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Seabirds in China in the face of industrial activities and oil spill: Lessons learnt from Bohai Bay

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Abstract. Seabirds play essential roles in both terrestrial and marine ecosystems, but oil spill and habitat loss through reclamation and degradation have long been adversely affecting their populations worldwide, and thus affecting the well-being of terrestrial and marine ecosystems. In this study, using Bohai Bay in north China, a semi-closed continental sea where oil and gas activities and habitat loss are happening at a rapid pace as an example, threats for seabirds and their overlap with highly-risked areas in terms of an oil spill are reviewed. The results showed that while Bohai Bay is one of the most important sites for seabirds and waterbirds on the eastern China coast, oil spills and habitat loss are affecting the population of the birds. We concluded that sea birds in Bohai are at severe risks of oil spill and habitat loss, oil spill risks are especially high for autumn migrants, residents and winter birds, while habitat loss harms less ocean-dependent species. Accordingly, more focused and oriented efforts should be done in establishing conservation areas among Bohai Strait and the north side of the Shandong Peninsula and the western Bohai coast where overlap between bird diversity hotspots and potential exposure to habitat loss and oil spill occurs. And a general insight into how are given species affected by the two factors is given. This study enhances our understanding of seabird's vulnerabilities, what has been neglected, and what should be more well-noticed in future conservational endeavors.

Keywords: Seabirds, Bohai Bay, oil spill, habitat loss.

1. Introduction

The coastlines and coastal wetlands of eastern and southern China are vital for the migratory seabirds and waterbirds of the East Asian-Australasian flyway (EAAF), but are being lost rapidly through reclamation for agriculture, aquaculture and industrial land, and are also under huge threat of oil spill [1]. It is estimated that over 80% of shorebird populations in the EAAF migrate through the coastal region near the Yellow Sea and Bohai Sea [2]. Accordingly, sixty coastal areas in China are recognized as Important Bird Sites (IBA) by Birdlife, all of which are in turn recognized as Key Biodiversity Areas(KBA) by IUCN. However, it is estimated that about one-third of intertidal wetlands in China had been reclaimed in a period of about 40 years from 7848.21 in the 1970s to 4895 in 2015, resulting in declines in the population of lots of seabird species [1,3]. Seabirds play a very important role in local ecosystems, and since some of them are top predators, they could further be indicators of marine ecosystems. On the other hand, as they interact with both marine and terrestrial environments, they provide nutrient inputs for both ecosystems as they forage on the sea and deposit extracted nutrients

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while releasing guano on the land [4]. Therefore, it is very important that they are properly protected. On the other hand, while the burgeoning technological development in China mainland is asking for more oil extraction, offshore oil activities have consequently gained more importance. Recent years have seen a significant increase in oil consumption and vessel traffic, and this in turn increases the risk of oil spills. In 2022, China's oil consumption is reported at 14,225,000 Barrels/Day, making it the second biggest oil consumer by country [5]. From year 1990-2010, about 22,035 tons of oil were lost to China's water as results of tanker incidents [6]. In this situation, chronic oil pollution could have long been undermining thousands of seabirds that either breed or migrate by China's coastlines and the well-being of both terrestrial and marine ecosystems. Globally, Oil spills have killed millions of seabirds, while an estimated one million tons of oil now enter the oceans each year: 45% from the land; 35% from marine transportation; 10% from oil tanker spills; and 5% from natural seeps[6]. Birds that interact with oil spill on a regular basis can suffer from sublethal to lethal consequences, which include anemia, decreased immune response, and organ damage that could further lead to neurological system and respiratory system damage as ingestion occurs while preening [4].

While it's already more than clear that some other factors such as human activities, habitat loss and overfishing have long been adversely affecting bird populations, current status of seabirds in China and their vulnerabilities to oil pollution and other human-imposed threats require attention. Even though there already is a considerable amount of studies and articles advocating the importance of the eastern coastal area of China to seabirds, reclamation and degradation of those areas are still happening at a rapid pace. Accordingly, using Bohai Bay, one of the most popular spots for seabirds yet the same time a main source of crude oil production for China, this article reviews the extent to which these factors are affecting seabirds that could be found on China's coastlines, efforts that had already been put into effect, and the direction on which future endeavors should be focused. The objectives of this study are to review the susceptibility of seabirds in China to chronic oil pollution and some other threats imposed by humans with a concentration of the previous one and to figure out to what extent are they negatively affecting the birds. The rest of this paper contains two main sections, with section one provides an overall review of China's possession of seabird species and a discussion about the case in Bohai Bay, north China, and section two focuses on the lessons learnt about what should be done to better understand how we can coexist with our seabird species in a time where coastal areas are under huge pressure of urbanization and oil spill are happening at a frequent basis.

2. Sebirds in Bohai in the face of major threats

2.1. A systematic review

China owns around 1500 thousands of species of birds, among which 77 can be recognized as marine bird species, including one CR species and 3 EN species. While the conservation of these particularly endangered species has reached success after an immeasurable amount of effort, the overall status of seabirds in China does not hold a positive perspective. The eastern China coast supports a huge variety of seabirds and waterbirds. For instance, the Lianyungang coast is one of the most important stopover sites for Asian Dowitchers. Roughly over 90% of Asian Dowitchers were recorded on a single day in two consecutive springs [6]. The government has been paying attention to some of the sites, for currently two areas in coastal China are listed as natural World Heritage sites(UNESCO) for their significance as migratory bird sanctuaries. But still, what had been done is far from enough. Of sixty IBAs in coastal China, only a poor number is properly protected, and the population decline in birds that adopt the EAAF such as the Red Knot is still ubiquitous [1]. Threats for seabirds still exist. This will be further discussed in the following contents.

2.2. Bohai Bay of North China

Bohai Bay, which is a semi-closed continental sea in North China is home to a huge number of seabirds and waterbirds and includes stopby sites used by Red Knot, Bar-tailed Godwit and several other birds that adopt the EAAF to take a 6-9 days rest before eventually setting off for their final destinations,

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breeding sites used by seabird such as several Petrel species, and wintering sites used by seabird such as several Cormorant species [7]. Consequently, Bohai Bay is a bird diversity hotspot in the eastern China coast (Figure 1). It is estimated that from year 2009-2016, a total of 50,000-100,000 red knots annually stopped along the Luannan Coast in Bohai Bay, while the total population size of Red Knots including two of its subspecies is estimated at approximately 100,000 birds, this implies that about 50%-100% of the entire population, and about the entire population of one of the piersmai subspecies in this flyway relies on the mudflats and saltpans of the coast for refuelling themselves for their final migratory flight to the New Siberian Islands [8]. Despite its importance, Bohai Bay has seen a dire loss of seabird habitats in recent years. Between 2000 and 2015, 1794.8 km2 (29.27%) of coastal wetland was lost to development, most of which were tidal flats that were lost by conversion into aquaculture and salt pan habitat or land for construction. Consequently, habitat for 73 of these 80 species has decreased in area over this time [9].

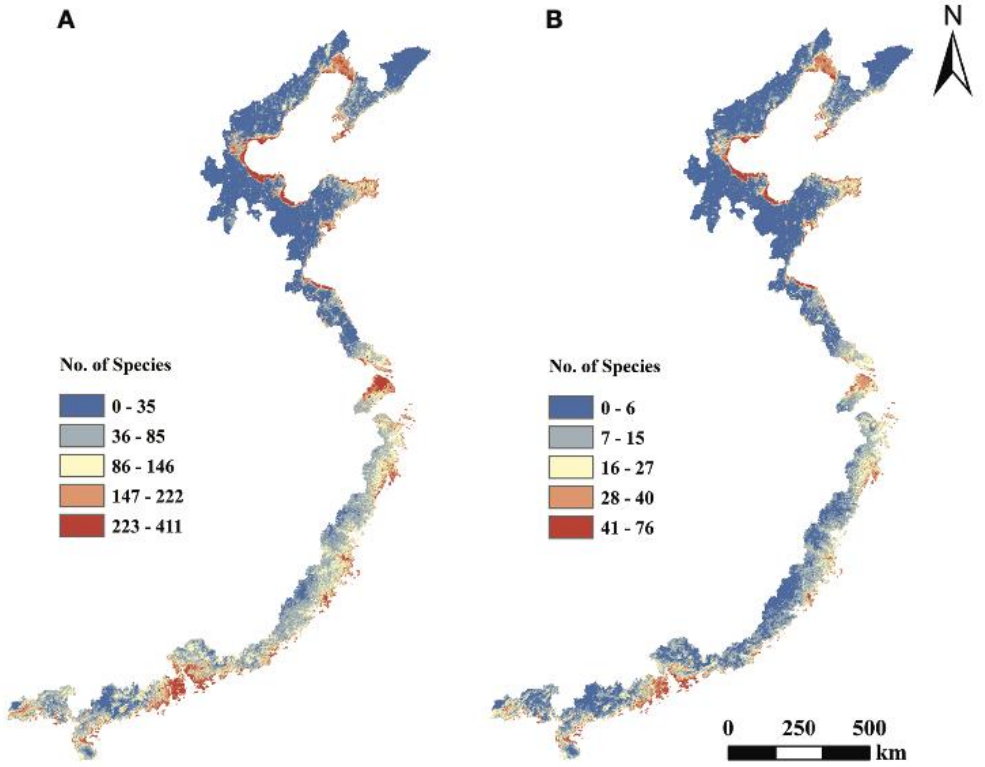

Figure 1. Distribution of bird species among coastal areas in eastern China. Note the projection in Bohai Bay.[10]

Also, as Bohai Bay is particularly important for crude oil production, oil spill risk in the area could be remarkably high. In this context, this section reviews the major existing threats for seabirds in Bohai Bay. With these issues solved, the conservation of seabirds that breed or winter here or adopting the EAAF could take a big step forward.

2.3. General review of existing threats

Temporal threats for seabirds that exist in Bohai Bay could be primarily categorized into oil spill and habitat loss, with the previous one contributing to the loss of seabirds that are highly dependent on the ocean, while habitat loss contributes to the loss of seabirds that migrate by coastal wetlands in the area.

2.3.1. Oil spill. While Bohai Bay is vital for a numerous number of seabird species, it also plays a very important role in oil production and is therefore covered densely by storage tanks, oil pipelines, oil

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platforms, and ship routes. With an annual output of crude oil reaching 3000·104, it accounts for about 70% of oil production in China [11]. In a study previously conducted, 428 oil and gas platforms were identified in the Bohai Bay, and offshore oil and gas activities are recognized to be very common [12]. Thus, Bohai Bay is highly vulnerable to oil spilss. On the other hand, wind, currents and Stoke drift can quickly spread the oil spill to adjacent coastlines [13]. The spread of oil spills following the wind or current could severely damage migratory seabirds. It is estimated that extremely high-risk areas are mostly located in Liaodong Bay and Bohai Bay; high-risk areas are located in the Bohai Strait and on the north side of the Shandong Peninsula [14]. This indicates that highly-risked areas are hugely overlapping with important sites for migratory birds such as Saunder's Gull and Relict Gull, which are all endangered species, see Figure 2 for detailed distribution of highly-risked areas and IBAs[1, 14]. Since oil spill kill seabirds at a mass rate, it is important that this threat can be properly recognized and solved. See figure for the distribution of oil spill risk in Bohai Bay and IBAs in the area.

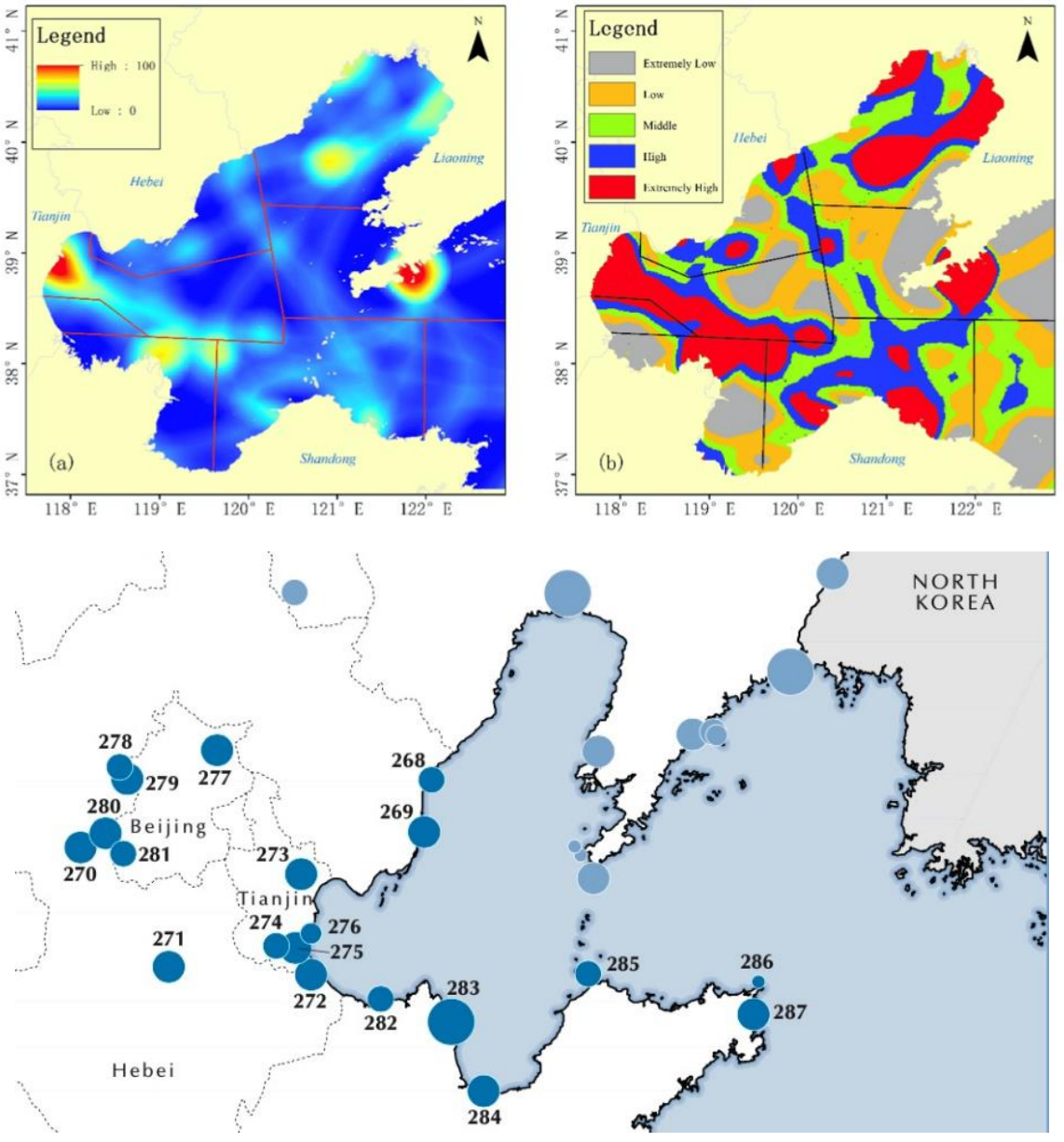

Figure 2. Distribution of highly risked area in terms of an oil spill(a,b), and important bird sites in Bohai area.[1, 14]

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Regarding oil spill management, China has implemented serval laws and regulations of government on marine oil management, which include the Marine environmental protection act of China(1982), the Maritime traffic safety act of China (1984), Maritime act of China(1993), Port act of China(2004), Tackling emergency affairs act of China(2007) [15]. But even though quite a lot of laws have been implemented, the major problem with this is the lack of subject of law-enforcement and supervisory organizations. Thus, the future endeavor should be primarily focused not on proposing and ratifying new legislation but on creating subjects of law-enforcement and making proper use of laws that have already been implemented. China has a set of well-established oil spill response systems, which had been applied in several previous cases such as the Dalian "7-16" pipeline accident and the Penglai 19-3 oil spill incident[16-17] As China acceded to the 'MARPOL73/78'' (the International Convention for the Prevention of Pollution from Ships) and the convention of 'OPRC 90', the Ministry of Transport and the State Environmental Protection Administration has also established the ''China's Northern Seas Oil Spill Emergency Response Plan'', ''China Marine Ship Oil Spill Emergency Response Plan'', and several similar plans. In 2009, the local governments enforced emergency plans in 58 coastal cities and 9 coastal provincial regions. Up to now, oil spill emergency response systems exist in terms of levels from national scale to individual ships. A number of equipped clean-up materials in coastal areas has also been increasing in recent years, which includes oil booms, skimmers, emergency ships and chemical dispersants [15]. But still, R&D projects are not sufficient, therefore leading to an insufficient capability for oil spill response. Also, governments in coastal cities are primarily focusing on the industrial and economic developments, there is a huge unawareness of the importance of protecting marine ecosystems from oil spill. This will be further discussed in the following discussion.

2.3.2. Habitat loss. Habitat loss is one of the most well-noticed problems in recent years, but still, the situation is poorly corrected. Biodiversity in the Bohai region coastal wetland has been facing gradual deterioration due to urbanization and human activities. Between 2000 and 2015, 1794.8 km2 (29.27%) of coastal wetland was lost to development, most of which were tidal flats that were lost by conversion into aquaculture and salt pan habitat or land for construction. Consequently, habitat for 73 of these 80 species has decreased in area over this time [18]. In the case of Nanpu saltpan, which is another vital site for migratory birds, more than 100 km^2 of saltpans have been lost 2001, and after 2010, Nanpu had lost respectively 20 and 100 km^2 of saltpans from city developments and projects. Moreover, the construction of a new road across the Nanpu Saltpans starting in 2015 has cut through many ponds, including the one with 96,000 birds on 16 May 2013 [19]. The impact brought by habitat loss is actually somewhat hard to gauge since several protected sites have been supporting a rather stable number of birds in some certain species. But still it is undeniably true that habitat loss has been negatively affecting the bird population in combination with some other factors such as climate change and pollution. As Bohai Bay has lost a huge number of bird habitats, it is important that this problem can be coped with most effectively. This will be further discussed in the following section. The Chinese government has been paying attention to the conservation of marine birds and their habitats. Internationally, the Convention on the Conservation of Antarctic Marine Living Resources, CCAMLR(1980), the Convention of International Trade in Species of Wild Fauna and Flora, CITES(1973), the Convention on the Conservation of Migratory Species of Wild Animals, CCALMR(1979), the UN Convention on the Law of the Sea(1982), and the Convention for Prohibition of Fishing with Long Driftnets in the South Pacific are all playing part in conserving marine bird species in China, but due to a lack of subject of law-enforcement and supervisory organizations, these Conventions are, in most situations, poorly executed [15].

On the other hand, China itself has established several legislations aiming to protect endangered seabird species and their habitats, while some conservation areas were established as well. However, even though some of the important bird sites have been gaining attention and protection in recent years, a lot of them are still under destruction and degradation. Saving only a few sites will not be enough to tackle the decline in bird populations that use the eastern China coast for migration. Small destructions are happening at a rapid pace, while at the same time being unnoticed. For instance, the Nanhui coastal

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area in Shanghai used to be vital for several endangered bird species such as the Nordmann's Greenshank(Tringa guttifer), but the place is now under huge destruction that aims to turn it into a park. These small destructions, when accumulated, can cause huge damage. Another problem with this is that no proper regulations could be applied to stop this kind of "harmless" small destructions, which always appear to be unnoticed, as in most circumstances only birders who used to visit the place know that another important site is under degradation. In another hand, since most laws are implemented in protected areas, those unprotected ones are consequently open to exploitation. So one of the roots here is that so many sites near coastal China are not properly protected. The lack of the subject of law enforcement, as mentioned before, is also something awaits to be changed. A lot of times it comes down to birders, naturalists, and conservation NGOs to negotiate with the government in order to save the sites, which in most cases ends with failure.

2.4. Discussion

Exposure potential to oil spill and habitat loss can be defined by behavior, frequency and residence type. Rather than habitat loss, ocean-dependent birds might suffer more from oil spill, while mutual birds might suffer more from habitat loss than from oil spill. Frequency of appearance could be put into calculation. But since a precise and detailed calculation would require more field research and data information, no exact digital index is provided here. This could be completed by further researches and will not present in this article(Table 1).

Since oil spill risk is remarkably high in Bohai Bay, all 37 seabird species that can be found here could be highly susceptible to oil spill in the region, especially migratory seabirds that are more dependent on ocean areas rather than inland-coastal areas, such as Streaked Shearwater(Calonectris leucomelas), Ancient Murrelet(Synthliboramphus antiquus), and Swinhoe's Storm Petrel(Oceanodroma monorhis). Also, Bohai Bay is important wintering site for some Cormorant species and murrelet species such as Long-billed Murrelet(Brachyramphus perdix) and Rhinoceros Auklet(Cerorhinca monocerata). The population of these species could have long been harmed by oil spill in Bohai Bay. Some other gull species might suffer less from oil spill, but due to the fact that some gulls are not completely dependent on inland wetlands, exposure potential could still be high. Overall, species that have a greater tendency of staying and foraging on the ocean and resting in the water would be more susceptible to oil spill. The sequence could be defined by murrelets/shearwaters and similar species, cormorant and similar species, gull and similar species, and tern and similar species. Given that oil spill generally occurred more frequently during the period from January to September than from October to December, autumn migratory species, wintering species and all-year-round species would be most affected. See Figure 3 for distribution of oil spill occurrences by time months. Once a seabird is contaminated with oil spill, the results could be lethal. Bird can die due to the inability of finding food and avoiding predators as a result of affected avian performance, and complications such as inflammatory response, damage to respiratory system can also kill a bird. As for breeding species in Bohai Bay, breeding success could be negatively affected, death of juvenile can be increased as a result of increased exposure to oil contaminated parent birds. Thus, the entire structure of the local bird population could be affected far less sustainable.

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Table 1. Seabird species in Bohai Bay, identifying their vulnerabilities to land reclamation and oil spill from frequency, residence type, and behaviors, respectively.

Name(ENG)	Frequency	Residence type	Behavior
Northern Fulmar	Extremely rare	Straggler	Ocean-dependent
Streaked Shearwater	Common	Resident	Ocean-dependent
Leach's Storm Petrel	Common	Straggler	Ocean-dependent
Dalmatian Pelican	Rare	Wintering	Mutual
Great Cormorant	Common	Resident	Mutual
Pelagic Cormorant	Rare	Wintering	Mutual
Japanese Cormorant	Rare	Wintering	Ocean-dependent
Red-faced Cormorant	Extremely rare	Wintering	Ocean-dependent
Great Frigatebird	Rare	Transient migrant	Ocean-dependent
Lesser Frigatebird	Rare	Transient migrant	Ocean-dependent
Black-tailed Gull	Common	Resident	Mutual
Mew Gull	Common	Migrant/wintering	Mutual
Glaucous Gull	Rare	Wintering	Mutual
Herring Gull	Common	Wintering	Mutual
Siberian Gull	Common	Wintering	Mutual
Slaty-backed Gull	Rare	Wintering	Mutual
Great Black-headed Gull	Common	Migrant	Mutual
Black-headed Gull	Common	Migrant/wintering	Mutual
Slender-billed Gull	Rare	Wintering/straggler	Mutual
Franklin's Gull	Extremely rare	Straggler	Mutual
Saunders's Gull	Rare	Breeding	Mutual
Relict Gull	Common	Migrant	Mutual
Little Gull	Rare	Migrant/straggler	Mutual
Ross's Gull	Extremely rare	Straggler	Mutual
Black-legged Kittiwake	Rare	Winter	Mutual
Gull-billed Tern	Common	Breeding/migrant	Mutual
Common Tern	Common	Breeding	Mutual
Little Tern	Common	Breeding	Mutual
Whiskered Tern	Common	Breeding	Mutual
White-winged Tern	Common	Migrant/breeding	Mutual
Marbled Murrelet	Rare	Wintering	Ocean-dependent
Ancient Murrelet	Common	Breeding	Ocean-dependent
Rhinoceros Auklet	Extremely rare	Wintering	Ocean-dependent

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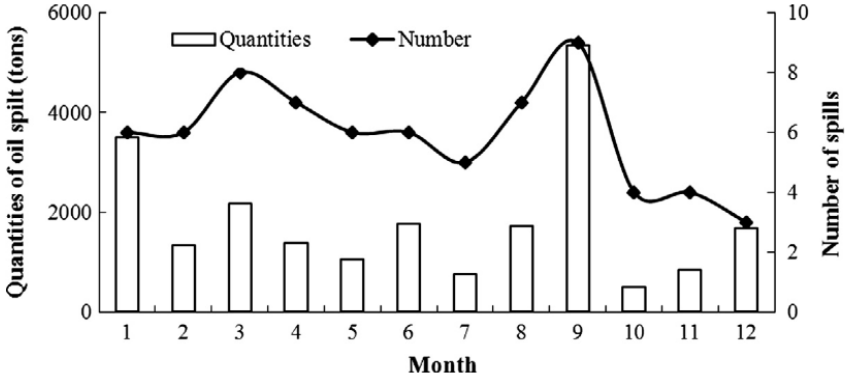

Figure 3. Oil spill occurrences and correspondence with time(month). [6]

The level of oil spill responding stockpile owned by Bohai Bay does not corresponds to its level of oil spill risk and its level of seabird diversity. Two of the stockpiles are located respectively in Dalian and Qinhuangdao, meaning that the west and south of Bohai Bay are not covered by any adjacent stockpile, while the same time being exposed to a considerable level of oil spill risk and vulnerabilities. See Figure 4 for detailed distribution of oil spill response stockpiles in China. Also, the unawareness of protecting seabirds and marine eco-systems among local governors is a huge problem. Having plans established and set does not necessarily mean that people are aware of the importance of the issue and can therefore effectively execute the existing plans. Development in these areas are gaining so much importance. So, it is very important that the next generation of local governors could be properly educated of the importance of preventing the occurrence of oil spill, since the fact is that once oil spill occurs, none of the previously established methods and plans could 100% recover the damage done to the local marine eco-systems.

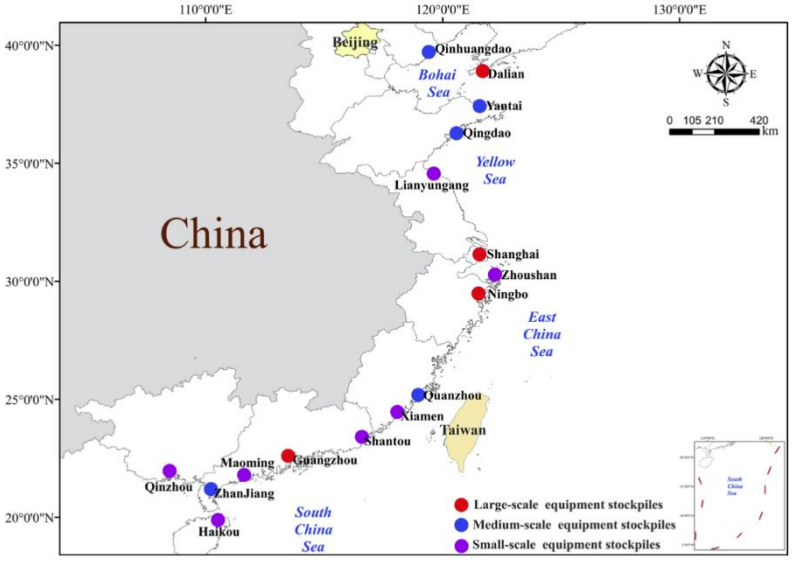

Figure 4. Distribution of oil spill response stockpiles in coastal China.[15]

As for plans and policies, more carefully designed and executable ones should be put into place given that the remarkable importance of Bohai Bay to seabirds and its projecting potential of oil spill. More stockpiles covering most of the ocean area should be built, and some of them should be primarily focused on protection of the area where a high risk of oil spill and a high level of bird diversity overlap, such as the coastline of west Bohai Bay. Traditionally, human activity would harm breeding species such as Saunder's Gull(Larus saundersi), Swinhoe's Storm Petrel(Oceanodroma monorhis) and some other terns

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and cormorants the most, since farmers and fishermen would go onto the islands and pick up the eggs for food or sale. But as laws regarding protection of most of the species were implemented, this was partially solved. Yet still what had been done is not enough, as this tradition still exist in a lot of places since there is a lack of the subject of law-enforcement and supervising organizations—as mentioned before. Illegal hunting is also happening. Lots of birds that migrate by China coastline are projected with bird nets and illegal hunters. Existing laws are indeed enough to stop these behaviors, but a lack of executive force just made this pretty impossible. Other than illegal hunting, habitat loss would move severely damage species that are highly dependent on coastal wetlands for stopover sites, such as gull and tern species. Overall, species like gulls are most dependent on coastal wetlands, the sequence could be identified as the opposite as in the oil spill case.

Habitat deterioration and habitat loss are both contributors to the loss of population of seabirds. Habitat deterioration can be induced by human activities. For example, Beidaihe coastal area, which an important birding site, is also an tourist attraction that is open to visitors and is really close to the city. This consequently leads to a very negative environment for birds to breed and rest, as noise and light pollution could also be extensive. On the other hand, plastic pollution is common among this place. Plastic waste could be seen basically everywhere, as they were initially left by tourists on the beaches and then probably taken away by tidal waves. These could all be adversely affecting the quality of the seabirds' environment and could be very lethal to the birds given that they could be already exhausted on their migratory paths. Habitat loss happens due to a lack of conservational areas. Lots of important stopover sites are not correctly recognized and are being severely damaged as urbanization and reclamation occur. This is not changed even after a serious of studies advocating the importance of these sites. Here this is emphasized again, that attention and conservation is required on these lands. The ultimate goal for conservation should be, in substance, to seek coexistence. We are not developing our cities in a way that is friendly to birds, as unequivocal as it can be, and conflicts have been going up and up as we are requiring more lands. Solution to this problem should be led by a shift in the ways in which the developers and governors think. Most apparently, important bird sites should be protected more properly, such as Beidagang wetlands and the Nanpu mudflat. A more complicated procedure should be involved when making decisions in exploiting a land, and city developers should hear more from conservation biologists, scientists, and even non-government conservation organizations. Also, as the same as it is in the oil spill issue, people should be aware of the importance of protecting those bird habitats, which requires more propagation effort. The threat for seabirds is not limited in Bohai Bay. Coastal areas along China's coastline are always under huge pressure of urbanization and land reclamation, and the situations are actually the same in essence. In one hand, laws and regulations have been implemented, the problem is a lack of awareness and executive force as stated above, while on the other hand, the problem is that more conservation area should be established at important bird sites, such as IBAs presented above or birding hotspots. More voices should be considered while making policies and decisions.

3. Conclusion

It is clear that the level of oil spill risk in Bohai Bay is very dangerous for seabirds, while habitat loss is also undermining their populations. These two factors are harming both non-ocean-dependent and ocean dependent seabird species. The same goes for the entire eastern coastline. This study points out the importance of establishing more oil spill avoidance and response mechanisms, more specifically targeted conservation areas, and more wide-ranging propagative effort. Coexistence simply requires everyone to realize the importance of coexistence itself in the first place. Limitation do exist in this study since there is a limited number of articles and resources available in a time where field research is not exactly practical. Future endeavors could be set to reveal exactly how are each of seabird species affected basing on their frequency of appearance and exposure potential to habitat loss due to industrial development and oil spill. With the point focused on each species, it would be a lot easier for specific conservation areas to be established in the most effective and targeted ways. One flaw about this study is that no exact digital index was given. The table presented only provided a general insight into

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exposure potential with three variables (frequency, residence type, and behavior). Future studies could focus on the establishment of complete mathematic modules that are based on more data from field research, which could further enhance our understanding of the vulnerabilities and susceptibility of seabirds in China to oil industrial development. Also, data used in the article might not be able to fully represent the status of seabirds in Bohai since it's based primarily on birding reports and previous researches (which are scanty). More field research and studies should be completed in the future in order to better understand our seabird species.

References

[1] Important Bird Areas in Asia-Mainland China

[2] K.Chen, X.Yang, and Y.lu, " Vital stopover of shorebirds migration on the East Asian-Australasian flyway: Wetlands of yellow sea and Bohai Sea," 10.13248/j.cnki.wetlandsci.2015.01.001

[3] Tayyibah Aziz, Frontiers Science, "Landsat Provides 'Complete Perspective' of Wetland Loss in China," February 14, 2020. Retrieved on February 29, 2023. Retrived from https://landsat.gsfc.nasa.gov/article/landsat-provides-complete-perspective-of-wetland-loss-in-china/

[4] Lindsay Young, Eric VanderWerf, "Conservation of Marine Birds," Academic press, London & San Diego & Cambridge & Oxford, 4-6 (2023)

[5] Isabella, World Populace, "Oil Consumption by Country 2022," June 3, 2022. Retrieved on February 29, 2023.

[6] Ziyou Yang, Katherine Kar Sin Leung, "Coastal wetlands in Lianyungang, Jiangsu Province, China: probably the most important site globally for the Asian Dowitcher (Limnodromus semipalmatus)," Avian Research, December 2021

[7] ZHAO Xinru, A Photographic Guide to the Birds of China, The Commercial Press, Beijing, 4-292(2018)

[8] Tamar Lok, Chris J. Hassell, Theunis Piersma, Roger Pradel, and Olivier Gimenez, "Accounting for heterogeneity when estimating stopover duration timing and population size of red knots along the Luannan Coast of Bohai Bay, China," Ecolog and Evolution WILEY, 6176-6183 (2019)

[9] DUAN Houlang, Xiubo Yu, Shaoxia Xia, and Guangshuai Zhang, "Waterbird habitat loss fringing the Yellow and Bohai seas along the East Asian-Australasian migration flyway," Land Degradation and Development, June 2021

[10] Peng Hou, Junjun Bai, Yan Chen, Jing Hou, JIajun Zhao, Yutiao Ma and Jun Zhai, "Analysis on the hotspot characteristics of bird diverisity distribution along the continental coastline of China," Frontiers in Marine Science, 1-11(2022)

[11] Y.Deng, Y.Xue, S.Yu, C.Liu, "Shallow hydrocarbon migratin and accumulation theory and discovery of giant oilfield group in Bohai Sea," Shiyou Xuebao/Acta Petrolei Sinica 38(1):1-8, January 2017

[12] Aiying Lu, Peng Li, Haitian Zhu, and Peng Chen, "Identification of offshore oil and gas platform in the Bohai Sea based on multi-source satellite remote sensing" Journal of Marine Sciences, 40(4):82-89, December 2022

[13] Qing Xu, Yongcun Cheng, and Bingqing Liu, "Modeling of oil spill beaching along the coast of the Bohai Sea, China," Frontiers of Earth Science 9(4): 637-641, June 2015

[14] Yebao Wang, Peipei Du, Baijing Liu, and Xiaoqing Wu, "Geographic information system-based comprehensive oil spill risk assessment in China's Bohai Sea," 01-11, March 2023

[15] Shangao Xiong, Hualou Long, Guoping Tang, Jun Wan, and Hongyuan Li, "The management in response to marine oil spill from ships in China: A systematic review", Marine Pollution Bulletin 96 (2015) 7–17

[16] Min Wang, Chuanyuan Wang, "Chemometric techniques in oil spill identification: A case study

DOI: 10.54254/2753-8818/6/20230311

in Dalian 7.16 oil spill accident of China," Marine Environmental Research 182(1-2): 105799, November 2022

[17] Zengan Deng, Ting Yu, Xiaoji Jiang, and Suixiang Shi, "Bohai Sea oil spill model: A nemberical case study," Marine Geophysical Research 34(2), June 2013

[18] DUAN Houlang, Xiubo Yu, Shaoxia Xia, and Guangshuai Zhang, "Waterbird habitat loss fringing the Yellow and Bohai seas along the East Asian-Australasian migration flyway," Land Degradation and Development, June 2021

[19] Weipan Lei, Jose A. Masero, Thenis Piersma, and Bingrun Zhu, "Alternative habitat: The importance of the Nanpu Saltpans for migratory waterbirds in the Chinese Yellow Sea," Bird Conservation International, 1-14, September 2018