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2020臺灣鯨豚及海龜擱淺報告

2020 Taiwan Cetacean and Sea Turtle Strandings Report

加拿大海洋資訊

Canada Ocean Information

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Saving and Protecting Cetaceans, Striving Towards Ocean Sustainability

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

Maritime nations are endowed with rich marine resources. This is why they must design comprehensive policies for oceans management that are focused on sustainable development. In this issue, we introduced one of the world's strongest maritime nations—Canada. Canada passed the Oceans Act in 1997, the first oceans management law in the world that aims to protect marine ecosystems at its core. The Oceans Act not only became a guiding principle for subsequent oceans strategies and oceans action plans, but also gave the Fisheries and Oceans Canada (DFO) the obligations and powers to coordinate across different government agencies, and set the DFO as the responsible agency for integrating oceans management in Canada. The Canadian government isn't just an international leader in terms of integrated oceans legislation. In September 2018, the country's government established the High Level Panel for a Sustainable Ocean Economy with other maritime nations (a total of 14). Panel members include nations from five continents and across three oceans. The goal is to include all territorial waters under the jurisdiction of the panel nations into sustainable management by 2025. This is in hopes of facilitating the economic transformation of sustainable oceans in five critical fields—ocean wealth, ocean health, ocean equity, ocean knowledge, and ocean finance.

In addition, Canada—the third country with the highest number of whale watchers in the world—implemented the "Marine Mammal Regulations" of the Fisheries Act to manage all marine mammal related business and tourism activities. The Species at Risk Act has strict regulations regarding the distance of whale watching to protect endangered species and threatened habitats; its management model can serve as a notable reference. The government of Taiwan released the "2020 Annual Report on Cetacean and Sea Turtle Strandings in Taiwan by the Ocean Conservation Administration of the Ocean Affairs Council." Through the recording and rescue work of the Marine Animal Rescue Network (MARN), as well as summarized and periodically announced reports by the Ocean Conservation Administration, we hope to build an emergency mechanism and conservation safety net for wild marine animals with collaborations between the government and the public. By doing so, we hope to improve wild marine animal rescue work and encourage the public to take care of marine animals and their ecosystems.

Ocean Conservation Administration releasing pygmy killer whales back into the wild. The ship set out from Anping Harbor in Tainan on June 20, 2020.
Image by Ocean Conservation Administration

2020 Taiwan Cetacean and Sea Turtle Strandings Report

Ocean Conservation Administration
Translated by Linguitronics
Keywords: Cetacean, sea turtle, stranding, pygmy killer whale, blue whale

5 in 7 species of sea turtles around the world are distributed in sea areas near Taiwan; so are around 90 species of cetaceans worldwide. In 2020, 22 species of cetaceans were witnessed along the coastlines of Taiwan. We found more than 28 species of them after joining rescue efforts. The Marine Animal Rescue Network (MARN) team [1] coordinated by the Ocean Conservation Administration (OCA) spearheads the rescue operations of injured wildlife marine animals. The team is responsible for taking charge of stranded cetaceans and sea turtles along the coastlines of Taiwan. According to statistical results in 2020 [2], the team received stranding reports of 161 cetaceans and 335 sea turtles. Since the founding of MARN, the procedures for reporting stranded marine animals and the division of labor for MARN members are increasingly mature. Advocacy efforts from each unit are effective, which allows the MARN team to continue with their work. This leads to a more comprehensive understanding of actual marine wildlife strandings in sea areas near Taiwan.

Distribution of stranded cetaceans

In 2020, there were 19 cases of stranded cetaceans in Kinmen and Lienchiang County each, the highest among all. Penghu County and Kaohsiung City each had 18 cases, coming in second. New Taipei City and Taitung County each also had more than 10 recorded cases. Compared to 2019, in 2020, there were more stranding cases in outlying islands. As for the significant increase of strandings in Kaohsiung, this was due to the mass strandings of pygmy killer whales there. Additionally, no strandings occurred in Chiayi County, Hsinchu County, and Hsinchu City in 2019, but all of these saw strandings in 2020.

Different species of stranded cetaceans

In 2020, a total of 21 cetacean species were stranded, the three species with the highest number of animals stranded was the same as in 2019: 46 finless porpoises (28.6%), 27 pygmy killer whales (16.8%), and 25 bottlenose dolphins (15.5%). These three species account for approximately 61% of all stranding cases.

Analysis on the reasons of cetacean strandings

Among the 161 cetaceans that were stranded in 2020, 8 were rescued and released back into the wild. The proportion of live marine animals stranded on land was significantly higher than in 2019. After examining and performing necropsy on the remaining 153 creatures, we made the following analysis for the reasons these animals were stranded:

I. It was impossible to discern the reasons of death for 85 of them because their bodies were severely decomposed. These account for 56% of the 153 animals that were dead.

II. 38 of these marine animals were found to have severe lesions in their internal organs after necropsy, and it was determined that infections caused the deaths of these cetaceans. They account for 25% of all 153 animals that were dead.

III. Furthermore, 24 of them had net marks and undigested food in their stomachs. It was determined that these cetaceans had food intake shortly before their deaths. They also had fractured snouts or upper and lower jaws as well as signs of dorsal and caudal fins having been cut off by external force. Through careful examination, their deaths may have been caused due to fishery bycatch. They account for 16% of all 153 animals that were dead.

IV. Tomographic scans revealed symptoms such as bone fracture, displacement or dislocation, or abnormally large soft tissue contusions. It was determined that 2 marine animals were killed by blunt force trauma, accounting for 1% of all 153.

V. Lastly, 2 were swept away by the waves after becoming stranded and weren't found while the other 2 have yet to be examined.

Pathological analysis of cetacean strandings

The deaths of 38 cetaceans were caused by infections. After going through pathological analysis, all were found to have organ lesions: 28 (74%) had pulmonary lesions and 9 of them showed obvious signs of asphyxiation; 16 (42%) had splenic lesions; and 15 (39%) had cardiac lesions.

Distribution of stranded sea turtles

In 2020, 335 stranded sea turtles were reported in Taiwan in total. 276 were dead stranded animals (82%) while 59 were live stranded animals (18%); The highest number of stranding cases were in New Taipei City. Pingtung County came in second, and Taitung and Penghu County both came in third. Among the live stranded animals, 37 were released back into the sea on the spot; 22 were hospitalized, 7 of which were released back into the ocean eventually. Green sea turtles are the most common species to become stranded.

Compared to 269 stranded green sea turtles in 2019 (207 dead, 62 alive), in 2020, there were an additional 69 dead animal strandings and 3 less live animal strandings. The total number of stranded green sea turtles rose by 66 in number.

Monthly distribution of sea turtle strandings

According to statistics, the monthly distribution of sea turtle strandings in 2020 consisted of 82 between March and May (spring), 68 between June and August (summer), 74 between September and November (autumn), and 111 between December and February (winter). Strandings occurred most often between autumn and spring. There were 42 reports of sea turtle strandings in August 2020, an unexpectedly high number of cases compared with previous summer, mainly due to 24 sea turtle hatchlings who lost direction in Kenting.

Body size distribution of sea turtle strandings

According to data presented by the MARN team, though each region has a different number of stranding cases, a majority of them are juvenile sea turtles between 20–65 cm in length. The reason may be that changes in temperature are more intense from autumn till spring. Adult sea turtles have higher resistance against lower temperature. However, juvenile sea turtles are smaller in size and their lungs have not matured yet. Under intense changes in the weather, they are unable to quickly dive deeper into the sea or swim to open seas. They subsequently become stranded in offshore areas that are not suited for swimming.

Analysis on the reasons of sea turtle strandings [3]

The main cause of stranding was drifting at sea. Strandings caused by loss of direction accounted for more cases in 2020 due to the incident of lost sea turtle hatchlings in Kenting. In regards to dead sea

turtle strandings in 2020, the MARN team carried out 74 necropsies (25 in National Taiwan Ocean University, 26 in the National Museum of Marine Biology and Aquarium, and 23 in Penghu County Government). After analysis, most deaths were due to parasitic infections, and the second highest reason of death consisted of traumas caused by boat propellers. As for deaths caused by multiple reasons, these may have been due to blunt force traumas.

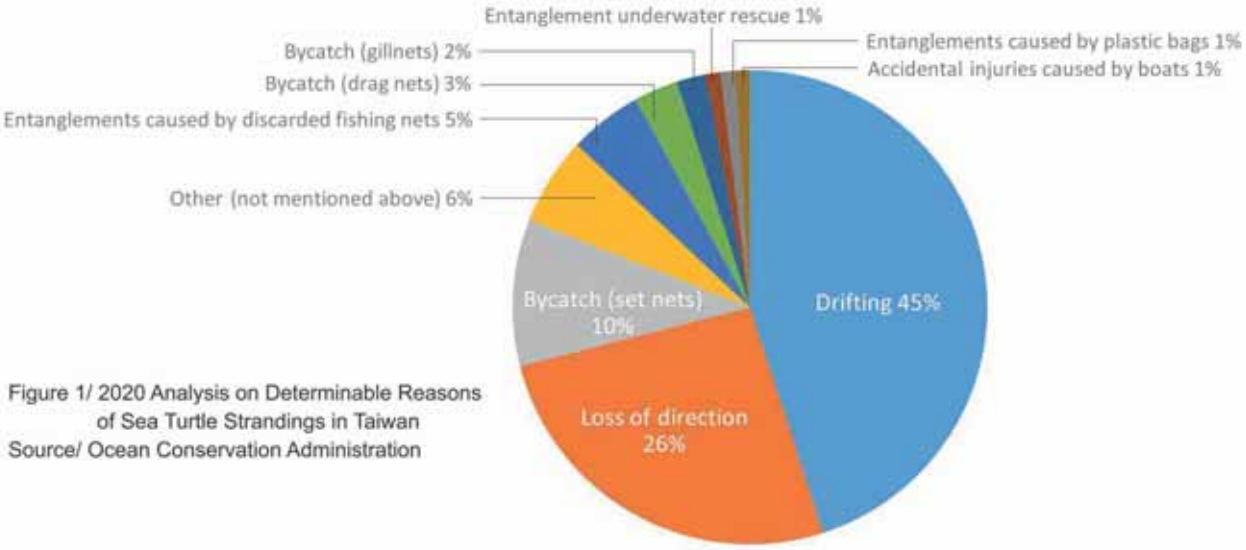

Figure 1/ 2020 Analysis on Determinable Reasons of Sea Turtle Strandings in Taiwan
Source/ Ocean Conservation Administration

Impact of Human Activities on Sea Turtles [4][5]

Sampling of digestive contents from 75 stranded sea turtles in 2020 showed that in 70 of them, man-made substances were found in their digestive tracts, accounting for 93.3% of digestive contents found. With regard to species, there were 2 hawksbill sea turtles, 1 olive ridley sea turtle and 65 green sea turtles. Another 2 green sea turtles have yet to be analyzed.

Contents were found in the different digestive tracts below: food pipe, crop, stomach, small intestines, and large intestines. These man-made substances can be divided into 9 categories: soft plastics, hard plastics, cotton threads, plastic threads, polysterene foam, foam, rubber, metals and others.

We know from the analysis of different categories of man-made substances and deaths that the most common digestive tracts to have man-made contents are the large intestines (71%) and the small intestines (15%). The man-made substances found in the largest quantities within these turtles' larges intestines were plastic threads (26%), soft and hard plastics (each account for 21%), and polysterene foam (16%); the rest account for less than 3%. From the sampling and distribution of these gastrointestinal contents, we know that man-made substances are found in far larger quantities within the intestines than other organs. This means that these man-made wastes have been inside sea turtles' bodies for weeks or even months.

Special stranding case 1: Lost pygmy killer whales in the Port of Kaohsiung

According to statistical data of cetacean strandings from 1994 to 2020, the earliest record of a pygmy killer whale mass stranding dates from 1996. After that, pygmy killer whale mass strandings were reported to happen along the coastlines of Tainan, Kaohsiung, and Pingtung in 1997, 2002, 2005, 2010, 2013, 2014, 2018, and 2020 from February till May.

On the night of April 25, 2020, the MARN team received a report that there were 20 pygmy killer whales lost and stranded in the Port of Kaohsiung. The team immediately activated rescue mechanisms. Some didn't follow up the herd, while some suffered from infections, which resulted in dead animal strandings. Among them, a female pygmy killer whale, about 2.3 m in length, was stranded on tetrapods

in the Port of Kaohsiung. When she arrived at the rescue center, volunteers had to stabilize her underwater 24 hours round the clock; the situation was rather dire. After 56 days of care and medical treatment, the female pygmy killer whale could finally breathe and float on her own. Her wounds had healed well and all test results showed her situation had stabilized. She also became more alert and wary of humans. Hence, it was even more difficult to perform underwater medical treatment. Through comprehensive judgements by the team's veterinarian, the team decided to release her back into the wild.

At 5 a.m. on June 20, all team members gathered at the Sicao Rescue Center. With feelings of eagerness but also a tinge of sadness, the team executed the operation. Around 6:50 a.m., the Coast Guard patrol boat carried the pygmy killer whale from Tainan's Anping Harbor and released her back into the wild, to the open sea about 110 meters deep. At 8:30 a.m. that same day, the pygmy killer whale finally went back to the ocean.

Special stranding case 2: Blue whale stranded on the shores of Changbin Township, Taitung

January 25, 2020 was the first day of the Lunar New Year. Members of the 10th Zone under the Coast Guard Administration (CGA) reported that people found a large blue whale, about 20 meters in length, stranded on Chengzipu Beach in Changbin Township, Taitung. The MARN team immediately activated rescue mechanisms upon receiving the report. Members of the CGA first rushed to the scene to maintain order. The MARN team and county government personnel then urgently dispatched a large crane to the site to immediately start necessary procedures. There were strong winds and waves along the coastline of Changbin. The dead body of the blue whale was very close to the edge wave and lay parallel with the coastline. The body was tilted towards its vertical left side and its epidermis had also fallen off. However, stranded whales usually have obvious throat pleats and their lower jaw skin is white. After necropsy and mitochondrial DNA sequence comparison, the species of the whale was determined to be one widely spread with a small population, a national first-class protected species that has very few stranding records in Taiwan: the blue whale.

There are few records of blue whales in Taiwan, and the stranding incident in 2020 is the first blue whale stranding since the rescue record of cetacean strandings began. The stranded whale was 20 meters in length; its mouth was 3 meters long and the length of its pectoral fin was over the height of an adult male human. To gain sufficient knowledge about the blue whale, the rescue team spent two days to transport the creature to a designated necropsy site in Tainan and took three days to perform necropsy on the blue whale. After examination, the cause of death was determined to be related to the net entangled around its head. The net was around 6 meters long and had a diameter of roughly 4cm. It was entangled around the gape between the upper and lower jaw of the blue whale and caused visible ligature marks. It was deduced that the entanglement led to long-term difficulty of food intake for the blue whale as it was slightly skinny, with signs of insufficient blubber and malnutrition. This subsequently led to its death and stranding.

This is the first ever official record of a blue whale stranding in the history of Taiwan. Blue whale strandings are not common around the world, therefore, it is not easy to obtain specimens of large whales and related research is limited. To seek more information about marine ecology from this blue whale stranding, the OCA invited and gathered cetacean experts in Taiwan to collectively conduct academic research and restore bone specimens. OCA also held a "Presentation on Handling of the 2020 Blue Whale Stranding" to openly describe the process and results of the incident as well as to impart general knowledge on the blue whale to the public.

Special stranding case 3: Lost sea turtle hatchlings in Kenting

On the night of August 9, 2020, 24 sea turtle hatchlings were found on a beach in Kenting. The case was reported to the MARN team and the hatchlings were then taken to the National Museum of Marine Biology and Aquarium for measurement and recording. The sea turtle hatchlings were then released back into the ocean at the original site with the guidance of the team.

It was determined that after these tiny sea turtles were hatched, they should have crossed the beach back to the ocean. However, nearby hotels have strong lights which looked especially bright on the beach at night. This misled these newly hatched sea turtles, which moved towards the light and got lost due to their phototactic behavior.

The last time that sea turtles were found to have laid eggs in Kenting was in August 2017. This incident has given confidence to sea turtle conservation activists, as it indicates that the environment around Kenting's beaches has improved. That being said, night activities on beaches at night should be avoided during summer to provide a friendly hatching environment for sea turtles.

2020 in Retrospect

The MARN team handled cases in 19 coastal counties and cities in Taiwan in 2020. There were a total of 161 cetacean strandings and 335 sea turtles strandings reported. The team also collected 475 scientific samples and 69 specimens. 8 cetaceans were released back into the wild and 37 sea turtles were released into the ocean from the original site. In addition, 7 sea turtles were released back into the wild while 15 remained under care.

2020 is a year worth commemorating. In addition to the blue whale stranding on the coastline of Changbin Township, Taitung—which was the first ever official record of a blue whale stranding in the history of Taiwan, there was also the pygmy killer whale mass stranding in the Port of Kaohsiung. There are few cases of cetacean mass strandings, but each time it happens, a lot of resources and personnel are required to handle it. The deaths of many animals is also inevitable. Through the efforts by the MARN team to record as much information as possible on marine animal strandings and through summarized and periodical stranding reports presented by OCA, the public is able to understand the influence and impact that human activities have on marine animals (e.g., fishery, boat navigation, marine litter, etc.) We hope to gain scientific evidence through data analysis to understand possible reasons for stranding and lower the negative impact caused by humans. This is in hopes to reach the goal of preserving the lives of wild marine animals.

The emergency mechanism for rescuing wild marine animals as well as the establishment of MARN are all possible thanks to joint efforts by OCA, CGA, local governments and NGOs dedicated to environmental protection and marine conservation. With the integration of different physical and virtual resources and the expanded range of action achieved by including the public in rescue work, Taiwan's people have heightened awareness towards wildlife conservation. The people are also more supportive and acknowledge the efforts of the MARN, established by OCA. This can all lead to a more successful result in promoting marine animal rescue work and jointly care for marine animals and marine ecology.

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Transformation Towards a Sustainable Ocean Economy: Realizing a Vision for Marine Protection, Production and Prosperity

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Keywords: Sustainable ocean economy, transformation, ocean policy body

Given the significance and influence of ocean on people's well-being and many marine ecosystems facing significant threats, 14 national leaders across the three oceans collaboratively established the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) in September 2018. The Ocean Panel commits to transformation towards a sustainable ocean economy where environmental protection and conservation, and economic production and prosperity, go hand in hand. Moreover, the Ocean Panel commits to sustainably manage 100% of the ocean area under national jurisdiction of all member states by 2025 and supports a global target to protect 30% of the ocean by 2030. The transformation involves five key areas: Ocean Wealth, Ocean Health, Ocean Equity, Ocean Knowledge, Ocean Finance. US$90 trillion is projected to be invested over the next decade on infrastructure alone, much of which will be on the coast. This article introduces this newly established Ocean Panel and the priorities actions of each area in achieving the transformation towards a sustainable ocean economy [1].

High Level Panel for a Sustainable Ocean Economy

The Ocean Panel is an ocean policy body made up of 14 world leaders. Co-chaired by Norway and Palau, it has members, including Australia, Canada, Chile, Fuji, Ghana, Indonesia, Jamaica, Japan, Kenya, Mexico, Namibia, Norway, Palau, Portugal. Members represent highly diverse oceanic, economic and political perspectives and are situated in five continents of Asia, Oceania, Europe, America, and Africa, respectively. The 14 members represent people across all ocean basins, nearly 40% of the world's coastlines, 30% of exclusive economic zones, 20% of the world's fisheries and 20% of the world's shipping fleet.

The Ocean Panel has been working with government, business and financial institutions, the science community and civil society to catalyze bold, pragmatic solutions across policy, governance, technology and finance to ultimately develop an action agenda for transitioning to a sustainable ocean economy. Guided by the Sustainable Ocean Plan, the Ocean Panel commits to sustainably manage 100% of the ocean area under national jurisdiction of all member states by 2025 and urges all coastal and ocean states to join this commitment so that by 2030 all ocean areas under national jurisdiction area sustainably managed. Furthermore, the Sustainable Ocean Plan will serve as a credible basis in 2030 for safeguarding the long-term health and resilience of the ocean, attracting investment and creating jobs to the benefit of coastal communities and national economics.

The Plan aims to facilitate sustainable use of the ocean and maximize benefits and value creation for current and future generations. It includes regulatory reform, strategic investments in emerging sectors, marine spatial planning, integrated coastal and watershed management, and the establishment and implementation of marine protected areas and other effective area-based conservation measures. It should be in line with the 2030 Agenda for Sustainable Development, build on integrated ocean management and ecosystem knowledge, address pressures from all land- and sea-based sources, and take account of predicated impacts of climate change. In addition, the plan should be developed and implemented through an inclusive, participative, transparent and accountable process.

Five key areas in transformation to a sustainable ocean economy

The transformation for a sustainable ocean economy is built on a framework with five key areas: Ocean Wealth, Ocean Health, Ocean Equity, Ocean Knowledge and Ocean Finance [2]. Each of these areas has its own focuses and each focus has its corresponding 2030 outcome and priorities action. Constraint by the space, only the 2030 outcome and two priority actions pertaining to each focus are presented.

Area I: Ocean Wealth

- Sustainable ocean food

2030 outcome:

Wild fish stocks are restored and harvested at sustainable levels, aquaculture is sustainably grown to meet global needs, and waste is minimized and managed throughout the value chain.

Priority actions:

i. Eliminate illegal, unreported and unregulated fishing by incentivizing the use of the latest innovations and technologies, such as digital traceability, to increase transparency; strengthening monitoring, control and surveillance; improving flag state control; effectively implementing the Port State Measures Agreement [3]; and enabling enhanced collaboration among all stakeholders in the supply chain.

ii. Prohibit harmful fisheries subsidies that contribute to overcapacity, overfishing, and illegal, unreported and unregulated fishing.

- Sustainable ocean energy

2030 outcome:

Ocean-based renewable energy is fast-growing and on the path to becoming a leading source of energy for the world.

Priority actions:

i. Invest in research, technology development and demonstration projects to help make all forms of ocean-based renewable energy, including wind, wave, tidal current, thermal and solar, cost competitive, accessible to all and environmentally sustainable.

ii. Work collaboratively with industry and stakeholders to develop clear frameworks addressing environmental impacts of ocean-based renewable energy and enabling co-existence and integration with other uses of the ocean.

- Sustainable ocean-based tourism

2030 outcome:

Coastal and ocean-based tourism is sustainable, resilient, address climate change, reduces pollution, supports ecosystems regeneration and biodiversity conservation and invests in local jobs and communities.

Priority actions:

i. Invest in sustainable tourism, build the resilience of coastal communities and indigenous people, promotes equal opportunity and equitable distribution of benefits.

ii. Invest in sewage and wastewater infrastructure for coastal and marine tourism to improve the health of coastal communities and reduce the impacts on coastal and marine ecosystems.

● Sustainable ocean transport

2030 outcome:

Shipping investments have effectively accelerated the shift towards zero-emission and low-impact marine vessels.

Priority actions:

i. Establish early national targets and strategies to support decarbonization of vessels.

ii. Incentivize sustainable, low-carbon ports that enable the transition to decarbonized marine transport and shipping fleets through renewable and zero-carbon fuel supply chains.

● Sustainable new ocean industries

2030 outcome:

Innovation and investments in new ocean industries have boosted environmentally responsible economic growth.

Priority actions:

i. Scale up environmentally responsible commercial farming of seaweed and algae to provide food and create alternatives for products such as fuels, aquaculture and agriculture feedstocks, biotech, and plastic alternatives.

ii. Advance carbon capture and storage in the sub-seabed through international collaboration, appropriate incentives and mapping the storage potential of sub-seabed geological formations.

● A precautionary approach to seabed mining

2030 outcome:

Sufficient knowledge and regulations are in place to ensure that any activity related to seabed mining is informed by science and ecological sustainable.

Priority actions:

i. Build partnership to increase research, innovation and deployment of urban mining (reclaiming and recycling metals from spent products, buildings and waste), and of innovative technologies that will reduce the need for new sources of metals and rare earth minerals.

ii. Initiate an international research agenda to improve understanding of the environmental impacts and risks of seabed mineral activities, especially regarding deep ocean ecosystems.

Area II: Ocean Health

● Reduce greenhouse gas emissions

2030 outcome:

Ambitious climate action has set the world on track to achieve the goals of the Paris Agreement and restore ocean health.

Priority actions:

i. Establish and implement emission reductions, covering all sectors, consistent with the Paris Agreement goal of pursuing efforts to limit global temperature increase to 1.5°C.

ii. Scale up investment in ocean-based renewable energy, green shipping, sustainable seafood production, and carbon capture and storage in sub-seabed geological formations.

● Protect and restore coastal and marine ecosystems

2030 outcome:

Coastal and marine ecosystems are healthy, resilient and productive, and nature-based solutions are key elements in developing coastal infrastructure.

Priority actions:

i. Halt the net loss and improve the conditions of coastal and marine ecosystems, in particular critical ecosystems such as mangroves, seagrasses, slat marshes, kelp beds, sand dunes, reefs and deep ocean ecosystems.

ii. Establish and effectively manage marine protected areas to conserve biodiversity and deliver climate, food, socioeconomic and cultural benefits.

● Reduce ocean pollution

2030 outcome:

The ocean is no longer a sink for pollution and ocean dead zones are minimized.

Priority actions:

i. Incentivize the development, production and use of sustainable alternatives to plastics to enable the phase out of problematic and unnecessary plastics.

ii. Use financial incentives, trade opportunities and extended producer responsibility to encourage sustainable product design and promote standards to maximize reduction, reuse and recycling in pursuit of a circular economy, as well as research on new biodegradable materials that substitute plastics.

Area III: Ocean Equity

● Promote equal opportunity for people to benefit from the ocean

2030 outcome:

People have equitable access to ocean resources, benefits are fairly distributed and the most vulnerable are protected from the risk of harm.

Priority actions:

i. Require transparent, responsible business practices that engage and benefit coastal communities, and protect the rights of all workers in ocean industries.

ii. Facilitate the full engagement of women in ocean activities to help unlock their economic and social potential, empower them to safeguard natural resources, and enhance opportunities to access decent work.

Area IV: Ocean Knowledge

● Build ocean literacy and skills

2030 outcome:

Through the UN Decade of Ocean Science ocean literacy has been enhanced worldwide. People understand the value of the ocean and have acquired the skills and knowledge to participate in the sustainable ocean economy.

Priority actions:

i. Make ocean knowledge available to everyone and invest in building ocean literacy and awareness among citizens, including through formal education.

ii. Invest in knowledge, technology and skills training for ocean conservation and management that the sustainable ocean industries of the future.

● Account for the value of the Ocean

2030 outcome:

Decision-making affecting the ocean reflects the value of and impacts on the ocean's natural capital.

Priority actions:

i. Develop a complete sequence of national ocean accounts that are actively used to inform decision-making.

ii. Establishing global partnerships to share best practices and build capacity in national ocean accounting.

● Harness ocean science, technology and data

2030 outcome:

A globally shared data revolution has contributed to sustainable ocean management worldwide.

Priority actions:

i. Promote transparent and open sharing and accessibility of ocean data.

ii. Scale up integrated local-to-global observation.

Area V: Ocean Finance

2030 outcome:

Sustainable ocean finance is accessible for all and drives ecologically sustainable and socially equitable economic growth.

Priority actions:

i. Direct public sector financing to investments in the sustainable ocean economy to unlock private sector financing.

ii. Support the development and application of a global 'ocean risk map' and 'risk index' to catalyze a responsible and sustainable ocean insurance market and investments in the resilience of islands and coastal communities.

Conclusion

14 national leaders across the three oceans established the Ocean Panel in 2018. The Panel commits to transformations towards a sustainable ocean economy and to sustainably manage 100% of the ocean under national jurisdiction. To fulfill this vision, the Ocean Panel set out five key areas pertaining to the transformation and their associated focuses and priority actions as well as the 2030 outcome of each focus. Taking these actions can safeguard the ocean's capacity to regenerate such that the ocean can deliver substantial economic, environmental and social values and offer solutions to global challenges, in particular climate change, acidification, ocean warming, marine pollution, overfishing, and loss of habitat and biodiversity.

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Systems and Regulations of Canada's Whale Watching Industry

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Keywords: Canada, Beluga Whale, Whale Watching

In early 2020, Port Hilford, a small sea port on the bay 750 km east of Québec, Canada, was proposed by the Whale Sanctuary Project, a non-profit organization, to be established as a coastal cetacean sanctuary due to the features of its natural environment. The sanctuary will house cetaceans in the bay that have been kept in captivity since they were young or that are injured and cannot be released back into the ocean. It is also expected to house cetaceans, such as the beluga whale (Delphinapterus leucas), from aquariums starting from the end of 2022. This will provide those creatures that were kept in captivity with a safe and stable place where they can retire [1][2]. This made the author of this article wonder what was the criteria that served as the basis for scientists' decision to choose this bay? Can captive beluga whales survive here? How will the educational planning of the sanctuary be conducted once the sanctuary is established? And, once the sanctuary is established, in order to collect funds, it may be inevitable to open the sanctuary for whale watching activities, so what are the regulations for whale watching in Canada? All of these questions prompted the author to want to have a deeper understanding of Canada's whale watching history and policies. In this article, the author will talk about the whale watching industry in Canada starting from the stories of the beluga whale sanctuary.

Whale Watching Areas in Canada

Québec and the Canadian Arctic regions are popular places for watching beluga whales in the wild. Besides the two places mentioned above, Canada also boasts other famous whale watching areas because the nation is surrounded by the Atlantic, the Arctic, and the Pacific Oceans. The waters near British Columbia, Nova Scotia and New Brunswick, and Newfoundland and Labrador all offer more than ten species of whales of all shapes and sizes to gaze at. These include: killer whales and belugas of the toothed-whale group (Odontocetes), humpback whales and gray whales of the baleen-whale group (Mysticetes), and the critically endangered North Atlantic right whales (according to International Union for Conservation of Nature and Natural Resources, IUCN). All of them are beloved and treasured species for cetacean lovers [3].

Figure 1/ Killer whales are the most popular species for whale watching in Canada
Image by Taiwan Cetacean Society

The beluga whale is widely found in the Arctic and sub-Arctic regions. It has been listed as a Near Threatened (NT) species on the Red List of Threatened Species by the IUCN. A matured beluga whale can be more than 4 m long and weigh more than 1,000 kg. The body size of a male beluga whale is usually slightly larger than a female one. Since ancient times, beluga whales have been an important source of food, oil, and leather to the indigenous peoples of the Artic. In modern times, beluga whales have become one of the most common captive species among sea creatures around the world because of different factors. These factors include the fact that their neck vertebrae are not fused together, giving the species greater mobility and flexibility in their necks; in addition, they have a wide range of facial expressions and sounds, and they can be trained. Of course, the beluga whale's habitats have also become a place for watching whales in the wild, including St. Lawrence River and the Gulf of St. Lawrence, both of which are in Eastern Canada. Port Hilford is seldom ravaged by hurricanes. It is also situated in the Nova Scotia peninsula that bounds the Gulf of St. Lawrence. It is near the natural habitat of the beluga whale, and therefore, the characteristics of the sanctuary's natural environment are very similar to the whales' original habitat [4][5][6].

Table 1/ Overview of Whale Watching Areas in Canada

Region	Whale watching places	Form of whale watching	Species seen while whale watching
Atlantic region			
Québec	St. Lawrence River Estuary, Saguenay Fjord, Mingan region	Motorized boat, land-based	Dall's Porpoise Harbour porpoise Atlantic white-sided dolphin White-beaked dolphin Beluga whale Minke whale North Atlantic Right Whale Humpback whale Fin whale Blue whale
Nova Scotia and New Brunswick	Bay of Fundy, Halifax, Cape Breton	Motorized vessel, non-motorized craft, land-based	Harbour porpoise Atlantic white-sided dolphin Long-finned pilot whale Minke whale North Atlantic Right Whale Humpback whale Fin whale
Newfoundland and Labrador	St. John's, Avalon Peninsula	Motorized vessel, non-motorized craft, land-based	Harbour porpoise Atlantic white-sided dolphin Killer whale Minke whale Humpback whale
Arctic region			
Canadian Arctic	Churchill, Pond Inlet and Baffin Island	Motorized vessel, non-motorized vessels, helicopter	Beluga whale Narwhal Bowhead whale
Pacific region			
British Columbia	Vancouver Island, Victoria, Long Beach, Telegraph Cove, Campbell River, Tofino	Motorized boat, non-motorized boats, and land-based	Dall's Porpoise Harbour porpoise Pacific white-sided dolphin Killer whale Minke whale Humpback whale Gray whale

Source/ [3]

Whale Watching Regulations in Canada

The Marine Mammal Regulations of Canada are part of the country's Fisheries Act. It became effective on February 24, 1993, and went through its latest amendment in 2018 [7]. These regulations mainly encompass the management of commercial tourism of marine mammals. However, to better protect endangered species that appear in the seas of Canada, such as beluga whales, killer whales, North Atlantic right whales, grey whales, and blue whales, the Species at Risk Act has stricter regulations regarding whale watching activities. This is not only to protect endangered species and their threatened habitats, but to prevent these species from disappearing [8].

In Canada, whale watching is done through a telescope which allows people to watch cetaceans from a safe distance. Whale watchers must keep a distance of at least 100 meters from the creatures. If whale watchers encounter resting whales or mother whales with their babies, they must keep a distance of at least 200 meters. However, when sea animals actively approach a vessel, the following behaviors are prohibited:

- Feeding cetaceans.
- Swimming, diving or interacting with cetaceans.
- Moving, surrounding whales or luring whales to move.
- Quickly changing the direction of the vessel or leaving the vessel in the way of cetaceans.
- Going near cetaceans when they are resting (when they appear to be floating without moving).
- Separating a herd of cetaceans or separating mother whales from their babies.
- Capturing one or a herd of cetaceans between vessels and coastlines or between two vessels.
- Multiple vessels approaching cetaceans at the same time.
- Vessels approaching cetaceans from the front or from behind, as this will interrupt their movement.
- Marking cetaceans.
- Even if cetaceans approach a port or coast, touching, feeding or disturbing them is prohibited.
- Going near cetaceans on airplanes.
- If whale watchers see porpoises or dolphins coming near the vessel to ride waves, they must avoid changing the direction of the vessel abruptly. Whale watching vessels should stay on the same route and reduce their speed; crossing herds of porpoises or dolphins is prohibited.

In addition, to avoid drones from causing unnecessary noise that may disturb the cetaceans, if whale watchers use a drone to take pictures or film videos, they must follow certain rules. For example, drones need to keep a vertical distance of 1,000 feet from the cetaceans. Drones also cannot enter an area with cetaceans within a 3,000 feet radius. Moreover, when a drone is taking photos or filming videos, it cannot take off, land or change its course or flying height.

In addition, whale watching regulations will be adjusted based on scientific research results. For instance, the Mingan Island Cetacean Study (MICS) conducted more than 40 years of research on baleen whales in the Gulf of St. Lawrence where beluga and blue whales appear. Thanks to the research results of the MICS, the Canadian government was able to list blue whales as endangered species for further protection. The members of the investigation station have also collaborated with the government to rehabilitate blue whales. Through photo-identification surveys of cetaceans, they were able to confirm the number of blue whale herds, their distribution areas, and distribution density in the Gulf of St. Lawrence. The surveys have also helped to plan a critical habitat for blue whales and to include them under the protection of the Species at Risk Act [9].

As for specific areas or seeing special species, the distance for whale watching will also be adjusted to protect the stability of cetacean herds. For example: Southern resident killer whales (SRKW) of the Pacific Northwest are now estimated to be less than 80 in total. They appear every year in the waters along British Columbia all the way down to Washington State from April to October. Because they are few in number, SRKWs are listed as endangered species in both Canada and the US, and are strictly protected and researched. To avoid whale watching vessels from causing too much noise and potential vessel crashes, there are stricter regulations in regards to the required distance for whale watching in British Columbia. If whale watchers encounter a herd of killer whales in this area, the speed of the whale watching vessel must be less than 7 knots and it must keep a distance of more than 400 meters from the herd (in other areas, whale watchers just need to keep a distance of 200 meters) to prevent vessels from disturbing killer whales. The same management method can also be applied to habitats

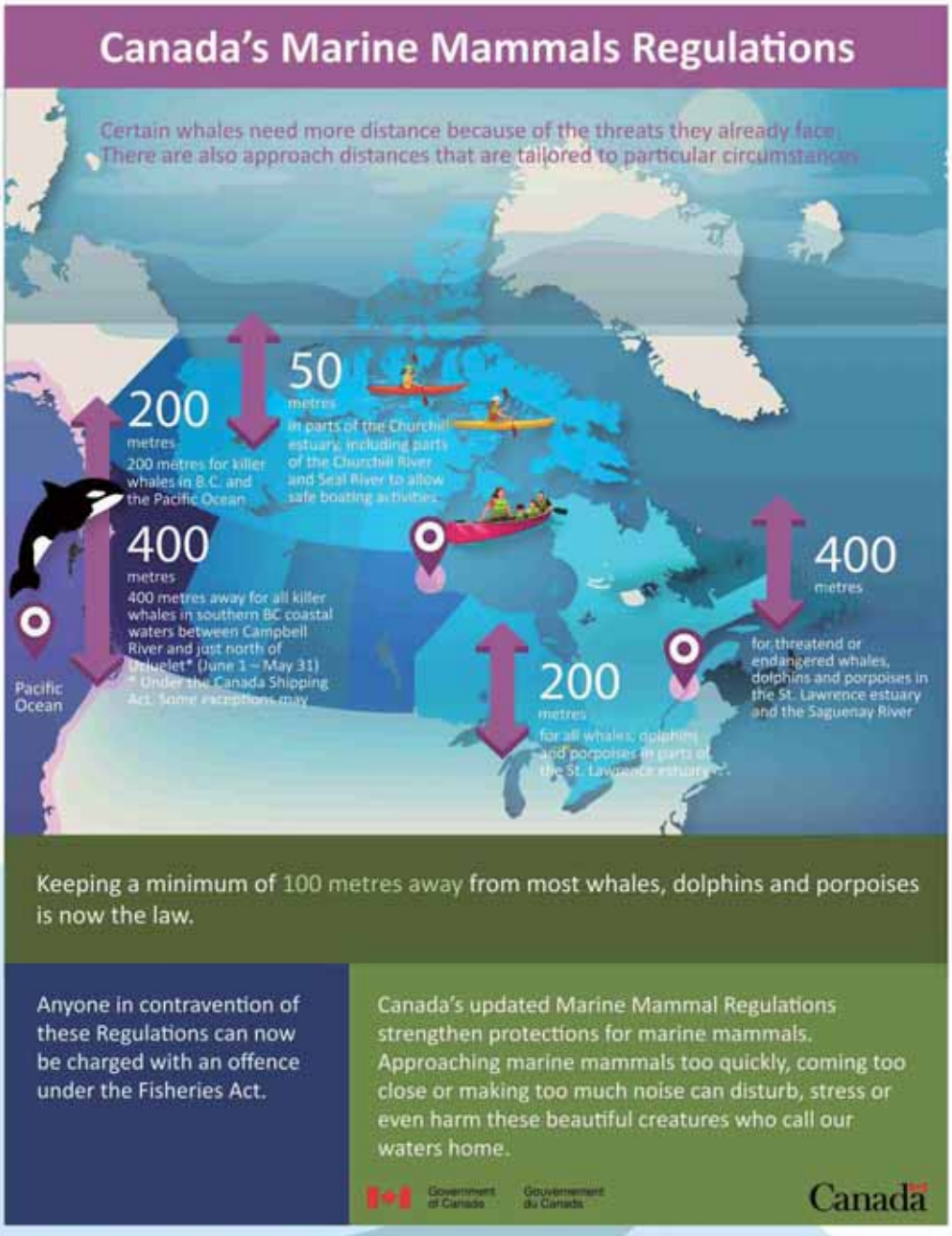

Figure 2/ Regulations of Different Whale Watching Areas in Canada
Source/ https://www.dfo-mpo.gc.ca/about-notre-sujet/publications/infographics-infographies/marine-mammals-regs-mammiferes-marins-eng.html

with narrow areas like the St. Lawrence River Basin and Saguenay River Basin. In these areas, if a whale watching vessel encounters endangered beluga and blue whales, the vessel must keep a safe distance of 400 meters, two times farther than in other areas to prevent vessels from disturbing these whales (Figure 2) [8][10][11].

Conclusion

In the author's opinion, there is a Chinese saying that best describes whale watching methods in Canada: "They can only be appreciated distantly, but not touched blasphemously." In 2008, the International Whaling Commission (IWC) published whale watching survey data showing that more than 13 million people around the world participate in whale watching activities every year. The whale watching industry and relevant industries are worth more than 2.1 billion USD. The number of whale watching tourists in Canada is as high as 1.1 million, the third highest number of whale watching countries in the world, just behind the US and Australia [12]. No matter how many tourists there are or how prosperous whale watching activities are, all who participate in whale watching must observe cetaceans through a telescope and all vessels must keep a distance of at least 100 meters. Furthermore, cetacean research results will continue to help adjust the management methods of the government. Regulation mechanisms are there to best protect local creatures according to the species, locations, and levels of conservation to ensure a protection-centered whale watching framework. Although there is some distance between whales and whale watchers, by reducing human disturbance, these beautiful creatures can behave in the most natural way. Watching whales jump, raise their tails to hit waves, and dive into the sea is an amazing experience, which can become one of the most cherished memories for tourists. This is what whale watchers cherish the most.

The Whale Sanctuary located in Port Hilford is at a higher latitude and is rarely hit by hurricanes. And its being nearby the Gulf of Saint Lawrence makes its environmental conditions similar to those of the original beluga whale habitat. In addition, it is believed that after the sanctuary in the whale watching area in Nova Scotia has been established and begins operations, its whale watching trips, recreational whale interaction, and educational activities can all be implemented in strict accordance with Canadian whale watching regulations. Let these beluga whales in long-term captivity enjoy their retirement in the best living environment and with the highest quality of life, for that is the purpose of whale and dolphin conservation.

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Canada's Oceans Strategy and Ocean-related Organizations

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Keywords: Fisheries and Oceans Canada, Environment and Climate Change Canada, Oceans Act, Canada

Canada is one of the world's strongest maritime nations and a pioneer in integrating maritime legislation. The Oceans Act authorizes maritime agencies to manage and coordinate matters related to oceans and the seas. In this article, the author introduces the Oceans Act system, marine science and technology research system, implementation of maritime policies, as well as goals and visions of marine management in Canada. Taiwan can learn from these various aspects of Canada's strategy to become a true maritime country.

A Brief Introduction Of Canada

Canada is situated in the northern half of North America. Geographically, it is surrounded by the Atlantic Ocean, the Arctic Ocean, and the Pacific Ocean. Canada is a major maritime nation in North America. It shares its southern border with the United States of America and has a massive land territory and exclusive economic zones. Canada is the second largest country in the world and has a coastline of 243,792 km, the longest in the world. The oceans are like lifelines, supporting the development of various coastal areas in Canada. Transportation both domestic and abroad is mainly by sea. One fourth of the population in Canada lives in coastal areas. Therefore, Canada's important urban centers and populated areas are all located along the coastlines. The government invests much effort and funds in the management of coastline environmental conservation and disaster relief and protection work. The marine industry is a significant contributor to Canada's economy.

Figure 1/ Territorial areas and coastlines of Canada
Source/ Coastline, Boundaries and Names of Canada
https://open.canada.ca/data/en/dataset/55d5eb69-f866-5be9-89c1-736e92df425e

Canada's Marine Strategy and Maritime Agencies

The author of this article (Yi-Che Shih) went to Canada in 2001 with Professor Wen-Yan Chiau (who received the Canadian MacKay Award back then) and visited the Fisheries and Oceans Canada (DFO), Canada Coast Guard College (CCGC), CCG Maritimes (Dartmouth), Environment Canada (EC), and Eastern Canada Response Corporation (ECRC), among others. We learned a lot from these units and came to understand their response mechanisms towards marine pollution (the Amorgos oil spill occurred that year in Taiwan). The author then received a scholarship from the National Science Council of Taiwan in 2005 and conducted a year of doctoral level research at the Bedford Institute of Oceanography (BIO), Canada. The author became even more knowledgeable about Canada's marine policies and the operations of related departments. This article is dedicated to introduce the key points of the author's takeaways from the experience.

I. Fisheries and Oceans Canada (DFO)

Canada established the Fisheries and Oceans Canada (DFO) in 1995. DFO belongs to the federal government and is responsible for drafting, implementing, and supporting the economic activities in Canada's marine and inland waters, as well as ecological and scientific research and policies. DFO is also in charge of protecting and ensuring sustainable use of Canada's fishery resources. DFO continuously provides safe, effective, and healthy environmental marine services and is a pillar for supporting the economic growth of marine and fishing activities. Furthermore, it leads innovation in the fields of aquaculture and biotechnology. DFO has excellent scientists and scientific research vessels. Through research, monitoring, and analysis, DFO provides policy suggestions to the government. DFO places great emphasis on the fishing industry, marine environment and ecology, and oceanography. For instance, in 2020, DFO raised the limit of Total Allowable Catch (TAC) for fishermen by 10% in the snow crab fishing areas offshore of Newfoundland and Labrador. This policy was conducted based on concrete scientific research and is a valuable reference for marine resource protection and sustainable fishing.

II. Environment and Climate Change Canada (ECCC)

Environment Canada (EC) was renamed as Environment and Climate Change Canada (ECCC) in 2015. It is the competent authority for environmental affairs in Canada and also an important department in managing the marine environment. To promote the protection of marine ecosystems and resources, as well as to prevent pollution and ensure a clean natural environment, ECCC's main responsibility is to formulate environmental policies and development plans, as well as the operation and management of resources in national parks. In addition, it also takes part in planning, managing, and establishing protected areas with federal and local departments. Last but not least, ECCC coordinates policies and practical means of protecting natural resources for the Canadian government. It enhances the protection of the marine environment and resources, prevents marine pollution, cleans up toxic waste, ensures a clean natural environment, and provides reusable resources and aquatic resources.

III. Eastern Canada Response Corporation (ECRC)

According to the Canada Shipping Act, CCG is responsible for handling and responding to large-scale marine pollution incidents and supervising other instances of marine pollution. Generally, private-sector Response Organizations (ROs) are in charge of tackling small and medium-sized oil spills; ECRC is one of them. The Transport Canada (TC) established an accreditation mechanism for private-sector ROs in accordance with the Canada Shipping Act. ECRC is the largest accredited RO in Canada. ECCC has built an oil spill database according to the statistical data compiled by each province.

With regard to countermeasures against oil spills caused by private companies, many private oil companies in Canada have established ROs based on geographic divisions to assist the government in handling relevant incidents. (Figure 2)

Figure 2/ Geographical mapping of private-sector ROs
Source/ Eastern Canada Response Corporation Ltd., Canada's Marine Oil Spill Response Organizations (1999)

A significant risk of a marine oil spill exists along the east coast of Canada due to increasing ship traffic and offshore oil exploration and development. Combine this with the natural hazards (such as weather and ice) associated with the North Atlantic Ocean and the presence of significant natural resources (such as wildlife and fishery) and the potential for a major oil spill with significant environmental impacts is created. Based on the lessons learned from past spills, the oil spill response community in the Atlantic Region has evolved an oil spill response network that focuses on improving the various procedures relating to spill prevention, preparedness, response, and damage restoration. An active player in these activities is the Regional Environmental Emergencies Team (REET) [1]. The members of these teams are from different federal, provincial, and national organizations. When tackling marine oil spills, REET provide technical suggestions as reference to the On-Scene Commander (OSC) of CCG.

IV. Canadian Coast Guard (CCG)

The Canadian Coast Guard (CCG) was established in 1962 and is subordinate to DFO. CCG is headquartered in Ottawa and has around 4,500 members. It has a budget of around CA$280 million (approx. NT$6.4 billion) per year. CCG became a part of DFO in 1995. Its main responsibilities include: CCG represents DFO in enforcing fisheries law, providing maritime navigation services, breaking ice, and safeguarding Canada's sovereignty in the Arctic region. It also provides maritime communication and traffic services, comprehensive technical support, and maritime search and rescue, not to mention responding to environmental emergencies and managing maritime security and fleets. It is a non-military institution but serves as an important support for military operations. The functions and responsibilities of CCG are very clear. In 2010, the Canadian International Council released the "Open Canada: A Global Positioning Strategy for a Networked Age Report" [2] and suggested that CCG should be fully in charge of Canada's marine security affairs (excluding military security). Therefore, developing a comprehensive maritime law enforcement plan is the goal of CCG. With regard to oil spills,

CCG will only interfere under these two conditions: First, the oil spill is caused by unknown parties—Canada calls it a "mystery oil spill"; second, the oil spill exceeds the cleaning capacity of private organizations (over 10,000 tons). Then only will the CCG use national resources to clean up the oil spill.

V. Bedford Institute of Oceanography (BIO)

The Bedford Institute of Oceanography (BIO) is located in Dartmouth, Nova Scotia. The federal government of Canada established it in 1962. BIO has become one of the largest research centers for oceanography in Canada. It is mandated by the Canadian government and also provides policy advice to the government as well as supports it during decision-making. Its major areas of research include a series of maritime issues, such as sovereignty, national defense, environmental protection, security and health, fishery, and natural resources, as well as marine and environmental management and planning.

Since its establishment, BIO has owned first-class equipment and had superb ocean navigation capabilities. It has become a world-class research institute in cross-disciplinary oceanography. Most of its members hail from departments from the federal government in Canada, such as the National Defence (DND), ECCC, DFO, and Natural Resources Canada (NRCan). BIO also partners with various universities, industries, advanced countries, and NGOs. Since its establishment, BIO has conducted insightful research regarding current systems around the world and in Canada, as well as climate change issues. BIO has also studied the marine geology of the Canadian Atlantic Ocean, which subsequently sets the foundation for oil and gas exploration. BIO is a significant contributor in this regard.

Organizational Establishment and Members of the Bedford Institute of Oceanography

Currently, the BIO has more than 600 scientists, engineers, technicians, and natural resource and environmental managers. Members of the BIO possess different fields of expertise, but do research together and collaborate with each other. The four departments of the federal government hold joint conferences every year to decide on major matters and research topics. The Director is in charge of management, whereas sub-agencies of the four departments have a certain level of autonomy and share resources such as laboratories, research office space, data, and equipment. In this aspect, BIO has built a sharing management mechanism for all scientific data to be "complete and open". BIO requires that scientific researchers and people from all levels of society should have convenient access to scientific data at an affordable cost. BIO highly values the building of technology data and the sharing of data. This has led BIO to become a crucial foundation for scientific research thanks to its prolific output. It is also a means for BIO to serve society and gain support from the people.

BIO places great emphasis on science education. It is the main focus of BIO's contribution to society, as it strives to provide educational experiences and resources to everyone. Regarding the training of professionals, employees at BIO provide training voluntarily on a regular basis. Marine scientific research conducted by BIO includes endangered species, oceanography, marine environmental science, hydrographic survey, habitat management research, the Oceans Act, the scientific advisory committee, and publications and annual reports, as well as related publications. Furthermore, to commemorate Dr. Archibald Gowanlock Huntsman, a great oceanographer, BIO established the Huntsman Award. The Award is presented by the Royal Society of Canada to recognize marine scientists that have made excellent contributions to oceanography. Numerous data and policies of government departments and research units in Canada can all serve as reference.

Background of Canada's Oceans Strategy

In 1987, DFO announced the Oceans Strategy, which despite posing a great challenge, also brought forth opportunities for Canada. The purpose of Canada's Oceans Strategy is to ensure that Canada gains the greatest social, economic, scientific and sovereign interests, as well as to raise awareness regarding the Oceans Strategy among all Canadians. Canada's marine policy is based on the legislative and policy

requirements of the Oceans Act. The Oceans Act empowers the Director of DFO to organize and monitor Canada's Oceans Strategy. DFO formulated Canada's Oceans Strategy for the 21st century. The purpose of Canada's Oceans Strategy is to draft clear goals and enhance collaboration between all stakeholders of marine management.

I. Canada's Oceans Strategy and Maritime Legislation

Around 150 years have elapsed since Canada's independence in 1867, and maritime legislation remains of great importance for securing order in maritime development and ensuring the nation's maritime rights and interests. Hence, Canada's maritime legislation has a long history. During the early years of its independence (1868), Canada promulgated its first Fisheries Act. In 1869, it passed the Coastal Fisheries Protection Act; the two laws have been the basis for Canada's fisheries management up until the present day. In 1997, Canada promulgated the Oceans Act and became the first country in the world to integrate maritime legislation. The Oceans Act stipulates the responsibilities of different units and coordinates all maritime affairs. The Act put the rights conferred to coastal countries by the United Nations Convention on the Law of the Sea (UNCLOS) to have their own domestic legislation into actual practice. Canada defined concrete standards for national marine strategies and policies through legislation to keep pace with changes regarding the oceans and seas after UNCLOS was enacted. In addition, maritime laws enacted by the federal government in Canada are quite comprehensive, including the Oceans Act, Canadian Environment Protection Act, Fisheries Act, Canada Shipping Act, Canada Wildlife Act, and Arctic Waters Pollution Prevention Act.

II. Canada's Oceans Strategy

Canada promulgated the Oceans Act and became the first country in the world to integrate maritime legislation. To implement the Oceans Act, Canada announced Canada's Oceans Strategy in 2002 to draw clear visions, principles, and goals for Canadian waters and ecosystems. Its main purpose is to understand and protect Canada's marine environmental plans and policies as well as to provide plans and policies to ensure sustainable development of Canada's economy. This has kept Canada at the vanguard of international maritime policies and plans. For example, Canada uses scientific methods to understand and protect marine ecosystems, conduct oceanographic research, and set boundaries for different species and important ecosystems. In addition, scientific methods allow Canada to develop assessment technology and set management goals for the ecosystem as well as to assess its health. To achieve these goals, Canada has formulated specific measures including putting more emphasis on marine research, protecting biodiversity of sea creatures, protecting the marine environment, drafting integration management plans, ensuring maritime security, encouraging the marine industry, promoting international collaboration, and enhancing public education.

Conclusion

The 21st century revolves around the oceans. The oceans and seas are the future of Taiwan. On the first World Ocean Day, the President reminded the Ocean Affairs Council to endeavor towards "robust oceans laws and ecological conservation", "promote the marine industry in response to policies", and "put more emphasis on oceanography and train experts in the field". From Canada's experiences, we know that the future development of an Ocean Economy, protection and management of marine ecosystems, safeguarding of marine security, and assurance of marine rights and interests all require research and innovation in the fields of marine science and technology to serve as pillar for our marine legislation. Then only can we promote sustainable development of the oceans and seas and become a true maritime nation.

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Remote Sensing Technology of Detecting Illegal, Unreported and Unregulated (IUU) Fishing

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Keywords: radar satellite, remote sensing, illegal, unreported and unregulated (IUU) fishing, Automatic Identification System (AIS), dark vessel, Sentinel-1, National Ocean Satellite Image Service (NOSIS), ICEYE, low-orbit micro-satellite constellation

Illegal, unreported and unregulated (IUU) fishing refers all types of abnormal fishing activities, and is a new term coined during the annual meeting of the Convention for the Conservation of Antarctic Marine Living Resources in 1997. The Food and Agriculture Organization of the United Nations (FAO) subsequently formulated the International Plan of Action to prevent, deter and eliminate IUU fishing (IPOA-IUU) in 2001, and defined IUU fishing in detail. It pointed out that the fundamental cause of IUU fishing is that some countries are unable to sufficiently supervise and control their fishing boats after granting fishing vessels the right to fly its flag, so the fishing vessels are not punished for engaging in IUU fishing. Many countries around the world have formulated their own National Plan of Action (NPOA) to show their political intention to jointly fight IUU fishing. Taiwan also established a NPOA for the prevention and elimination of IUU fishing in 2013 to show its determination to combat IUU [1]. However, general coastal environment monitoring system and illegal fishing management still has room for improvement, and monitoring technologies urgently need to be improved to achieve the goal of preventing IUU fishing. This article introduces breakthroughs in radar satellite remote sensing image acquisition and time series data analysis, as well as services provided by the National Academy of Marine Research, Ocean Affairs Council using these technologies, in hopes of utilizing the technologies and services to achieve the goal of preventing IUU fishing.

Advantages of satellite remote sensing and limitations of optical images

Remote sensing is the science and technology for obtaining information and analyzing objects, regions, or phenomena without making contact [2]. Using Earth-orbiting satellites for remote sensing provides the advantage of longer time period, larger range, stable cycle, and almost real-time monitoring. Hence, NASA sent the first satellite dedicated to exploring Earth's resources Landsat-1 into orbit in 1972. Over the past nearly 50 years, according to the United Nations Office for Outer Space Affairs, over 7 thousand satellites were sent into orbit [3]. Satellite remote sensing technology developed during the arms race between the United States and Soviet Union has not become mankind's most powerful tool for monitoring Earth, and various commercial services and applications have flourished.

Among the images that can be photographed by a satellite, optical images in the visible light and near infrared range are the closest to what is seen by the naked eye and also the easiest to determine. Hence, efforts have been focused on increasing temporal and spatial resolution. However, 52% of the area on Earth's surface is covered by clouds at any given moment [4], and the

ratio is increased to 55.0-56.5% if only oceans are considered [5]. Hence, optical satellite images that cannot see through clouds are inherently limited in practical applications. A breakthrough in the limitation of clouds blocking images is needed to monitor IUU fishing at key times and locations.

Radar satellite remote sensing and synthetic aperture radar imaging principles

Radar satellites detect the echo signal of specific wave length radar waves emitted by the satellite after interacting with the surface to determine surface properties, and is categorized as active remote sensing. Radar satellites do not rely on electromagnetic waves emitted by the sun as a signal source, and the wave length of electromagnetic waves used by the satellites is longer than water droplets in clouds, so the waves are not blocked by water droplets. Hence, compared with optical satellite images, radar satellite images provide the advantage of being able to acquire images and penetrate clouds at any time of the day.

The spatial resolution of radar satellite images is limited by the orbit altitude and length of the radar's antenna, and cannot meet requirements on higher spatial resolutions. However, using a synthetic aperture radar, continuous and overlapping electromagnetic waves that were emitted at different times during the satellite's high speed flight and received at different locations can be used for calculation to increase image resolution. Hence, radar satellites can provide meter-level spatial resolution images using synthetic aperture radar technology, and some satellites are even able to provide 25 cm-level ultra high spatial resolution images.

Dark vessel identification and IUU fishing monitoring

The Automatic Identification System (AIS) on vessels can exchange electronic data with nearby vessels, base stations, and satellites, providing real-time information for identification and positioning. The International Convention for the Safety of Life at Sea (SOLAS) requires vessels with a total tonnage of 300 tons and above and all passenger vessels regardless of tonnage to install an AIS. During a voyage, vessels can send its accurate GPS location, International Maritime Organization (IMO) No., MMSI, name, vessel type, dimensions, speed, and course to AIS base stations and satellite systems, providing key information needed for monitoring and management. Yet, the contents of AIS messages are not always correct and reliable, because illegal vessels can falsify text in their AIS message, and even provide prefabricated coordinates of their course. A so called dark vessel is a vessel that intentionally turns off its AIS to avoid being monitored and tracked, in order to engage in IUU fishing. Therefore, if the location of vessels at sea can be rapidly and accurately identified in radar satellite images without being affected by the weather and clouds, dark vessels can be rapidly identified and marked by comparing the vessels with AIS location information, so as to further determine if they are engaging in IUU fishing. The Canadian government launched an international cooperation project with a budget of US$7 million at the beginning of 2021. The project uses radar satellite remote sensing technology to quickly identify dark vessels and thereby combat IUU fishing [6].

Explosive growth in radar satellite image sources

The first commercial radar satellite is the RADARSAT-1 launched by Canada in 1995. The United States, Germany, Japan, China, India, and Israel subsequently launched their own synthetic aperture satellite missions. Even though commercial services and applications of radar satellite images have flourished, active remote sensing requires a high power radar transmitter, satellites have a relatively high payload and technical threshold, and also have relatively high construction, launch, and operating costs. Hence, there are relatively few sources of commercial radar satellite images in the market, and prices are much higher than optical images. Even though the use of radar satellite images can break through limitations of clouds covering images when monitoring IUU fishing at key times and locations, typical research institutes can rarely afford long-term time series data from observations of the same location. As a result, we are currently in an awkward phase where the technology is feasible but not practical.

The European Commission renamed the Global Monitoring for Environment and Security the Copernicus initiative in 2012, and planned a series of sentinel satellite missions the following year. The first mission was to launch the radar satellite Sentinel-1, which is able to generated synthetic aperture radar satellite images of land and ocean that is not affected by the time of day and weather. The images cover large areas photographed over a long period of time at stable cycles. Sentinel-1 is a sun synchronous orbit satellite at an altitude of 693 km, ad consists of two satellites in the same orbit - Sentinel-1A and Sentinel-1B, which were launched in April 2014 and April 2016. The Copernicus initiative fully supports the open data policy, and not only established a Sentinel Hub, but also provides the massive amount of high quality remote sensing images photographed during the sentinel satellite missions. It also developed software with powerful functions - the Sentinel Application Platform (SNAP), so that users can process the images into different level products, significantly increasing sources of radar satellite images.

ICEYE is a spin-off of the Radiologic Technology Department of Alto University in Finland in 2014, and specializes in the manufacturing of micro satellites. The ICEYE-X1 satellite, which only weighs 70 kg, successfully entered orbit in January 2018. It is the world's first synthetic aperture radar satellite to weigh less than 100 kg, and is mainly used to monitor sea ice movement, marine oil leaks, and prevent IUU fishing. The second satellite ICEYE-X2 also successfully entered orbit in December 2018. Compared with ICEYE-X1, ICEYE-X2 has multiple imaging modes, including the Stripmap mode with a resolution of 3 meters and Spotlight mode with ultra high resolution of 50 cm. Two more SAR satellites were successfully launched in July 2019 to form a satellite constellation. Radar satellite image products with a spatial resolution of 1 meter formally began commercial operation in October 2019; wide area imaging services that can cover an area of 10,000km^2 also formally began commercial operation in May 2021. As of 2021, there are 10 ICEYE satellites in orbit to form a satellite constellation, and the number is expected to increase to 18 in 2022. This is another form of explosive growth in the source of radar satellite images.

Radar image time series analysis and variance detection

Radar waves are highly sensitive to bodies of water, and a thin layer of water covering the area being detected will cause mirror reflection of the radar waves, resulting in an extremely weak echo signal, which will look very dark on the image. Hence, there is usually a significant difference in the strength of echo signals from vessels and the ocean surface when using radar images to detect vessels at sea, so there is very good contrast. It is worth noting that waves on the ocean surface caused by wind will result in scattered reflection, and the occasional relatively strong echo signal is known as sea clutter. The standard used to filter noise in an image can easily result in confusion and incorrectly report vessels that are detected. Thanks to the explosive growth in sources of radar satellite images, we can use time series images from radar satellites making long-term observation of the same location. This is the equivalent of providing multiple perspectives from multiple observations. Hence, time series data analysis technology can more objectively determine the area of noise and accurately detect true variance - vessels.

In terms of variance detection work, Reed and Yu [7] proposed calculating the constant false alarm rate (CFAR) to detect abnormal areas in multispectral optical images. Their basic assumption is that background interference of most optical images can be described using a Gaussian stochastic model with a rapidly changing average that changes with location plus a slowly changing covariance. Anything that matches this model is background interference, anything that does not match is an abnormal area and a potential target. They used multispectral optical images from Landsat to build the database needed for simulations and conducted tests. The method was later applied in the detection of variance in hyperspectral images [8][9][10]. Reed and Yu [7] also recommended expanding CFAR

applications to radar target detection. SNAP software is an automatic vessel detection product based on a dual parameter CFAR model. The entire processing process includes land sea mask, calibration, and the method proposed by Crisp [11], which consists of two steps - adaptive thresholding and object discrimination. ICEYE established a machine learning convolutional neural network (CNN) framework, which is able to identify important features of vessels and classify different types of vessels after sufficient training and verification [12]. It further expanded to visible ship wake detection on this basis to determine the course and speed of vessels [13].

National Academy of Marine Research Satellite and Marine Database Services

The Ocean Affairs Council, Executive Yuan oversees ocean affairs, and established the National Academy of Marine Research to handle information collection for ocean research and development and promote results and technologies. The National Academy of Marine Research began systematically collecting, building, and processing satellite images of Taiwan's surrounding sea areas in 2021, and provides a variety of value-added services and products, including approximately 620 Level-1 GRD images from radar satellite Sentinel-1 between 2014 and 2021, as well as products of ocean surface vessel distribution. Using the image photographed at around 10:00 A.M. on June 4, 2020 Taiwan time as an example, the spatial resolution of the GRD product taken by radar satellite Sentinel-1 in IW mode was 10 meters, and the size of objects that can be detected is approximately 30 meters. Products of vessel distribution on the ocean surface include the coordinates of the center of each target, as well as the length and width of the target. The product of ocean surface vessel distribution overlapped with images from radar satellite Sentinel-1 on the same day, and results are displayed on the National Ocean Satellite Image Service (NOSIS) platform (https://nosis.geonet.tw).

Radar satellite Sentinel-1 can photograph one image of Taiwan every 2-4 days (including raising and lowering altitude). After the National Academy of Marine Research obtains the data, it will use SNAP software to produce a product of vessel distribution on the ocean surface, and publish it on NOSIS. The product can be used to identify dark vessels and combat IUU fishing when combined with AIS data provided on the website Marine Traffic (https://www.marinetraffic.com/). The location of vessels according to AIS data can retrieved from the website Marine Traffic (https://www.marinetraffic.com/) when Sentinel-1 was photographing an image of Taiwan on June 4, 2020.

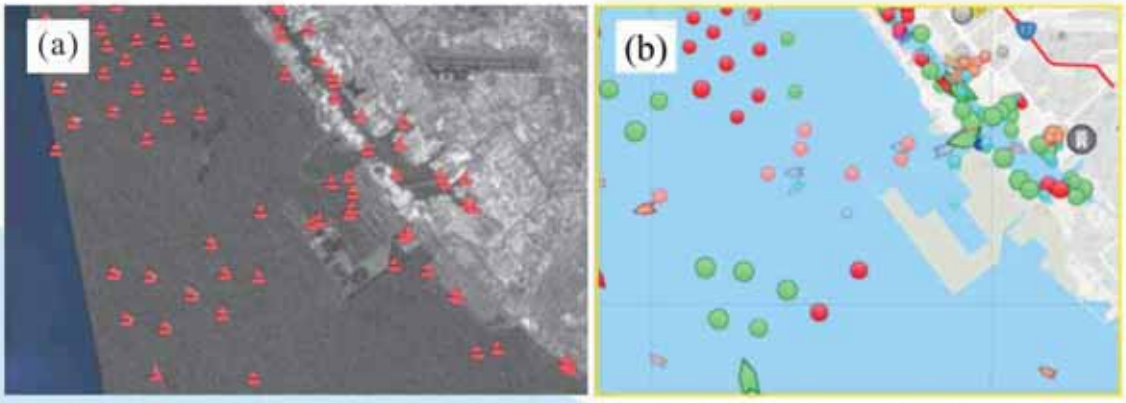

Figure 1/ (a) Image of Kaohsiung City Xiaogang Distrct photographed by Sentinel-1 at around 10:00 A.M. Taiwan time on June 4, 2020, (b) Vessel location according to AIS data retrieved from the website Marine Traffic
Source/ (a) https://nosis.geonet.tw; (b) https://www.marinetraffic.com/

Kaohsiung City Xiaogang District is enlarged and displayed in Figure 1 for more thorough comparison. Vessels on the ocean surface displayed in the radar image shown in Figure 1(a) is similar to the distribution of bright red or green dots in the AIS data displayed in Figure 1(b). This shows the accuracy of vessel distribution on the ocean surface in images from Sentinel-1. Furthermore, the lighter red and green dots in Figure 1(b) are the last location of vessels according to AIS data, and the vessels may have

turned off their AIS and left the location. These are dark vessels that were rapidly identified and marked, and whether or not the vessels are engaging in IUU fishing can be determined based on the data.

Conclusions

The prevention of IUU fishing is an important project launched by the Food and Agriculture Organization of the United Nations that has gained the support of many countries (including Taiwan) around the world. Satellite remote sensing has the advantages of long-term, large area, stable cycle, and almost real-time monitoring. Radar satellites have the advantage of acquiring images in any weather at any time of the day regardless of clouds, which can be used to monitor IUU fishing at key times and locations. However, typical research institutes can rarely afford long-term time series data from observations of the same location. As a result, we are currently in an awkward phase where the technology is feasible but not practical. The Copernicus initiative, which has fully supported the open data policy in recent years, provides a large number of high quality remote sensing images photographed during sentinel satellite missions to all sectors free of charge. The radar satellite constellation of ICEYE, a spin-off of Finland's Alto University, has also successfully begun commercial operation, and provides many high quality products. Hence, there has been explosive growth in sources of radar satellite images. Technology to rapidly, accurately, and automatically detect vessels on radar images is already mature, and dark vessels can be rapidly identified and marked by comparing the vessels with AIS location information, so as to further determine if they are engaging in IUU fishing.

The National Academy of Marine Research began systematically collecting, building, and processing satellite images of Taiwan's surrounding sea areas in 2021, and provides a variety of value-added services and products, including approximately 620 Level-1 GRD images from radar satellite Sentinel-1 between 2014 and 2021, as well as products of ocean surface vessel distribution. These are published on the NOSIS. When combined with AIS data provided by the website Marine Traffic, the product can also be used to identify dark vessels, and further determine if the vessels are engaging in IUU fishing. Even though it is free to download images photographed by Sentinel-1 from Sentinel Hub, there is a 1-2 day time gap. Real-time information and services are not available. However, using the service model and capabilities obtained through the work and then purchasing the commercial image services from the radar satellite constellation of ICEYE will reduce this time gap. Experience accumulated from the work can be used to establish Taiwan's own low-orbit micro-satellite constellation in the future.

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Introduction to Canada's Oceans Act

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Canada passed the Oceans Act in 1997. The Act is the first maritime law in the world committed to protecting marine ecosystems at its core. It is also regarded as a model for other nations and regions.

Background and Development

Different from most maritime nations, Canada's maritime related laws were scattered across the regulations for transportation, fishery, naval defense, and ecological conservation. The nation lacked a comprehensive act specifically for maritime related regulations. Canada passed its first maritime law in 1997—the Oceans Act S.C. 1996, c. 31. According to the Act's first Article, it may be cited as the Oceans Act. The Oceans Act is said to be the first flagship maritime protection law. It is also the first maritime law in the world with the protection of marine ecosystems at its core. Canada's Oceans Act has been regarded as a pioneering law by the international community, hence, other nations have paid close attention to its practical experience and success in managing territorial waters [1].

Before Canada completed the legislation of the Oceans Act, the nation implemented many decisive measures to defend its territorial waters and marine resources. In 1977, when Canada wanted to solve long-term overfishing issues by European countries on the Grand Banks, which are the waters overlaying with the North American continental shelf in the southeast of Newfoundland, under the leadership of the Fisheries Minister at the time, Mr. Roméo LeBlanc, Canada extended its fisheries jurisdiction to 200 nautical miles [2]. This is the most iconic example of the many decisive measures the Canadian government took. The declaration of the exclusive rights of 200 nautical miles of marine resources later became what we know as an Exclusive Economic Zone, included by the United Nations Convention on the Law of the Sea (UNCLOS) in 1982.

As for the intention of using legislation as the necessary basis for oceans management, this can be traced back to the first Oceans Strategy proposed by Canada in 1987. In addition to the four policy goals of the Oceans Strategy (coastline economic development and marine industry promotion, oceanography, management and protection of marine resources and environment, sovereignty), Canada also needed to establish a new oceans management basis through legislation [2]. After the Oceans Strategy was proposed in 1987, it took 10 years, since the process had stagnated for some time, to complete the legislation of the Oceans Act [3]. Despite that, the Advisory Council on Science and Technology of Canada, which directly reported to the Prime Minister, released a research report called "Opportunities from our Oceans" in 1994. That same year, Brian Tobin, the Minister of Fisheries and Oceans Canada (DFO), also released "A Vision for Oceans Management." Both of these important policies became crucial for the foundation and enactment of the Oceans Act [2][4].

Canada's Oceans Act came into effect in January, 1997. Its main elements include: In reference to regulations on delimitation of maritime boundaries from the UNCLOS, the maritime zones of Canada were extended to include the exclusive economic zones, contiguous zones, and territorial waters through legislation. (Compared to Canada, Taiwan's Law on the Exclusive Economic Zone and the Continental Shelf of the Republic of China was announced on January 21, 1998.) The Canadian Coast Guard, which used to be under the leadership of the Transport Canada (TC), was transferred to the DFO.

Canada also built a comprehensive oceans management strategy to fulfill its obligations of international oceans management as stipulated in the UNCLOS. At the same time, it also allowed subsequent planning of international environmental policy activities to gain more momentum.

All in all, Canada's Oceans Act, enacted in 1997, is regarded as a model for other nations and regions. Especially in terms of tackling three contemporary oceans management challenges: incorporate the principles and methods of Sustainable Development, intend to solve the fragmentation of marine management, and manage the oceans in a more integrated and ecosystem-centered manner [5].

Overview of the Oceans Act

I. Basic Structure

Regulations in the Oceans Act are mainly divided into three parts. As mentioned above, the first part is to regulate Canada's jurisdiction in territorial waters through legislation. In addition, the Act is consistent with the provisions of the UNCLOS. It defines Canada's territorial waters, contiguous zones, exclusive economic zones, and continental shelf. It also states the Canadian government's compromise to protect and manage these waters.

The second part of the Oceans Act is related to specific policies and plans that the Minister of DFO is in charge of. For instance, Canada's Maritime Strategy according to Article 29, as well as three specific regulations regarding planning tools: I. Marine Protected Areas (MPAs); II. Quality of the marine environment; III. Comprehensive management plan. These plans are critical tools to implement national maritime strategy goals. They help Canada understand and protect marine environments, support sustainable economic opportunities, and be an international leader in oceans management.

The third part states the duties of the Oceans Act. According to Article 2, the Minister of DFO is the main federal institution responsible for oceans management within Canada. This section also includes resource management, science, hydrology, Coast Guard team, and other responsibilities into the scope of oceans management.

II. Strategies and Action Plans

As mentioned before, Canada's Oceans Act was enacted and came into effect in 1997. The current Act is the latest version since the amendment in May, 2019, but its main structure is still based on the Oceans Act of 1997.

The preamble of Canada's Oceans Act clearly interprets the Canadian federal government's intention to become a world leader in oceans and marine resource management. The preamble also states that the Act will be based on the three fundamental principles of sustainable development, precautionary methods, and integrated management (Article 29 and 30).

The prominent results of the Act are: oceans strategy, integrated management plans, and national network of MPAs. First, according to Article 29 of the Oceans Act, one of the important roles of the Minister of DFO is to facilitate the new integrated management plans in collaboration with federal government agencies, government institutions at all levels, aboriginal organizations and affected coastal communities, among other interested parties to collectively form an oceans strategy in accordance with the principles of Article 30.

In regards to integrated oceans management, the evaluation scope must include estuarine, coastal and marine waters. In addition, all activities or measures in or affecting estuaries, coastal waters and marine

waters are also included (Article 31). As for the network of national MPAs, it is mainly the responsibility of other federal government agencies (e.g., the Parks Canada Agency and Environment and Climate Change Canada) to set up MPAs, according to law. Hence, the Oceans Act authorizes the Minister of DFO "to coordinate and provide related assistance for the purposes of planning and implementing MPAs on behalf of the federal government" (Section 1, Article 35). In addition to coordinating with different agencies, the Oceans Act also gives powers to the Minister of DFO to establish new MPAs (Section 1, Article 35).

Five years after the Oceans Act came into effect, Canada's Oceans Strategy (COS) was finally enacted in 2002, which provided a policy framework for Canada's ocean management [6]. And under the sustainable principle of the Oceans Act, COS is used to bring forth development, integrated management, and precautionary approaches. Furthermore, Canada launched the Canada's Oceans Action Plan (OAP) in 2005, which was organized with four mutually related pillars: international leadership, sovereignty and security, comprehensive ocean management that promotes sustainable development, and health of the oceans and oceanography technology. The OAP warrants that a series of actions will be completed in two years to implement the Oceans Act and oceans strategy. This includes a series of measures and relevant funding sources [3].

III. Coordinating and Integrating the Functions of Government Agencies

One of the highly acclaimed regulations of the Oceans Act is that the Minister of DFO shall coordinate and integrate with government agencies, as stated in Subsection (b), Section 1, Article 32: "For the purpose of the implementation of integrated management plans, the Minister (of DFO) (b) shall coordinate with other ministers, boards and agencies of the Government of Canada the implementation of policies and programs of the Government with respect to all activities or measures in or affecting coastal waters and marine waters." Through coordination between the Minister of DFO and other ministers, boards and agencies of the Government of Canada, the goal is to create a more consistent mechanism for oceans management in Canada.

In addition, on one hand, existing maritime affairs are spread across different agencies within the federal government. On the other hand, maritime affairs are always changing and developing. Hence, the Oceans Act gives the DFO the power to implement integrated management. When there are maritime affairs not assigned to any other department or agency of the federal government, the DFO shall hold power and duties over the matter (Article 40). Furthermore, the DFO shall propose strategies that "promote necessary development activities to enhance understanding, management, and sustainable development of the oceans and maritime resources" (Section 2, Article 32).

Despite all of this, some critics are skeptical of the implementation results and think that although the Oceans Act is dedicated to integrate oceans management plans, when it comes to relevant affairs, implementation plans still follow existing departmental laws and regulations. "There are no visible changes made to the fact that oceans and coastline management is still divided among different government agencies and regulations are still fragmented..." [7]. According to analysis by scholars, the main reason is that all agencies are very cautious about retaining their duties and power, not only departments within the federal government, but also federal and state government agencies. Moreover, the Oceans Act is based on collaborations between different maritime agencies, but each agency has their own legislation, missions, resources and prioritized policies. Without adequate incentives, it can be difficult to promote collaboration across different agencies. Therefore, although the Oceans Act aims to promote collaboration and dialog between different maritime agencies through regulations, as well as giving the DFO the powers and duties to coordinate policies across government agencies, without

adequate incentives and under the current governing framework, the outcome of the legislation has fallen short of its ideal goals [3][8]. In light of this, we know that coordination and integration between various government agencies cannot be achieved just by legislation alone.

Prospects of New Amendments to the Oceans Act— Concluding Remarks

In May 2019, the federal government of Canada passed draft amendments to the Oceans Act. The amendments are summarized as follows: I. Speed up the designation process of MPAs, as well as enhance their efficiency; II. Add the legal definition of "ecological integrity"; III. Clarify the application of the precautionary approach, upholding that even without scientific certainty of the risks related to marine activities, precautionary measures should still be implemented.

Furthermore, to enhance protection of non-biological resources in oceans, the Canadian House of Commons passed amendments to the Petroleum Resources Act as a supplementary regulation to the Oceans Act. The amendments authorize Natural Resources Canada, Crown-Indigenous Relations, and Northern Affairs Canada to ask rights-holders and rights groups to voluntarily give up their rights to petroleum and natural gas through negotiations. If the mentioned rights are to be abolished due to the designation of MPAs, reasonable compensations should be given.

In regards to MPAs, the new amendments authorize the federal government to temporarily delimitate important natural areas to swiftly implement conservation measures. These amendments shall help ensure that rare species and important habitats can be protected by law before being officially designated as MPAs. It also ensures the safety of the species and habitats during the long negotiations before being officially listed as MPAs. This emergency protection usually lasts for five years, and aims to provide sufficient time for agencies to negotiate with each state, region, rights-holders, aboriginal communities, and the public to reach a win-win consensus.

Before the amendments were announced, MPAs, as designated by Canada, already account for 8.27% of Canada's territorial waters. Through these amendments, the federal government of Canada aims to designate 10% of its territorial waters as MPAs in 2020, which will serve as a testament to the country's commitment to the world. In June 2021, Canada further committed to expanding MPAs to 25% of its territorial waters by 2025, and expects to expand MPAs to 30% of its territorial waters by 2030 [9].

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