variation in observing distance based on various conditions, e.g., species, size, or mother-calf (Table 3B). Furthermore, 28 data entries (40.6%) specify minimum distances based on species or the size of cetaceans. The mainstream requirement for observing distance is at least 100 meters (17 entries), followed by a minimum of 200 and 300 meters (3 entries each) in the regions with large cetaceans. Most guidelines advocate that no more than three (21.7%) vessels can be around the cetaceans (Table 3C). The terms of the guidelines in Taiwan are consistent with the mainstream requirements. The distance between vessel and animal should be no less than 50 meters (no species difference), and no more than three vessels should be at this distance from the cetaceans.

The interacting characteristics in the guidelines include swimming with, touching, and feeding cetaceans, as well as noise regulation and observation time. Most guidelines conditionally allowed people to swim with cetaceans (23 guidelines, accounting for 33.3%, Table 4A), but neither touching (30 guidelines, accounting for 43.5%, Table 4B) nor feeding (35 guidelines, accounting for 50.7%, Table 4C) cetaceans is permitted. Most guidelines also prohibit making noise during whale-watching activities (50.7%, Table 4), and for the time of observation, most guidelines suggest that it should not exceed 30 minutes (42.0%, Table 4D). The Taiwanese guidelines do not permit people to swim with cetaceans, and of course, touching and feeding are not permitted either. The suggested observation time conforms with

TABLE 2 The questionnaire for the industry of whale-watching.

Terms	n	p-value
Part 1		
Vessels should approach cetaceans from the side	17	1.000
Vessels should slow down when approaching cetaceans	18	0.688
When encountering cetaceans riding waves, vessels should maintain a stable speed	18	0.625
When encountering cetaceans riding waves, vessels should not change course suddenly	18	0.625
Do not deliberately chase cetaceans	18	0.625
Keep more than 50 meters from cetaceans	17	0.500
Do not put litter or any artificial objects into the ocean	17	0.500
Do not feed cetaceans	18	0.500
Do not touch cetaceans	18	0.500
Multiple vessels should be on the same side of cetaceans as much as possible	18	0.176
Keep more than 300 meters from calves	17	0.070
Vessels should stay parallel to the cetaceans	18	0.063
Avoid approach calves	18	0.063
Do not break up or cut into the group of cetaceans	18	0.063
Keep less than three vessels around the cetaceans at a time	18	0.008*
Do not deliberately encircle cetaceans	18	0.008*

(Continued)

TABLE 2 Continued

Terms	n	p-value
Part 2		
When vessels enter within 300 meters of the target cetacean, the maximum speed of the vessels shall not exceed 6 knots	17	1.000
If vessels encounter a large whale (more than 10 meters in length), such as a humpback whale, the distance should be more than 300 meters	18	1.000
When cetaceans exhibiting disturbed behavior, keep at a distance of more than 300 meters	17	1.000
Do not do improper sailing methods such as reversing the vessel or accelerating rapidly within 300 meters of cetaceans	18	1.000
Do not chase calves	18	1.000
Do not play or imitate cetaceans' sounds	18	1.000
When observing or moving with cetaceans, vessels should be parallel to the cetaceans	18	0.727
When entering the range within 300 meters of cetaceans, the observation time is up to 30 minutes	18	0.688
Vessels should slow down when they come within 300 meters of the target cetacean	18	0.500
Do not block cetaceans between vessels and shore (or artificial structures)	18	0.375
Do not approach cetaceans from the front and rear of the individuals	18	0.313
Keep quiet and do not make noise	18	0.313
Keep more than 50 meters from dolphins	17	0.250
Multiple vessels are not allowed to encircle cetaceans within a radius of 500 meters at the same time	18	0.031*

Part 1 includes terms from the original guideline in Taiwan. Part 2 includes terms added to this study. n means the sample size of the Wilcoxon Signed Rank Test. Significant differences between the acceptability and the feasibility ($p \leq 0.05$) are marked in star (*).

the mainstream guidelines throughout the world, not exceeding 30 minutes.

The management characteristics mainly included managing pollution/rubbish from vessels and/or visitors and conditional allowance of watching pods with calves. There were 25 guidelines (36.2%) on managing the state of pollution/rubbish (Table 5A), and most guidelines allowed people to watch pods with calves (40.6%, Table 5B) conditionally, e.g., keeping a longer minimum distance away, such as 200m. The Taiwanese guidelines also advocate the management of pollution/rubbish. However, there is no indication of noise. The Taiwanese guideline does not endorse people viewing pods with calves either.

The acceptability and feasibility of whale-watching guidelines

To assess the practicality of whale-watching guidelines based on the concept of cetacean conservation, we employed a questionnaire to analyze whether there are differences in whale-watching operators' perceived acceptability and feasibility of guideline elements. If an item exhibits high acceptability and achievability scores with no significant differences, it can be inferred that it has high practicality. The interviewees left some questions regarding acceptability and feasibility unanswered. The number of valid responses for each question is indicated in Table 2. In the first part, wherein the questions were regarding the original terms of the whale-watching guidelines in Taiwan, interviewees presented positive attitudes (the range of the means of scores: 4.16-4.89) toward all terms in the whale-watching guideline. However, for the feasibility, the terms "no more than three vessels around the cetaceans at a time (Wilcoxon Signed Ranked Test, n = 18, p = 0.008)" and "do not encircle the cetaceans (Wilcoxon Signed Ranked Test, n = 18, p = 0.008)" were considered difficult to

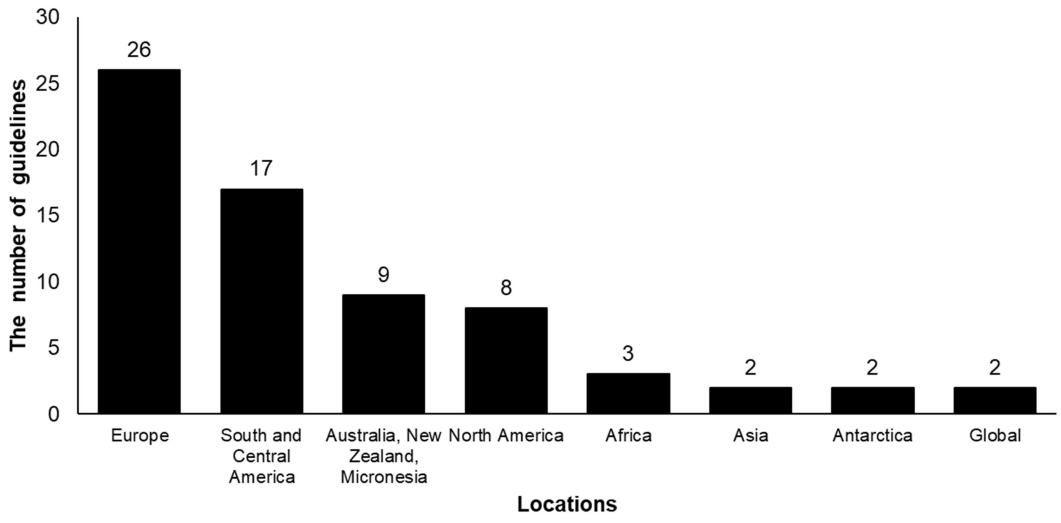

FIGURE 2
The number of collected whale-watching guidelines by continent.

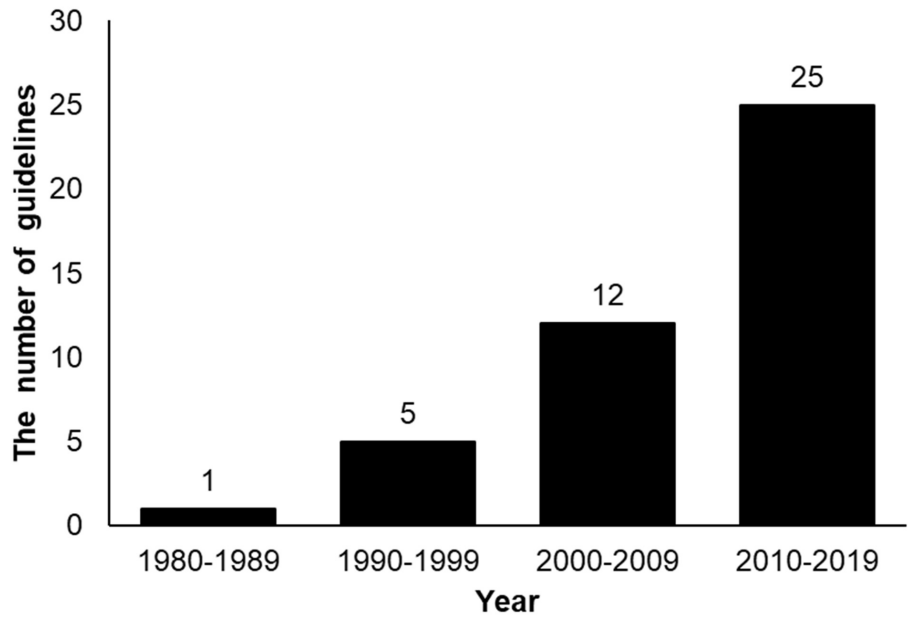

FIGURE 3
The number of collected whale-watching guidelines every 10 years.

comply with (Table 2). In the second part, wherein the questions were added terms of the whale-watching in this study, interviewees presented positive attitudes (the range of the means of scores: 4.21-4.74) toward all terms in the whale-watching guidelines. However, for feasibility, the terms "do not encircle the cetaceans with multiple vessels within the 500 meters from animals (Wilcoxon Signed Ranked Test, n = 18, p = 0.031)" were considered difficult to comply with (Table 2).

The cetacean-friendly guideline for the vessels' behavior in offshore wind farms

Based on experiences of interactions between vessels and cetaceans in the whale-watching industry and the information from the whale-watching guidelines, we compiled a cetacean-friendly guideline for vessel activity in offshore wind farms (Figure 4). While cruising, if no whales or dolphins are encountered, maintain a stable heading and velocity. If cetaceans are spotted, generally avoid approaching them actively. If the cetaceans voluntarily leave, continue observing them until they are at a distance. However, when the cetaceans do not voluntarily depart and are circling the vessel, reducing velocity or stopping the vessel and waiting for the cetaceans to depart is recommended. If the cetaceans are not circling the vessel, we suggested that the vessel slowly move away from the cetaceans on their side.

Following are descriptions of the guidelines.

1. Scenario of spotting cetaceans from afar

Cetaceans may be sighted from a distance. After spotting any cetacean, keep observing the behavior and swimming direction of the animals. The vessel maintains its original course if the animals ignore the vessel and swim away. Conversely, if the cetaceans move toward vessels initiatively, refer to the following conditions for encountering cetaceans nearby.

2. Scenario of encountering cetacean aside

TABLE 3 The summary of the approach characteristics from collected whale-watching guidelines.

Approach characteristics	n	Percentage	Taiwan
(A) Approach Distance (meters, n = 69)			
No data	3	4.4%	
10 – 49	10	14.5%	
50 – 99	36	52.2%	✓ (50 m)
100	19	27.5%	
200	1	1.5%	
(B) Approach Distance for different species (Yes/No, n = 69)			
No data	3	4.4%	
Yes	28	40.6%	
No	38	55.1%	✓
(C) Number of Boats at a Time (n = 69)			
No data	28	40.6%	
More than one of the above	9	13.0%	
More than two of the above	14	20.3%	
More than three of the above	15	21.7%	✓
More than four of the above	1	1.5%	

The check mark (✓) means the term is the same as that in the guidelines in Taiwan.

TABLE 4 The summary of the interaction characteristics from collected whale-watching guidelines.

Interaction Characteristics	n	Percentage	Taiwan
(A) Swimming (n = 69)			
No data	27	39.1%	
No swimming allowed	19	27.5%	✓
Swimming allowed	0	0.0%	
Swimming allowed, with conditions	23	33.3%	
(B) Touching (n = 69)			
No data	39	56.5%	
No touching allowed	30	43.5%	✓
Touching allowed	0	0.0%	
Touching allowed, with conditions	0	0.0%	
(C) Feeding (n = 69)			
No data	33	47.8%	
No feeding allowed	35	50.7%	✓
Feeding allowed	0	0.0%	
Feeding allowed, with conditions	1	1.5%	
(D) Noise (n=69)			
No data	34	49.3%	✓
No noise allowed	35	50.7%	
Noise allowed	0	0.0%	
Noise allowed, with conditions	0	0.0%	
(E) Dwell Time (minutes, n = 69)			
No data	24	34.8%	✓
15	5	7.3%	
20	5	7.3%	
25	1	1.5%	
30	29	42.0%	
45	2	2.9%	
60	2	2.9%	
90	1	1.5%	

The check mark (✓) means the term is the same as that in the guidelines in Taiwan.

Cetaceans may appear near the vessels suddenly or even actively race with a moving vessel, such as bow- or wake-riding, and may suddenly surround the vessel. The relevant considerations are listed below:

(1) The direction and velocity of the vessel

The vessel should stay as parallel to the cetacean as possible and change direction slowly. Also, slow down gently to leave from the side of the cetaceans. These procedures must keep as stable a velocity and direction as possible. Do not move to the position in front of or behind the cetaceans. It is important to provide exit routes for the cetaceans. Cetaceans may also lose interest and leave voluntarily when vessels slow down or stop.

(2) Do keep distance from cetaceans

In the offshore wind farms on the west coast of Taiwan, most of the cetaceans are small and medium-sized. Depending on their size, keep them at least 50 meters away. If there are calves, keep them at least 300 meters away.

(3) Do not actively interact with cetaceans

Do not make sounds to attract cetaceans and do not feed or touch them.

3. Precautious responses to encountering cetaceans

Cetacean encounters are rare events. There are no sightings of cetaceans most of the time in the ocean. When cetaceans are not spotted, to reduce the potential impacts on cetaceans during the voyage, the relevant precautions are listed below:

(1) Limitation of vessel velocity

During the months when cetaceans are observed often or when entering areas where cetaceans are more likely to appear, e.g., Wildlife Important Habitat Area for Indo-Pacific Humpback Dolphin (The Ichthyology Society of Taiwan, 2020), reduce vessel velocity below the fastest swimming speed of the cetaceans. Low vessel velocity can avoid collision with cetaceans, and low vessel velocity also reduces ship noise impact on cetaceans (Currie et al., 2017; Erbe et al., 2019; Schoeman et al., 2020).

(2) The limitation of noise

People on the vessels should not play sounds to interfere with the communication among individual cetaceans.

(3) The limitation of pollution

Do not dispose of food, garbage, or oil in the ocean.

Discussions

This study attempts to produce local guidelines for protecting cetaceans under the disturbances of human activities in the Taiwan ocean. An important element of the guidelines is self-governance. Self-governance is defined as a major resource for those involved in making and adapting guidelines over time (Ostrom, 1999) and has been considered to improve resource management in marine-related industries (Parsons et al., 2003; Lee and Rahimi Midani, 2015; Osmundsen et al., 2021). Therefore, in this study, we collected opinions from the local whale-watching companies, hoping to efficiently protect cetaceans, protect people, and protect the ecosystem. As a result, we discussed the comparison of whale-watching guidelines from different locations and the disparity between the people's perceived acceptability and feasibility of the whale-watching guidelines. In addition, captains should log cetacean activities and practices for future adjustment of the guidelines.

Cetacean diversity in Taiwan

The surrounding waters of Taiwan host a diverse cetacean community. Among the 93 known species of cetaceans globally,

TABLE 5 The summary of the management orientation characteristics from collected whale-watching guidelines.

Management orientation characteristics	n	Percentage	Taiwan
(A) Control of pollution/rubbish (n = 69)			
No data	44	63.8%	
Controls stated	25	36.2%	✓
(B) Restrictions on viewing pods with calves (n = 69)			
No data	28	40.6%	
Viewing not allowed	13	18.8%	✓
Viewing allowed	0	0.0%	
Viewing allowed, with conditions	28	40.6%	

The check mark (✓) means the term is the same as that in the guidelines in Taiwan.

there have been records of 33 species in the vicinity of Taiwan, including seven species of Balaenopteridae, one species of Eschrichtiidae, one species of Physeteridae, two species of Kogiidae, four species of Ziphiidae, Delphinidae (six species of Globicephalinae; 10 species of others), and two species of Phocoenidae (Table 1; summarized from Shao et al., 2020; Ocean Conservation Administration, 2022). In Taiwan, records of cetacean occurrence are primarily categorized into two main parts: sighting and stranding, with a few records dating back to the Japanese colonial period when captures were documented (Shao et al., 2020). Among these records, there is a wealth of sighting data along Taiwan's eastern coast. The data are likely attributed to the development of whale-watching activities along Taiwan's eastern coast, starting in 1997 (Chou, unpublished data). Through the growth of the whale-watching industry, there are many years' worth of data that can be used to understand the distribution of cetaceans (Yu et al., 2019). Today, 27 different species of cetaceans have been recorded, through sightings or strandings, along Taiwan's eastern coast. On the other hand, the cetacean record of the western coast of Taiwan primarily relies on stranding records, with sighting data gradually accumulating due to environmental assessments related to developments such as ports and offshore wind farms in recent years. Until now, 20 species of cetaceans have been recorded (on the western coast of Taiwan (Shao et al., 2022; Ocean Conservation Administration, 2022). The difference between cetacean fauna in the east and west is that in the west, it might be related to the oceanic topography and currents.

Human impacts on cetaceans

Cetacean stranding data has been recorded since 1994 and provides a great source for learning cetacean distribution in Taiwan (Yang et al., 2008; Li et al., 2021). Researchers have also started studying the potential impacts of human activities on cetaceans through the examination of stranded cetaceans. For example, the formation of bubbles in the cetacean's middle ear might have been caused by sonar used during military activities in the Taiwan Strait that year (Yang et al., 2008). Li et al. (2021) also analyzed autopsy data from 73 stranded cetaceans and found that the stranding causes for eight individuals could be attributed to human activities such as bycatch, ship strikes, or related diseases caused by human activities. The blue whale carcass that washed ashore on the east coast of Taiwan in 2020 was investigated by the Marine Biology and

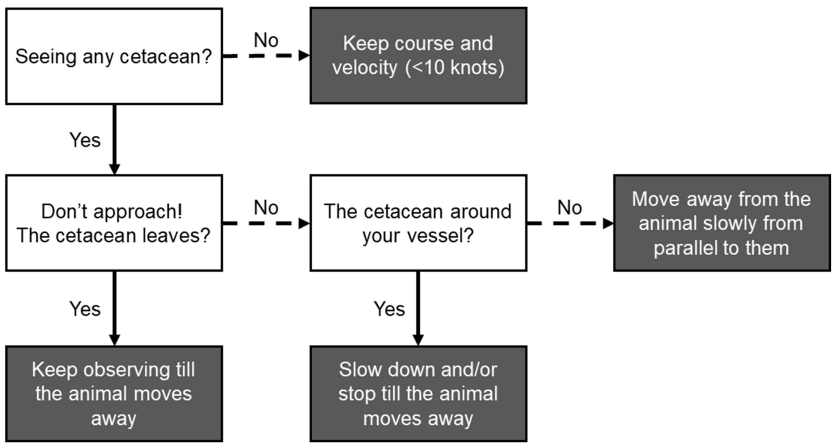

FIGURE 4
The standard operating procedures for encountering cetaceans.

Cetacean Research Center (MBCRC), National Cheng Kung University, and it was deduced that the whale had starved to death due to entanglement of fishing gear around its head (Marine Biology and Cetacean Research Center, 2020).

In addition to records of stranded cetaceans, through the examining physical injuries of live individuals, for example, using photo-ID techniques for the Indo-Pacific humpback dolphins, researchers can also assess the impact of human influences on live cetaceans. For instance, researchers discovered that over 30% of the 93 identifiable individuals (Wang et al., 2007; Slooten et al., 2013) and over 50% of the 78 identifiable individuals exhibited injuries possibly related to fishing interaction, i.e., bycatch or ship strikes (Wang et al., 2017).

Summarizing the above, human interference with cetacean conservation in the vicinity of Taiwan includes ship strikes, noise pollution, and entanglement in fishing gear.

The impact of whale watching on cetaceans

Humans' utilization of cetacean resources has transitioned from historical whaling to relatively less impactful whale-watching activities. However, it is essential to continue addressing the disturbances caused by whale watching on cetaceans. Common contributing factors include vessel activities and the noise generated during whale watching (Guerra et al., 2014; Amrein et al., 2020). Previous research has indicated that cetacean behavior may be influenced when vessel frequency increases, such as shifting vocalization, leading to longer dive times and disruptions in activities such as feeding and nursing offspring. The common bottlenose dolphins were observed upward shifting their whistle with the presence of one or more vessels (Heiler et al., 2016). How vessels navigate, including their heading and velocity, plays a significant role. For instance, higher vessel velocity can increase the chances of colliding with cetaceans (Parsons, 2012). Improper vessel activities, separating cetacean groups, or restricting their movement paths can increase stress levels in cetaceans and potentially impact their physiological states, including their immune systems (Parsons, 2012; Cárdenas et al., 2021). These disturbances may affect cetacean habitat selection and, directly or indirectly, their survival (Barragán-Barrera et al., 2017). Therefore, it is essential to build guidelines for mitigating the impact of whale-watching activities on cetaceans.

Comparison of whale-watching guidelines

After integrating the collection of different whale-watching guidelines, geographically, there are more guidelines in Europe and America. This may be related to the maturity of tourism or the abundance of cetaceans. However, it can also be viewed as the sequence of regional development of the whale-watching industry. The very first whale-watching was conducted in California, USA, in the 1950s, then in European countries (New et al., 2015; Hoyt, 2021). Therefore, the result showed that sites in Europe and America had more guidelines than other regions, possibly due to the whale-watching industry being developed in Europe and America earlier. On the other hand, the distribution of the published year showed that the number of guidelines has increased since the 2000s. From this result, the appearance of cetacean conservation regulations may have fallen 20 to 25 years behind the beginning of the whale-watching industry. This illustrates the closely intertwined history of the development of whale-watching guidelines and the whale-watching industry in various regions.

By comparing the whale-watching guidelines between Taiwan and others, we found that most terms of the guidelines in Taiwan were similar to those in other sites. This also means that Taiwanese regulations are in agreement with international standards. However, there was something different due to different environments and cetacean species locally. Taiwanese guidelines do not allow people to swim with cetaceans, except to protect cetaceans; this is regarded as a safety measure for whale watchers (Rocha et al., 2022). Taiwanese guidelines also do not allow people to actively approach calves, therefore helping to reduce the interruption of cetacean breeding.

There were different applied scales in different whale-watching guidelines. Most of them were local (67 guidelines), and two of them were globalized. Comparing the terms of localized and globalized whale-watching guidelines, we can find some terms with basic principles of vessels' behavior. For example, the vessels must keep a distance of at least 50 meters from dolphins and at least 100 meters from whales. The localized guidelines provide more details based on environmental or industrial backgrounds than the globalized guidelines. The distance limitations between vessels and cetaceans may be variable based on the body sizes of different cetaceans. Furthermore, increasing the feasibility, these adapted guidelines with the local environment or industrial culture have been found to increase the compliance of the local operators and the sustainability of whale-watching management (Amerson and Parsons, 2018).

The feasibility of whale-watching guidelines

In Taiwan, the interviewees of the whale-watching companies agreed with the concept of cetacean-friendly whale-watching for the sustainability of the whale-watching industry. However, a few terms could still be challenging to achieve, especially in Wushi, where the number of whale-watching boats is the highest in Taiwan. Moreover, the industries want to improve tourists' satisfaction by increasing the chances of seeing cetaceans. Therefore, it could be harder to comply with the term "no more than three vessels around the cetaceans at a time." In order to prevent or reduce conflicts between tourists and cetaceans, balancing tourists' satisfaction and cetacean protection, whale-watching industries can use alternative methods to improve tourists' satisfaction, such as applying environmental education on-board and during tours (Parsons and Brown, 2017). Tourists should acknowledge that watching cetaceans is not the only activity in whale-watching tours as there are many other activities related to the ocean to motivate customers. Whale-watching operators also emphasized that their itineraries now include introductions to the local ecology and

culture, which allows tourists to understand that whale-watching activities are just one part of ecotourism. Additionally, they offer compensation in the form of discounts for tourists who do not spot cetaceans during their trip, encouraging them to return and explore marine ecosystems further. Consequently, ecotourism can be promoted with a more sustainable whale-watching tour.

Guidelines for vessels in offshore wind farm operation

Vessel guidelines for offshore wind farms were compiled based on the experiences of interactions between vessels and cetaceans related to whale-watching. However, there are differences between these two businesses. The most critical difference is that the wind farm industry does not search and watch cetaceans actively, with guidelines suggesting that velocity should be considered. Low vessel velocity is very important to mitigate collision risk. There was a positive relationship between the vessels' velocity and the fatality rate of cetaceans when the velocity of the ship was over 10-12 knots on the east coast of the United States and Canada (Laist et al., 2001). With a 10-knot velocity limit for vessels in the United States, in the North Atlantic Right Whale Sanctuary, the simulation data showed that when the occurrence rate and mortality rate of right whales were highest, the mortality rate dropped by 22% after the velocity limit measures in winter (Crum et al., 2019). Even though the speed-limited vessels' velocity is still faster than the average swimming velocity of right whales (0.39 meters per second, approximately 0.76 knots), the mitigation measure of reducing vessel velocity was still helpful in protecting cetaceans. The speed-reduced measure in small boats was regarded to help converse cetaceans (Schoeman et al., 2020), and when the speed of a small boat was not over 12.5 knots, the chances of being able to notice a humpback whale at over 300 meters were three times higher (Schoeman et al., 2020). Moreover, within 300 meters, the distance of noticing a humpback whale was also increased (Currie et al., 2017).

In Taiwan, cetacean-friendly whale-watching has been developed by the government since 2018 and is supported by the industry. The whale-watching guidelines are still adjusting according to the increased studies related to cetaceans in Taiwan. This experience from the whale-watching industry is suitable to be applied to the interaction between vessels and cetaceans in other industries. High vessel activity in the Taiwan Strait is expected because of the ambitious development of offshore wind farms. In this study, we recommend guidelines for offshore wind farm operations, evaluate the effectiveness of cetacean protection, and adjust the guidelines over time and across different contexts.

Vessel and cetaceans in offshore wind farm areas

Based on records from offshore wind farms, commonly observed cetacean species include the Indo-Pacific bottlenose dolphin, the long-beaked common dolphin, the false killer whale,

TABLE 6 Cetaceans observed in offshore wind farms of Taiwan.

Cetacean	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)	Long-beaked common dolphin (*Delphinus capensis*)	False killer whale (*Pseudorca crassidens*)	Indo-Pacific humpback dolphins (*Sousa chinensis*)	Wide-ridged finless porpoise (*Neophocaena phocaenoides*)
Status IUCN	NT	DD	DD	CR	VU
Status Taiwan	Rare and valuable	Rare and valuable	Rare and valuable	Endangered	Endangered
Distribution	Observed on the Eastern, western, and southern coasts of Taiwan; stranded on all the coasts	Taiwan's northeast, east (including outlying islands), and north coasts and Kinmen	Taiwan's northeast, east, and southwest coasts and Penghu	Taiwan's west coast and Kinmen	Taiwan's north and west coasts, Kimen and Matsu
Water depth	>50m	>50m	>50m	1-15m	20-50m
Group size	Generally, 20-50; sometimes over hundreds	Generally, 100-200; sometimes over hundreds	Generally, 5-25; sometimes over dozens	Generally, less than 10; sometimes 20-30	Generally, 2-4
Swimming ability	High	High	High	Low	Low
vessel attraction	Neutral, positive	Neutral, positive	Neutral	Neutral; may follow trawlers	Negative
Bow-riding	Yes	Yes	Occasional	No	No
Risk of vessel strike	High	High	High	Medium	Low

the Indo-Pacific humpback dolphin, and the wide-ridged finless porpoise (Chen and Lee, preparing). Rarely, cetaceans belonging to Globicephalinae, Ziphiidae, and Balaenopteridae have also been observed in offshore wind farms. To assess the risk of ship strikes, we have summarized the specific traits of known cetacean species at offshore wind farms, including their behavior, ecological characteristics, and patterns of interaction with vessels in Table 6. We discussed the impact of the interaction patterns between cetaceans and vessels and then discussed how opportunities for encounters at sea and the swimming ability of the animals influence the possibility of the occurrence of ship strikes. Some cetaceans may actively approach vessels, riding the bow wave, potentially increasing the risk of ship collisions. Previous research on cetacean-vessel collisions has found that before such collisions occur, cetaceans often exhibit behaviors such as surfacing near the water's surface or approaching the vessel (Ritter, 2012). In offshore wind farm areas, common dolphins like the Indo-Pacific bottlenose dolphin, long-beaked common dolphin, and false killer whale are often observed to approach vessels. Moreover, these species tend to form large groups. These characteristics suggest these cetaceans might be at a higher risk of vessel strikes. The physical condition of cetaceans, such as their swimming abilities, can influence their chances of being struck by vessels. For example, individuals with slower swimming speeds may have a poor ability to respond to approaching vessels, potentially increasing their risk of collision (Dolman et al., 2006). In Taiwan's offshore wind farm areas, the endangered Indo-Pacific humpback dolphin and wide-ridged finless porpoise are less likely to approach vessels actively. However, they have poor swimming abilities. Especially in the case of the finless porpoise, it is difficult to spot them due to their cryptic behavior and lack of dorsal fins. Therefore, it is also essential to implement guidelines for vessel activity to reduce the risk of collisions. We also recommend that the guidelines in this study consider the characteristics of cetaceans living in this ocean and keep adjusting to updated survey data on cetaceans.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Both authors worked together and contributed equally in this study. Y-JC did most of the data collection and analyses. P-YL initiated the idea and manage the project. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.1215905/full#supplementary-material

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