國際海洋資訊
International Ocean Information

9
December 2020
雙月刊 | Bimonthly

「2020臺灣海洋國際論壇」報導
A Report on the Taiwan International Ocean Forum 2020

新加坡海洋資訊
Singapore Ocean Information

海洋委員會 Ocean Affairs Council 發行

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Creating Key Competitiveness Through Ocean Sustainability

Translated by Linguitronics

Minister of the Ocean Affairs Council: Chung-Wei Lee

Embraced by the sea on all sides, Taiwan's surrounding oceans feature high marine biodiversity and offer access to rich fishing grounds and abundant marine energy. The key to Taiwan's marine management therefore lies in using marine resources sustainably. The Ocean Affairs Council held the "Taiwan International Ocean Forum 2020" on November 5 to discuss the development direction of marine debris processing technology, ocean energy, and marine scientific research. In this issue of "Special Report", we will in particular introduce discussion highlights from the forum to our readers. "Latest News", contributed by the staff from the Marine Ecology and Conservation Research Center of the National Academy of Marine Research, offers insight into using "artificial algae forest" to rehabilitate marine habitats and achieve the goal of sustainable fishery resources. Furthermore, this year, as we experience the least rainfall in four decades, all of us here in Taiwan are even better aware of the importance of water resources. In light of this predicament, "Industry Dynamics" introduces how Singapore, the theme country of this issue, utilizes seawater desalination to ensure an increased and stable water supply. Its diversified water resource planning "Four National Taps" is worthy of our reference.

Singapore, located at the intersection of the straits of Malacca and Singapore, is not only the world's third largest oil refining center, international shipping center, international trade center and regional tourism center, but also a necessary midway point on the trade route between major trading countries such as China, Japan, and Republic of Korea and the Middle East and European Union. Due to its unique geographical location, it is even more important for Singapore to fine-tune and monitor its cooperation and coordination with other countries in all aspects of maritime affairs. This issue introduces how Singapore formulates demarcation regulations in accordance with international law and conducts maritime negotiations with neighboring countries such as Malaysia and Indonesia. In particular, the "International Issues" column focuses on the Maritime Domain Awareness (MDA) system in Southeast Asia, and introduces the Southeast Asian MDA system consisting of three maritime information centers engaging in the reporting, sharing, and fusion of information, and explains how the system operates successfully and efficiently, creating a paradigm that may serve as a reference for Taiwan's future establishment of related mechanisms.

Singapore Marina Bay
Image by akenarinc from Pixabay
https://pixabay.com/photos/marina-bay-singapore-ao-city-1435072/

Understanding the Ocean, Becoming Great Because of the Ocean – A Report on the Taiwan International Ocean Forum 2020

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Keywords: Marine Waste, Marine Energy, Marine Scientific Research

The Ocean Affairs Council (OAC) held the 2020 Taiwan International Ocean Forum on November 5, 2020, and planned two panels, "Ocean Energy Research and Innovative Development" and "Reducing Marine Debris by Marine Science." The OAC hopes to contribute to scientific research and marine environmental sustainability and allow Taiwan to accord with international trends through knowledge and experience sharing.

Group photo of honored guests at the 2020 Taiwan International Ocean Forum
Image by Ocean Affairs Council

The OAC held the 2020 Taiwan International Ocean Forum at the Ambassador Hotel Kaohsiung on November 5, 2020, and Deputy Minister Ching-Piao Tsai of the OAC gave a speech during the opening ceremony. After the United Nations (UN) announced the goal of "innovation for a sustainable ocean" in 2020, the decade starting from 2021 will be the "UN decade of ocean science for sustainable development." The two panels of the forum this year are "Ocean Energy Research and Innovative Development" and "Reducing Marine Debris by Marine Science." The OAC hopes to establish the future vision for an ocean nation through the participation of industry, government, academia, and research institutes in publication and discussion, and bring Taiwan into accord with international trends.

Due to the impact of COVID-19, the forum this year featured virtual-real integration, and invited foreign scholars to pre-record videos or show their findings via video conferencing. AIT Kaohsiung, Australian Office Taipei, British Office Taipei, Japan-Taiwan Exchange Association Kaohsiung Office,

and National Taiwan Ocean University provided assistance and support to the event. Besides sharing knowledge and experience, the event also declared to international society Taiwan's determination to participate in international ocean affairs.

Opening ceremony and keynote speech

After the opening ceremony, Jonathan D Lindsay, Operations and Technology Director of the European Marine Energy Centre (EMEC), gave the first keynote speech on "Ocean Energy Research and Innovative Development in Europe" in a pre-recorded video. Lindsay first shared developments in marine energy in the UK and indicated that global warming is not only an unprecedented topic of concern, but also a priority of European countries in policy making. According to estimates, the installed capacity of marine energy devices in Europe can reach 100 GW, accounting for 10% of Europe's total power generation. Many European countries have already established marine energy testing centers, and planned numerous national-level testing projects. So far EUR165 million has been invested in 44 R&D projects, of which 19 are ongoing. In the future, marine energy needs to be combined with government subsidies, bank financing, and insurance to lower the financial costs and increase the possibility of commercialization.

Jenna Jambeck, Professor at the University of Georgia gave a speech on "Plastic Marine Debris from Sea to Source." Jambeck and 13 women joined the cross-Atlantic eXXpedition voyage in 2014, and began a survey of the Ganges River in 2019, researching plastic waste discharge before and after the rainy season. She worked with members in five countries that the Ganges River flows through, and successfully gathered water and air samples. Jambeck believes that working together with local communities puts things in context, while UAV tracking and AI recognition technologies improve recognition of plastic. Jambeck hopes to gain greater influence in the future and continue to take action to prevent more waste from flowing into the ocean.

Panel 1: Reducing Marine Debris by Marine Science

Hsin-Chen Sung, Deputy Director-General of the Ocean Conservation Administration, was the first speaker, who introduced "The Opportunities and Challenges for Marine Debris Governance Using Oceanic Scientific Approach." Marine debris disposal is already an important topic of concern worldwide. Taiwan uses remote sensing technology and AI to expand monitoring and obtain real-time information, bringing together local governments and fishermen's associations to clean marine debris from the source, which is then used to produce fuel oil through pyrolysis. In the future, the Ocean Conservation Administration will also plan platforms and design a certification mechanism and QR code for tracing product footprints, in order to help citizens better understand products made from marine debris. Chi-Farn Chen, Professor at National Central University, was the second speaker, who introduced "Studies on Marine Debris Identification Using UAV Image with Artificial Intelligence." Having studied the application of AI technology in marine debris monitoring and identification, he is currently capable of recognizing images with a ground resolution better than 5 cm; the marine debris is divided into PET bottles, Styrofoam, and fishing float ball. Professor Chen explained that he hopes to combine the current AI model with an app, and encourage public participation to increase training data. An open data platform can be established in the future and shared with the government and NGOs to increase the model's recognition accuracy.

Atsuhiko Isobe, Professor of Kyushu University, was the third speaker, who introduced "Recent Advances in Ocean Microplastic Research in Japan." Japan dispatched 2 vessels to conduct an on-site survey of the concentration of microplastic (smaller than 5 mm) and medium plastic (larger than 5 mm) in middle and upper layers of the sea area around Japan. The total amount of microplastic found within

the research area was 1.72 million pieces/km2, 16 times the amount in the North Pacific. Another on-site survey was conducted in the Southern Ocean in 2016. Based on numerical model and cross-ocean survey results, the research team estimates that mass concentration in the upper layer of the western and central parts of the North Pacific will reach 103 mg/m3, and the microplastics will become a potential hazard to marine organisms in this region. Chelsea M. Rochman, Professor of Ecology at University of Toronto, was the fourth speaker, who shared "Think Global, Act Local: Local Knowledge is Critical to Inform Positive Change When It Comes to Microplastics." Her research team visited four river and lake basins in the US and Canada, and found that microplastics flowed into the basins through urban wastewater, agriculture runoff, and storm runoff; installing filters in washing machines, building bioretention cells or rain gardens for stormwater drainage systems, and setting up seabins or recovery wheels at branch streams can effectively filter microplastics and reduce discharge. Rochman believes that collaboration among the world, nations, and regions, as well as solutions adapted to local conditions, are all indispensable.

During the afternoon session, Ingrid Giskes, Director of Global Ghost Gear Initiative (GGGI), was the fifth speaker, who defined “ghost gear” as lost or abandoned fishing gear, which accounts for 46-70% of large debris. A small amount of the fishing gear was abandoned due to illegal fishing, but most were accidentally lost. Giskes shared the example of Indonesia promoting labels for fishing gear and tracking debris hotspots in Vanado and Canada using a low cost method. She said that GGGI launched a global ghost gear information platform and multilingual app, and published a best practices framework in 2017, in hopes of facilitating international cooperation. Chia-Ying Jessie Ko, Associate Professor of National Taiwan University, was the sixth speaker, who introduced "Global Distribution and Cleanup Opportunities for Marco Ocean Litter." Her research team conducted a global analysis and believed that "wind" was very important to the regional redistribution of marine debris, particularly at the equator and north pole. As a result of cross-ocean debris transport due to the effect of wind resistance, marine debris may gather in polar regions. Hence, projects for information exchange and cooperation between countries helps the public to understand and take action. Achieving multi-faceted response in science, policy, and practice is the only way to ensure that the marine environment is protected.

Ellen Ramirez, Deputy Chief at the National Oceanic and Atmospheric Administration (NOAA), USA, was the seventh speaker, who introduced "Strengthening the Marine Debris Monitoring Capacity." Ramirez explained that the Satellite Analysis Branch makes climate predictions and collects and analyzes information on ocean microplastics, using light wave analysis to generate different wavelengths, using multi-spectral, monochromatic, and panchromatic analysis to find gathering points of marine debris, and importing data into the spectral database. However, remote sensing and satellite technologies have a limited scanning range. The combination of visual inspection and spectral inspection can be considered to distinguish between plastic and other components. Kuo-Tung Chang, Associate Professor of National Kaohsiung University of Science and Technology, was the eighth speaker, who introduced "Development of Marine Debris Drifting Simulation Technology and Its Dynamic

Discussion among scholars from various nations over video conferencing during the Taiwan International Ocean Forum 2020
Image by Ocean Affairs Council

Map Based on Wind and Ocean Currents Information." Associate Professor Chang explained that wind and ocean currents cause marine debris to drift, and his team used the Lagrangian formulation and ocean simulation technology to calculate the drifting of marine debris at different times. Simulation results can be used when considering response measures, and will draw public attention.

Panel 2: Ocean Energy Research and Innovative Development

Cameron Johnstone, Executive Director at the University of Strathclyde, was the first speaker during the morning session, who introduced "How Much Can Tidal Energy Learn from the Wind Energy Sector in Reducing Costs through Physical Scaling Up on Size." Electricity generation of wind turbines can be increased from 100 kW to 7,000 kW by increasing the diameter of the rotor, but there are no spatial limitations on the diameter of wind turbines, while tidal turbines need to withstand the density of seawater, which is 860 times higher than that of air. At present, the maximum diameter is 27 m, so installed capacity can only be increased to 2,000 kW (33%-50% higher than current demonstration turbines). Johnstone discussed how to develop less complex turbines with the optimal size. Jiahn-Horng Chen, Vice President of National Academy of Marine Research, Taiwan, was the second speaker, who introduced "The Opportunities and Challenges to the Development of Ocean Energy in Taiwan." Taiwan has an abundance of ocean energy potential, but aside from current technology bottlenecks, the impact of typhoons and earthquakes in Taiwan on ocean energy should not be overlooked. Vice President Chen explained that the OAC has subsidized the independent development of two ocean current energy generators and is currently preparing for tests in the ocean. With regard to thermal energy, eastern Taiwan is one of the best places in the world for developing thermal energy. The Industrial Technology Research Institute has developed a 5 kW thermal energy electricity generation system. As for wave energy, the high density of wave energy in some parts of Taiwan has attracted the interest of a number of companies.

Yi-Hsiang Yu, Senior Research Scientist of National Renewable Energy Laboratory, USA was the third speaker, who shared "Ocean Energy - Recent Development and Future Perspective of Wave Energy Technologies." Research institutes and developers in ocean nations such as Ireland, Denmark, Portugal, Sweden, the UK, and the US have already proposed many wave energy designs and tests. However, the design of a successful wave energy converter must take into consideration the device's power output, installation and maintenance costs, and environmental impact in order to be cost effective. Ken Takagi, Professor at the University of Tokyo, was the fourth speaker, who shared the "Recent Development and Future Perspective of Ocean Current Turbines." The Kuroshio Current flows past both Taiwan and Japan and has potential ocean current energy. Professor Takagi introduced the full scale floating dual turbine system developed by the Ocean Energy Technology Development Project of Japan's New Energy and Industrial Technology Development Organization (NEDO), which further developed the 100 kW “Kairyu” (Sea Dragon) ocean current turbine system. The system successfully generated 100 kW of electricity in the towing test. At present, NEDO has entered the "Ocean Energy Electricity Generation Long-term Demonstration Project" phase, and actual application is expected to begin after 2030, allowing ocean current electricity generation to be applied in remote islands of Japan.

During the afternoon session, Markus Mueller, Professor at the University of Edinburgh, was the fifth speaker, who shared "A Study on Ocean Energy Power Transmission and Conversion." He introduced power conversion options and direct drive system, as well as developments in C-GEN technology. Chih-Wei Yen, Division Director of the ITRI, was the sixth speaker, who shared "Anti-typhoon Procedure and Technology of Marine Energy Systems." Ocean current energy equipment mainly withstands waves, ocean current, and wind at sea. July to September of each year is the typhoon season in Taiwan, and theextreme waves brought by typhoons are a threat to ocean current energy equipment. Division Director Yen analyzed the wave energy electricity generation system and found that its structure may be

damaged when the typhoon season arrives, facing issues of passing the dead points when moving up and down and the floating structure leaking and sinking. Hence, proposing a feasible strategy for resisting typhoons is the only way for Taiwan to develop a commercialized ocean current energy system.

Andrea Copping, Senior Program Manager of Pacific Northwest National Laboratory, USA, was the seventh speaker, who introduced "Environmental Impact Assessment and Economic Evaluation of Ocean Energy Development." Copping ascertained the potential environmental impact of ocean energy, including sea animals colliding with tidal turbines, noise from ocean current energy equipment disturbing sea animals, and impact from electromagnetic fields surrounding power cables, through the Ocean Energy Systems Collaboration Project. Information on most impacts could be obtained from the oil drilling and offshore wind power industries, while a small portion required on-site surveys. However, the cost of related industries is still relatively high, and it is currently more likely to generate electricity in rural areas, offshore farming, or ocean exploration. Lastly, Mark Hemer, Principal Research Scientist of Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, introduced "Potential Pathways for a Promising Offshore Renewable Energy Sector." Australia has an abundance of easily accessible offshore renewable energy, which has not yet become the mainstream in Australia. However, Australia recently established the Blue Economy Co-operative Research Centre (CRC) to implement the "Offshore Renewable Energy System Project." Hemer believes that offshore renewable energy can contribute to Australia's carbon reduction goal, and briefly described the industry's development potential and challenges of related departments in the report.

Conclusion

Deputy Minister Ching-Piao Tsai of the OAC gave a speech during the closing ceremony of the forum this year, and thanked the honorable guests and experts from various countries for their support, as well as their contribution to scientific research and marine environmental sustainability. Marine debris has become an international issue and challenge, and even more of the correct measures must be immediately taken to make the ocean safer and cleaner. Tidal energy and wave energy are feasible alternatives for renewable energy in the future, but there are still many challenges that need to be overcome. Deputy Minister Tsai promised to use the professional knowledge and recommendations provided during the forum for direction when formulating policies to establish a development vision for an ocean nation with environmental sustainability. With the ending of the forum, action can begin. As described in the National Ocean Policy White Paper, let us no longer be limited by the ocean, and instead make Taiwan great because of the ocean!

Group photo at the 2020 Taiwan International Ocean Forum
Image by Ocean Affairs Council

Introduction to the Maritime Domain Awareness (MDA) System in Southeast Asian Countries

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Translated by Linguitronics
Keywords: Maritime domain awareness, information sharing, information fusion

The Maritime Domain Awareness (MDA) system in the Southeast Asian region is a very successful example of regional cooperation. This short article will introduce the approaches to realizing maritime information sharing among countries in the MDA system in Southeast Asia, and explain the possible policy implications for Taiwan's future establishment of the MDA system.

Introduction

Many of the maritime security issues that the global community of today is concerned about are non-traditional maritime security issues including terrorism, illegal fishing, maritime drug trafficking, and weapons proliferation, etc. After the 9/11 terrorist attacks, the United States began to advocate and establish a Maritime Domain Awareness (MDA) system globally in order to prevent the ocean from becoming a loophole for counter-terrorism. The U.S. government defines MDA as: An effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy, or environment of the United States [1]. As what the United States emphasizes is an effective understanding of the "global" maritime domain (according to the definition of MDA by the International Maritime Organization, emphasis is not placed on the "global" aspect), therefore, in addition to planning the establishment of MDA in the United States in 2004, the U.S. has also promoted the establishment of MDA cooperation systems in other regions. In fact, the concept of MDA was proposed by the US Coast Guard in as early as 1990. In the past, in order to ensure the safety and security of ship navigation, objective ocean conditions such as the ship's navigation environment were regarded as vital information that must be fully grasped. Today, however, MDA entails more than just information control for the purpose of ensuring navigation safety, but is to a larger extent necessary for identifying and preventing potential threats.

Among the regional MDA systems established under the influence of the United States, the MDA system in Southeast Asia can be said to be a very successful example of regional cooperation. For a single country to establish the MDA system, the most vital and most challenging aspect is the information sharing mechanism between agencies. If there is not a sufficient culture of trust and sharing between agencies, however good the hardware equipment of the MDA system may be, it will not be able to achieve the integration of maritime information and effectively carry out the preventive functions of non-traditional security. This shows that in order to establish an MDA system within a country, it is still necessary to overcome the difficulty of "not" sharing information, not to mention the establishment of such a system between different countries. Therefore, the successful practice of the MDA system in Southeast Asian countries is worthy of our reference, specifically the system of confidence-building and information cooperation among such countries.

Accordingly, this short article will focus on introducing the approaches to realizing the sharing of maritime information among countries in the MDA system in Southeast Asia, and explain the possible policy implications for Taiwan's future establishment of the MDA system.

Background and considerations of establishing the MDA system in Southeast Asia

As mentioned in the preface, the United States has promoted the establishment of MDA systems in other regions for counter-terrorism policy needs. In this context, the special geopolitical, economic and social factors in Southeast Asia have naturally driven the United States to promote the establishment of the MDA system in the region. In terms of global shipping volume, about 30% of shipping volume or 50% of shipping tonnage will pass through the Strait of Malacca in Southeast Asia [2]. Furthermore, on this important shipping route, the number of pirates has increased since the 1980s, which has forced Southeast Asian countries to cooperate in adopting a counter-piracy mechanism. In addition, this region is inherently rife with disputes over island sovereignty and maritime delimitation, hence countries must cooperate pragmatically to prevent maritime incidents that may affect the fragile shipping environment and economic development of this region.

Due to the aforementioned background factors, Southeast Asian countries are also to a considerable degree keen to cooperate in the establishment of the MDA system. However, MDA is not just a simple hardware device that becomes operational as soon as it is set up. It is instead a system that must rely on the collection of information on various potential threats or abnormal and suspicious ships and personnel. In addition to the collection of information, it is necessary to further identify the relevant interests or infrastructure in the sea areas that may be affected by abnormal conditions, and allow the corresponding countries to quickly determine which specific responses should be adopted. Therefore, the collection of such data and the establishment of a database often involve cooperation and coordination across agencies, countries, and public and private sectors (ocean or ocean-related industries), which is beyond what any single government agency can undertake. If the MDA is to target a larger maritime domain, the tasks entailed will be beyond what any single country can take on.

As evidenced above, when establishing an MDA cooperation system, Southeast Asian countries must overcome the issue of trust between countries in the presence of interconnected economic interests, limited national capabilities, and maritime disputes in certain areas in order to successfully enable a mechanism highly reliant on information flow, sharing, analysis and response to smoothly operate in this region.

MDA establishment in Southeast Asia

As aforementioned, to establish an MDA system, it is necessary to overcome the problems of trust and cooperation between countries so that MDA can effectively exert its preventive effects. In the development process of the MDA system in Southeast Asia, today's example of transnational MDA cooperation was also achieved through a process of conceptual changes and confidence building between countries. With regard to the overall MDA framework, there are three maritime information sharing centers in Southeast Asia. However, it should be noted that the concept of information under the MDA system also differs in degree based on the amount of artificial processing involved. In short, in the context of the MDA system, "information" can be divided into three types: the raw data of maritime anomalous events, information that is filtered through certain knowledge (such as big data computing models) of maritime anomalies, and information that is filtered and then fused and analyzed with other information. The three information sharing centers under the MDA system in Southeast Asia also reflect the division of labor for the above three types of information.

In terms of the types of information mentioned in the previous paragraph, the center that primarily processes information characterized as raw data is the Piracy Reporting Centre (PRC) established by the International Maritime Bureau (IMB) of the International Chamber of Commerce (ICC) in Kuala

Lumpur in 1991 [3], while the information center that primarily processes data filtered through certain knowledge is the Information Sharing Centre (ISC) established in Singapore in 2006 under the framework of the Regional Cooperation Agreement on Combating Piracy and Armed Robbery Against Ships in Asia (ReCAAP) [4]. As for information that is filtered then fused and analyzed with other data, the responsible site is the Information Fusion Centre (IFC) operated by the Singapore Navy established in 2009 [5]. Judging from the names of these three centers (reporting, sharing, fusion), we are able to identify their main functional differences and their respective roles in constituting the MDA system in Southeast Asia. The following is an introduction to the main operating modes of these three centers.

I. IMB Piracy Reporting Centre (PRC)

PRC is an information center established by the International Maritime Bureau under the International Chamber of Commerce in response to the first contemporary wave of pirates in the South China Sea and the Strait of Malacca in the 1980s. Since the International Chamber of Commerce is a non-governmental organization, PRC itself is also a non-governmental organization in terms of legal status, and has observer status in the International Maritime Organization. The main purpose of establishing PRC is to raise awareness of specific high piracy risk maritime domains, ports or anchorages in the shipping industry, and to convey relevant information to local law enforcement agencies to ensure that the captain can obtain assistance when necessary. Under this premise, subjects with whom PRC shares information include the International Maritime Organization, government or intergovernmental law enforcement agencies and the shipping industry.

Regarding the scope of piracy information covered by the PRC, it does not distinguish whether the information falls within the definition of piracy in Article 101 of the United Nations Convention on the Law of the Sea (that is, it does not distinguish between piracy and armed robbery at sea), nor does it distinguish whether such acts occurred in high seas. More importantly, the scope of geographic information covered by the piracy incidents reported by the PRC include piracy incidents in the global waters. Before 2007, PRC would publish a report on piracy incidents each year, supplemented by a quarterly report. Since 2007, real-time live reports and maps of piracy incidents (Figure 1) and a 24-hour maritime security hotline have been set up on the PRC website.

From the above brief description, we can see that the primary purpose of PRC is to inform and share information about various piracy incidents in real time, so that governments or the shipping industry can quickly respond. Therefore, in terms of the various non-traditional security prevention aspects that contemporary MDA focuses on, PRC plays a relatively minor role [6].

Figure 1/ The real-time pirate distribution map on the Piracy Reporting Centre website
Source/ https://www.icc-ccs.org/index.php/piracy-reporting-centre/live-piracy-map

II. ReCAAP Information Sharing Centre (ISC)

ISC itself is a formal international organization composed of 20 contracting states. Aside from the ISC established under the ReCAAP Agreement, ReCAAP is also fitted with a governing council responsible for directing the daily operations of the ISC and contacting national focal points. At present, in addition to the 20 contracting states, there are also 8 partner organizations. The funding source of this organization is mainly provided by the Singapore government, while other countries provide human resources. As for the main purpose of the establishment of ISC, the primary goal is to promote and strengthen the combat and prevention of piracy and armed robbery in Asia by various countries. Therefore, ISC distinguishes whether a specific event belongs to piracy under the Convention on the Law of the Sea or not.

Generally speaking, in order to achieve the above-mentioned organizational purpose, ISC's primary tasks can be divided into three parts: 1. Collection, verification and dissemination of information; 2. Data analysis and research; 3. Staff training, education and awareness raising. To achieve these three tasks, the ReCAAP Agreement has stipulated that each country must set up focal points, establish event databases, and utilize network-based information sharing software. ISC's information collection sources are mainly provided by the focal points in various countries, or provided by other units (such as the aforementioned PRC), and the International Maritime Organization, etc. (Diagram of the ReCAAP ISC's focal point notification procedure. Retrieved from https://www.recaap.org/piracy_definitions_and_actions). Once the information is collected by ISC, it will be further verified by the focal points in various countries, and then shared through the network of relevant organizations, and consolidated into monthly and annual reports. Because the ISC network has the ability to verify and analyze data, it will further divide individual incidents into four levels based on the degree of economic loss and violence (the first category encompasses incidents of the greatest severity; the fourth category encompasses incidents of the least severity).

Compared with the aforementioned PRC, ISC's information sharing is not completely conducted in real-time, and the goal of its information sharing is not to allow governments to quickly respond, therefore the function of ISC is limited. A scholar once mentioned that because ISC collects information from focal points in various countries, the nature of its operation is highly dependent on the intentions of various governments. However, the successful operation of ISC and the accumulation of mutual trust between countries culminated in favorable conditions for the further establishment of IFC in 2009 [6].

III. Information Fusion Centre (IFC)

The purpose of the IFC is to promote and collaborate in strengthening the sharing of maritime security information in Southeast Asia. The marine security information covered by this center includes not just information on pirate hotspots in Southeast Asia (South China Sea, Malacca), but also other issues such as weapon proliferation, marine terrorism, arms and drug smuggling, or fishing crimes. In addition, although it is a regional MDA in Southeast Asia, the scope of the center includes waters as far as southern Africa, the Indian Ocean, and part of the Western Pacific (IFC VCR Area: https://www.ifc.org.sg/ifc2web/app_pages/User/common/aboutvcr.cshtml#tab4). The legal basis for the operation of IFC is composed of a series of bilateral agreements or memorandums signed between the Singapore government and different countries as well as agreements signed with other centers.

At present, IFC has a total of 24 participating foreign countries, and IFC itself has signed agreements with 97 information centers. Participating countries send liaison officers to be stationed the center in Singapore to keep in constant touch with the 24-hour command office. As emphasized by IFC itself, the main factors for the success of IFC's information integration are the international liaison officer system and information technology. The liaison officer system not only serves to facilitate coordination between multilateral naval headquarters, but also ensures that real-time information is shared face-to-face on a daily basis when incidents occur. The information technology utilized by IFC is mainly based on the information of the Automatic Identification System and system for Long Range Identification and Tracking of Ships, while the Open and Analyzed Shipping Information System (OASIS), a software developed in collaboration with the Singapore government, identifies different marine security incidents. In addition to OASIS, IFC also has a system referred to as Sense-Making, Analysis and Research (SMART) that enables users to customize rules for connecting different "points" into a "surface" to construct a trend of potential threats to marine security.

As IFC has a liaison officer system that allows countries to gather in Singapore, even though some countries are distrustful of each other politically, substantial cooperation can be achieved with Singapore as the intermediary country [6]. In addition, due to Singapore's own talents and abilities, it has been able to develop a fairly advanced information system, and when a potential threat or marine security incident occurs, the marine security departments of the relevant countries can be contacted to take specific action based on the judgment of the information system. Therefore, trust between countries is a key factor for the success of IFC.

Conclusion

From the foregoing description, we can see that the success of the MDA system in Southeast Asia is to a certain degree enlightening for other countries or regions. In particular, if Taiwan intends to take part in relevant systems, the country itself must have the corresponding organizations and capabilities when establishing the MDA system. First of all, as information related to maritime security is scattered across different locations within a country, the MDA system must be formulated based on the concept of a network, whether domestically or transnationally. In other words, each country itself must have infrastructure and laws and regulations that can link all such information. Furthermore, after various information is linked to become a network, information hubs must also be established so that specific information can be stored in specific units. Lastly, the experience of establishing an MDA system in Southeast Asia also tells us that it may be necessary, from a cost perspective, to "with moderation" allow different MDA centers to cover information in overlapping areas.

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The Importance of Desalination in Singapore's Water Supply Strategy

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Keywords: desalination, national taps, emerging water sources, climate change, water resources, Singapore

With the rapid growth of the global population, traditional water resources development often encountered with problems such as good sites for dam hard-to-find and hydrological uncertainties due to climate change, resulting in development difficulties. Due to its short construction time and being non-weather dependent, desalination has become an important emerging water resource in all countries. At the end of the typhoon season in 2020, Taiwan has suffered a tough problem of low precipitation since no typhoon have entered. Major reservoirs such as Feitsui Reservoir, Shimen Reservoir, and Zengwen Reservoir have not even reached half of their designed storage capacity. The way Singapore uses seawater desalination technology to enrich water supply and meet the domestic and industrial water demand is indeed an important reference for Taiwan's water resources development policy.

Figure 1/ Singapore opened Marine East Desalination Plant in 2020 (the plant is under its rooftop park)
Image by Keppel Infrastructure

Traditional water resources often encountered with various problems such as hydrological uncertainty, rapid population growth, rapid increase in domestic and industrial water demand, insufficient drought resistance of water storage facilities, and reduced water supply due to water quality degradation. With the rapid increase in water demand, countries around the world have searched for emerging water resources. Seawater desalination has the advantages of short construction time, flexibility of expansion in capacity, and providing stable and clean water that it has become an important emerging water resource in various countries. Singapore is an island state surrounded by the sea. Due to its small land area and limited water resources in the local catchment, it has long been extremely dependent on the imported water from Malaysia. Since the water supply from utilizing desalination technology is stable, it is also not affected by uncertain hydrological conditions such as drought, and uneven precipitation distribution. Hence, using desalination to increase water supply has the advantage of inexhaustible seawater.

Early History of Water Resources Development in Singapore

During the British colonial period in Singapore, the British built the MacRitchie Reservoir in 1866 to provide water resources. In 1927, Singapore signed a water purchase agreement with the neighboring Johor of the Unfederated Malay States. It allowed Singapore to rent land and use water in Johor, and then import raw water and use it after filtration treatment. After the Japanese invasion of Malaya in 1942, the Battle of Singapore broke out. When the British troops retreated, they blew up the Johor-Singapore Causeway and destroyed the water pipeline to Singapore, making Singapore's reserved water only last for two weeks [1]. After the World War II, Singapore's population grew rapidly and demanded more water for urban development. The water resources imported from Malaysia became more important. After Singapore became an independent state in 1965, its water resources have long relied on imported water from Malaysia. If Singapore's foreign policy conflicts with Malaysia's interests, Malaysia can threat to cut off Johor's water supply, which has prompted strong motivation for Singapore to further develop its own water resources. Singapore established PUB, Singapore's National Water Agency, as a result. While importing water from Malaysia, it is also actively carrying out more water resources development plans in its own territory [2]. Due to the abundant precipitation in Singapore, about 2,200 mm per year, PUB built dams at the estuary to contain the freshwater in the early days, and built 17 reservoirs to store rainwater.

Four National Taps

In order to meet the water demand, Singapore has successively developed diversified and sustainable water resources. These water resources are called "Four National Taps", including [3][4]:

- Water resource from local catchment
- Malaysia imported water
- High-grade reclaimed water (NEWater)
- Desalination water

In the early days, Singapore had only the first two taps. Due to the small land area, water sources developed from the local catchment were limited as well. In 1962, a 100-year water purchase agreement was signed with Malaysia, stating that one million tons of water can be purchased from Malaysia every day. Since the contract will expire in 2061, the imported water is not a long-term solution for Singapore's water demand. Since the Singapore government hopes that water resources can be self-sufficient, it started a NEWater Study in 1998 to investigate if the treated reclaimed water can meet drinking water standards. In 2002, Singapore opened its first NEWater plant, and its water quality exceeded the World Health Organization (WHO) drinking water standards, thus signifying the

commencement of the third tap. After two years of monitoring to ensure the safety of water quality, a marketing campaign to open a NEWater Visitor Centre was also carried out. In 2005, Singapore's first desalination plant started to operate, marking the official opening of the fourth tap.

Singapore currently uses about 430 million gallons of water per day. According to PUB's prediction, total water demand is expected to almost double by 2060 [4], primarily due to demand from non-residential use. Through integrated water resource management, the Four National Taps overcome Singapore's long-term problem of lacking natural water resources and meet the water demand. In addition, with the active support of the government, Singapore has become a global hub of water research and technology.

Figure 2/ NEWater Vistor Centre
Image by Shaun Wong from Filckr (CC BY-NC-ND 2.0)
https://www.flickr.com/photos/shaunwong/2439666209/

Figure 3/ NEWater
Image by Tristan Schmurr from Filckr
(CC BY 2.0)
https://www.flickr.com/photos/kewl/6903183981/

Development of Seawater Desalination

As early as the 1970s, PUB began to conduct feasibility studies using seawater desalination technology to provide alternative water resources. However, due to the high cost of seawater desalination technology at that time, the research was not commercialized. Until the end of the 1990s, the continuous improvement of seawater desalination technology, especially the gradual popularization of reverse osmosis (RO) technology, greatly reduced production costs. It laid the foundation for the successful development of desalination plants in Singapore in the 2000s. The current commercial desalination plants in Singapore are shown in Table 1.

Table 1/ Current status of Singapore's desalination plant [4][5]

Name of Plant	Date of Commissioning	Operator
Singspring Desalination Plant	2005	Hyflux/Keppel
Tuas South Desalination Plant	2013	PUB
Tuas Desalination Plant	2018	PUB
Marina East Desalination Plant	2020	Keppel
Jurong Island Desalination Plant	Under construction	Tuas Power/Singapore Technologies Marine

Source/ https://www.water-technology.net/

Singapore's first desalination plant is the Singspring Desalination Plant, located in the Tuas Industrial Zone. It is the first time PUB has adopted a public-private partnership, employing a "design, build, own and operate" approach (DBOO) to grant private sector on developing infrastructure. In 2004, PUB awarded a contract to Hyflux for plant construction, which was completed in 2005 with a total capital investment of approximately NT$3.8 billion. The second Tuaspring Desalination Plant was built in 2011 and opened in 2013. It is currently the largest desalination plant in Asia. The plant itself is equipped with a combined-cycle power plant (CCPP) with a capacity of 411MW, which can provide reliable power source for the desalination process, and the excess power was sold to the Singapore National Grid. According to the water purchase agreement with PUB, the Tuaspring Desalination Plant should supply PUB with desalinated water for 25 years from 2013 to 2038. In 2019, PUB took over and renamed the plant as Tuas South Desalination Plant [4][5][6].

As the sea water quality near Tuas is stable and suitable for the development of desalination, the third Tuas Desalination Plant (Figure 4) is also located in the Tuas Industrial Zone, next to the first two plants. For the first time, the Tuas Desalination Plant uses advanced pre-treatment technology, including dissolved air floatation and ultrafiltration technology. Different from the first two desalination plants, the Tuas Desalination Plant was operated by PUB after its commission [4]. The fourth Marine East Desalination Plant, is the world's first dual-mode seawater desalination plant. It can treat fresh water from the estuary reservoir of the marine barrage during the wet season and desalinate seawater during the dry season. It is even less susceptible to the climate factors. The humanized design of Marine East Desalination Plant also includes a rooftop park on the desalination facility, which is open to the public for various activities [7].

Figure 4/ Tuas Desalination Plant
Image by Singapore's National Water Agency

Conclusion

Singapore was originally an extremely water-scarce country, and its natural conditions are more difficult than Taiwan. However, the Singapore government attaches great importance to the problem of water shortage. With the government's foresight and ambition, the Four National Tap policy has made Singapore from a water scarce country to a water technology powerhouse that can export recycled water and seawater desalination technology. In addition, there is no more water shortage problem for private industries in drought. Taiwan's industrial water demand is increasing year by year, but the development of traditional water resources is getting more difficult. Singapore's experience in using seawater desalination to enrich domestic water resources can be an important reference for Taiwan to diversify the planning of water resources.

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Image by Pride Advertising Agency Ltd.

Overview of Singapore's Ocean Policy

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Translated by Linguitronics
Keywords: Singapore, ocean policy, fisheries, maritime safety, Law of the Sea

Singapore, with its unique geographical location, is an important maritime strategic hub and port in the world. It is the world's third largest oil refining center, international shipping center, international trade center and regional tourism center, also a necessary midway point on the trade route between major trading countries such as China, Japan, and Republic of Korea and the Middle East and European Union. This article introduces Singapore's maritime policies, including primarily the nation's fisheries administration, maritime security, and maritime law enforcement.

The Republic of Singapore is a city-state and island country, also referred to as Singapore, with a total of 63 islands large and small, and a largely gentle terrain. The main island, Singapore Island, accounts for more than 90% of the nation's total area Singapore's total area is approximately 724.4 square kilometers, its coastline is 193 kilometers, and 3 nautical miles of territorial waters and exclusive fishing zones. As such, it is a country whose economic development is highly dependent on the ocean. A portion of the country's territory is obtained via reclamation. The area of reclaimed land was 581.5 square kilometers in the 1960s, and it is estimated that by 2030, surface area will increase by another 100 square kilometers. According to the Population in Brief 2020 published by the National Population and Talent Division of the Prime Minister's Office of Singapore, the nation's total population has reached 5.69 million. Although small in area and population, the country is an important maritime strategic hub and port in the world due to its unique geographical location (at the intersection of the Straits of Malacca and Singapore, as shown in Figure 1). As the Strait of Malacca is the key to controlling sea and land traffic from and to Europe, Asia, and Australia, it is one of the most important shipping routes in the world, enabling Singapore to become one of the busiest seaports across the globe. The country is also the world's third largest oil refining center, international shipping center, international trade center and regional tourism center, also a necessary midway point on the trade route between major trading countries such as China, Japan, and Republic of Korea and the Middle East and Europe. With links to more than 600 ports in the world, statistics from 2012 to 2019 show that Singapore's container port ranks second in the world only after one other port, Shanghai.

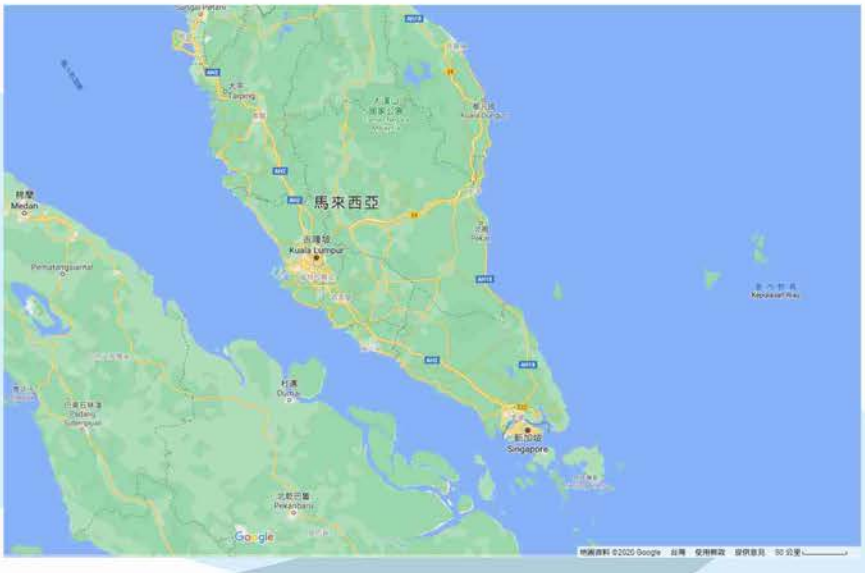

Figure 1/ Map showing location of the Straits of Malacca and Singapore
Source/ https://www.google.com.tw/maps/@1.2877667,103.8512191,15z

Fishery policy practices

Singapore's coastal marine ecosystem is very limited due to the profound impact of urban development and the port industry. As the port industry is one of the country's largest in terms of source of revenue, the port range has expanded to almost the entire territorial waters, and reclamation has spread throughout the southern and northeastern coasts of the main island (Figure 2). Due to the small size of the country, the lack of rich fishery resources near the coast, and the advanced development of the national economy, there is no advantage in developing ordinary fisheries, hence the number of fishermen in Singapore is significantly lower than other countries in Southeast Asia. Since Singapore's territorial waters are basically occupied by commercial ports and fishing ports, there are only two major fishing ports for marine fisheries, namely Jurong Fishery Port, the largest fish market, and Punggol Fishing Port. Fishery and its products are however an important source of animal protein for the local population, accounting for 30% of animal protein consumption. Singapore's fishery is mainly based on marine fishing, while the proportion of freshwater fisheries is limited with two thirds of marine catches coming from nearshore waters and one third from coastal waters.

Due to small land area and a highly developed economy, the development and utilization of coastal areas is also imperative as agricultural land with lower economic value has been repurposed for projects with higher economic benefits. Following the development of fish ponds into residential and commercial land, the space for coastal fishing and related fishery activities is becoming increasingly small, contributing to the decline of coastal fishery development in Singapore. However, Singapore has favorable climatic conditions, low risk of fish farming, and advantages in seedling and aquaculture. Coupled with a good infrastructure and well-developed logistics and transportation conditions, Singapore is able to play the role of a fishery re-export trader in ASEAN countries, making the country the world's largest ornamental fish exporter and a fishery transshipment center for the Southeast Asia region.

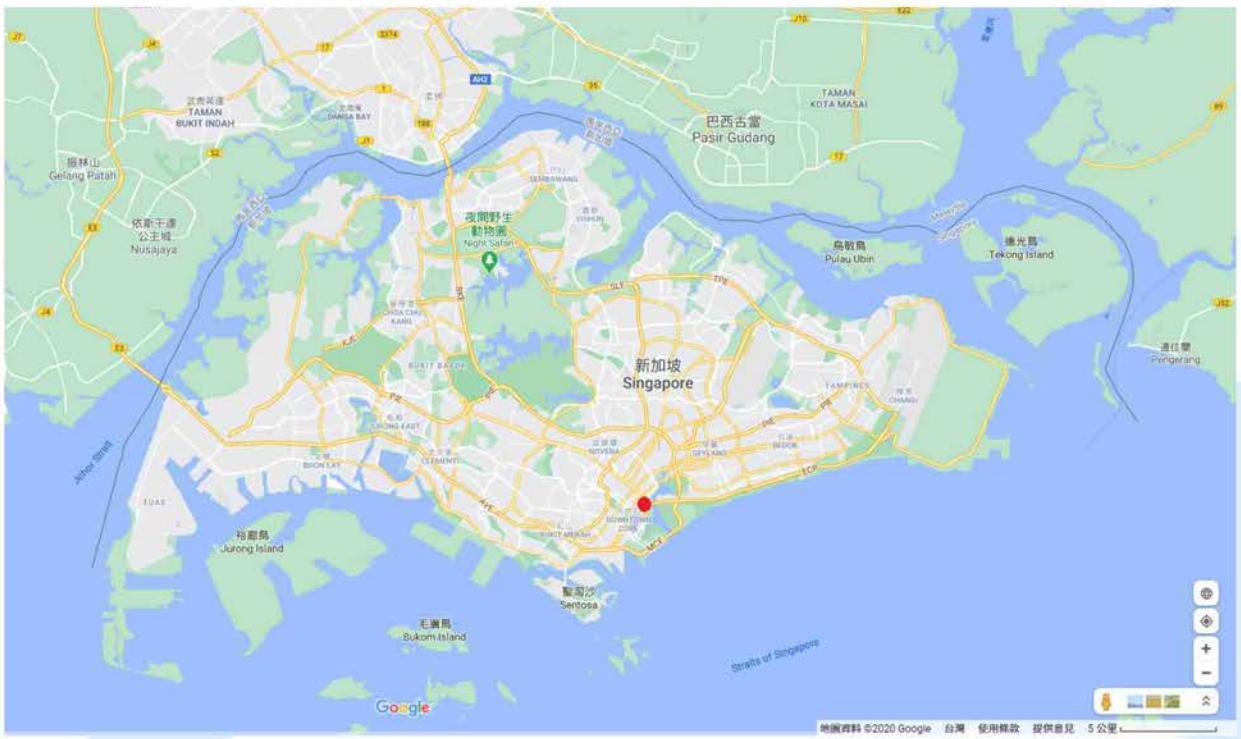

Figure 2/ Location of Marina Bay, Singapore (red dot)
Source/ https://www.google.com.tw/maps/@1.2877667,103.8512191,15z

Marine foreign and security policy

Although Singapore is not directly threatened by any other country, neighboring territorial waters have considerable influence on the country's national defense policy, primarily territory and maritime rights conflicts with neighboring countries. First, the country needs to emphasize its sense of independence to neighboring Malaysia and Indonesia. Since Singapore became independent from Malaysia in 1965, there have been tensions between the two countries on multiple occasions as territory and ocean delimitation disputes exist between Singapore, Malaysia, and Indonesia. Second, in order to cope with potential threats from neighboring countries in Southeast Asia, Singapore's diplomatic and defense agencies have established extensive bilateral and multilateral ties and cooperation networks. In 1990, it was also agreed that the United States would deploy troops in the country to ensure that ships of the US Seventh Fleet could smoothly pass through the Malacca Strait. After 2000, the country also dedicated considerable effort to strengthening its relations with the United States. With US Air Force and Navy units respectively visiting Singapore many times over the years, the country has gradually defined its stance and position in the South China Sea.

Singapore closely monitors the freedom of navigation and regional territorial disputes in the South China Sea. The country's fundamental stance in terms of its South China Sea policy is that conflicts must be resolved peacefully based on international law while supporting the Declaration on the Conduct of Parties in the South China Sea entered into by and between ASEAN member states and China. Singapore believes that the declaration is an important confidence measure for cooperation and stability among all parties in the South China Sea, and has also issued a position statement on the South China Sea issue at the ASEAN Regional Forum (ARF), the main points of which include: 1. Singapore has no claims for sovereign territories in the South China Sea, nor does it participate in disputes arising therefrom. However, as a major trading nation, any issues affecting the freedom of navigation in international waters are related to Singapore's key interests; 2. China should more clearly state its claims for sovereignty and maritime rights in the South China Sea, because vague claims often cause serious international concerns; 3. Singapore hopes that the countries in dispute can exercise restraint and create conditions conducive to the peaceful settlement of disputes in the South China Sea; 4. Singapore hopes that the disputing parties can sign and implement the South China Sea Code of Conduct as soon as possible.

Maritime safety practices

Southeast Asian countries generally face serious threats of piracy. After the Asian financial turmoil, the waters of Southeast Asia have become the most rampant waters for piracy in the world, one of the reasons being that most ASEAN countries have weak maritime security forces. Except for Singapore, Malaysia, and Vietnam, the majority of ASEAN countries have very limited maritime military power and outdated weapons and equipment. In addition, Southeast Asian countries have tortuous coastlines, and as disputes over the ownership of many sea areas still exist for countries along the coastline, it is difficult to effectively supervise all activity in these areas. In response to this issue, the Singapore government issued Defending Singapore in the 21st century and a strategy titled The Security Environment In The 21st Century, clearly proposing to expand its scope of military defense and play a greater role in regional affairs. As such, its main task is to resist threats from the sea, protect maritime communication lines, conduct maritime patrols, and combat piracy. There is no doubt that Singapore's navy now consists of the most outstanding naval personnel among Southeast Asian countries and possesses the most advanced maritime science and technology armed forces.

International Law of the Sea practices

Singapore is the latest country to become independent among Southeast Asian nations, therefore the history of development and practice of its Law of the Sea are not as complicated as that of other Southeast Asian countries. As Singapore is one of the world's international commercial port, trade and

financial centers, its practices of international Law of the Sea and policy stances are informed thereby. It advocates maintaining maximum freedom of navigation on the existing high seas for two major reasons: 1. The Strait of Malacca is vital to Singapore's free navigation, and 2. With territorial waters surrounded by Malaysia and Indonesia, Singapore's stance in terms of the Law of the Sea is that of a geographically disadvantaged country; the small island country has very restricted maritime space, and the expansion of maritime jurisdiction appears to have limited possibility. For these reasons, what is of utmost importance for Singapore is that all countries maintain narrow territorial waters and that any form of extending national maritime jurisdiction to the high seas is not approved.

The official position stated by the country in 1968 was that it did not have any national plans and legislative arrangements related to the research and development of natural resources on the seabed, sea level and subsoil, or oil drilling and exploration and seabed mining. By openly acknowledging its geographical disadvantages and pursuing other goals instead, Singapore has evolved into a world economic and trade center. The position that Singapore has taken in favor of complete freedom of navigation on international waterways is commendable for many countries that use the strait. Because Singapore is a coastal state on an international maritime lifeline (the Strait of Malacca), its position has been affirmed by most representatives of ASEAN nations. These representatives are also happy under certain circumstances to support Singapore's position as a geographically disadvantaged country. Since the United Nations Convention on the Law of the Sea recognizes that 12 nautical miles of territorial waters and 200 nautical miles of exclusive economic waters have become part of customary international law, the Minister of Foreign Affairs of Singapore issued a statement on September 15, 1980 announcing that Singapore will expand its territorial waters to 12 nautical miles and obtain an exclusive economic zone in accordance with international practices. As Singapore is a geographically disadvantaged country in the Southeast Asia region, in theory, it is unequipped to establish its own 200-nautical-mile exclusive economic zone. According to the delimitation principle of international law, negotiating with countries to reach a consensus on a 200 nautical mile exclusive economic zone will likely prove to be futile for this country. Therefore, Singapore did not propose to delineate the maximum boundary of its exclusive economic zone, but merely requested the sharing of certain benefits from the development of resources in this area.

Maritime law enforcement agency

Singapore's maritime law enforcement is performed primarily by agency, mainly the Police Coast Guard (PCG) or Marine Police Force, which is subordinate to the Singapore Police Force (SPF) of the Ministry of Home Affairs and is a level 4 agency that has undergone changes and restructuring along with the history and development of the country's police organization. PCG is a law enforcement unit of the SPF that performs maritime missions, undertaking typical coastal defense missions. Its tasks include law enforcement in Singapore's sovereign waters, and maritime search and rescue in collaboration with the Maritime and Port Authority of Singapore (MPA) and the Immigration and Checkpoints Authority (ICA). After Singapore became a trading port in 1819, its waters were infringed by pirates over the course of many years. It was not until 1840 when Singapore publicly supported Britain's anti-piracy activities that circumstances improved. In 1866, the police began to perform water duties, establishing a mobile police station in the meantime with patrol boats patrolling the waters. It was not until 1924, however, that the unit became an independent functional agency and was renamed the Coast Guard. On February 13, 1993, the Marine Division was restructured and reorganized into the Police Coast Guard (PCG), giving maritime law enforcement greater powers, including preventing the entry of illegal immigrants at sea, preventing the entry of illegal foreign ships, and guarding of the Horsburgh Lighthouse on the disputed island of Pedra Branca. PCG also performs maritime border control and anti-terrorism tasks. After 9/11, the Singapore government began to attach importance to the prevention of maritime terrorism, designating Changi Naval Base as the headquarters for leading anti-terrorism missions at sea and reinforcing inspections of ships, especially passenger liners returning from abroad. Since 2004, PCG personnel have strengthened anti-terrorism training and refined various

professional skills and equipment necessary for exercising their duties. The country's law enforcement team is responsible for an increasing number of maritime management tasks, and the subordinate PCG has also been entrusted with the responsibility of comprehensive law enforcement due to its efficient law enforcement capabilities.

In addition, to regulate maritime and port operations, Singapore has promulgated the Maritime and Port Authority of Singapore Act, designating the Maritime and Port Authority of Singapore (MPA) as the responsible agency. Singapore is currently the only country outside of Hamburg that serves as a venue for the International Tribunal for the Law of the Sea for resolving maritime disputes. The country furthermore enacted the Fisheries Act (Fisheries Act 1996) to protect and conserve fishery resources, the Prevention of Pollution of the Sea Act (The Prevention of Pollution of the Sea Act) to prevent marine pollution as well as other marine-related laws. The purpose of the latter is to prevent marine pollution, whether the source is land pollution or ship pollution, while also giving the MPA the power to take preventive measures to prevent pollution, including denying entry or detaining ships.

Even though Singapore seeks to resolve disputes through various political and foreign policy approaches, the country has nevertheless established a strong navy and protects maritime security through a modernized defense industry. In the early 21st century, Singapore also played a strategically important role in Southeast Asia, remaining committed to maintaining a delicate balance between military power building and international cooperation. In 2019, Singapore and China furthermore formally signed an agreement on defense exchanges and security cooperation. In light of this new relationship, although the Starlight Project, a long-term collaboration between Taiwan and Singapore, continues to operate as usual, as training of Singaporean troops in Taiwan has been suspended due to the epidemic, subsequent developments and changes will require continuous monitoring and attention.

Figure 3/ Singapore Police Coast Guard Patrol Boat Images by Investigation Branch Special Service Company, CGA, OAC

Figure 4/ Singapore Police Coast Guard Training Center
Images by Investigation Branch Special Service Company, CGA, OAC

Artificial Algal Forest: A New Opportunity for the Development of Ocean Farming

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Keywords: Marine environment, cultivation, artificial algal forest, Ocean farm, Genus Sargassum

In recent years, the marine ecosystem has been under great pressure due to issues such as human activities, habitat destruction, pollution, invasive alien species and climate change. Without adequate management and proper protection mechanisms, many species will be on the verge of extinction; some species have already become extinct, and ecosystems are becoming imbalanced. These issues will, directly or indirectly, have an impact on human development and survival. Therefore, if we want to achieve sustainable biodiversity, we need to protect it by implementing a variety of strategies, including conservation, rehabilitation, sustainable use of resource, education and research, etc. Among these, rehabilitation works include the cultivation of species and habitat improvement or restoration. One of the ways to rehabilitate habitats is by introducing artificial algal forest.

Feeding green sea turtles with Sargassum
Image by Marine Ecology and Conservation Research Center, National Academy of Marine Research

Importance of Seaweed

In general, seaweed refers to the macroalgae that grow in the ocean. They did not have roots, stems or leaves because their inner structure lacks vascular tissue; therefore, they mainly rely on root-like attachments at the base to help them cling to reef rocks in the intertidal and subtidal zones. Currently, Taiwan have been recorded about 600 macroalgae species on the coast, which can be classified into four groups: Cyanophyta, Chlorophyta, Ochrophyta and Rhodophyta. Seaweeds play a crucial and fundamental role in the ecosystem. They not only produce oxygen, provide food, purify water, and help

calcium carbonate ($CaCO_3$) be deposited into coral reefs, but also the seaweed forest they create can provide marine life with a place to live, forage, reproduce and shelter. In addition, the nitrogenous waste excreted by marine life and residual bait, among other sediments, provide ample nutrients for algal forest. Furthermore, seaweeds can carry out photosynthesis and carbon dioxide fixation, which optimizes the seabed environment and increases fishery resources. The purpose of the construction of artificial algal forest through artificial or semi-artificial methods is mainly to repair or rebuild an ecosystem. Additionally, planting techniques are used to create algal beds, so they can gradually form natural algal forest in the wild, and to take advantage of the multifaceted functions that algal forest provide to gradually replenish the ocean resources.

The Benefits of Developing Ocean Farms Through Artificial Algal Forest

There is currently no consensus on the definition of ocean farms in academic or industrial circles in Taiwan or overseas. A broad definition would be that a ocean farm is a defined sea area with a laissez-faire management system and a systematic and adequate approach to the rehabilitation and release of local marine resources. More specifically, a marine farm can be defined as a designated sea area or an environment protected by a natural barrier where local native species are cultivated in a planned manner; in these areas, marine organisms cultivated using artificial seedling technology are released (kept) to create a leisure and sightseeing ecological ocean farm compound. Currently, there are already several successful cases in Taiwan. For example, the Agriculture and Fisheries Bureau of Penghu County Government used artificially cultivated Sargassum spp. on bricks to create artificial algal beds in the local Wukan protected area, which provided sufficient food sources for the sea urchin larvae, increasing their survival rate. The Penghu Marine Biology Research Center from the Fisheries Research Institute, Council of Agriculture used artificially grown Sargassum spp. in ropes to make an artificial algal bed of 240 square meters at the local sea area in Hongluo village. In this area, 50 thousand swimming crab larvae were released. The abundant food resources found on the algal bed provided them with enough sustenance to improve the effectiveness of their release. Therefore, the use of Sargassum in the development of ocean farms not only increases marine resources along the coast, but also provides the following benefits:

I. Aquacultural and Ecological Value

Ocean farms can be to establish a basis of economical seaweeds culture technology and to conduct research or develop indoor mass production methods, as well as to provide food sources for marine organisms or raw materials for enhancing fishery resources. In addition, artificial algal forest planted in the wild can supply places for other marine life to grow, forage, reproduce, and shelter; they can also produce oxygen and purify the marine environment.

II. Environmental Protection Value

Ocean farms can improve the ocean's ecosystem, purify the marine environment, and absorb ammonia and heavy metal ions in the ocean. Furthermore, the nitrogenous waste excreted by marine life and residual bait, among other sediments, can allow algae to fully absorb nutrients, carry out photosynthesis, and carbon dioxide fixation. As a result, it can optimize the seabed environment. In addition, marine farms can serve as a natural biological filter for the treatment of wastewater and water quality improvement, which has a high potential for development.

III. Value for the Marine Tourism Industry

Underutilized fishing ports can be redesigned into cultivation demonstration centers, and floating box net platforms can be installed for planting native species of artificial algal forest, thereby creating a natural sightseeing park. Additionally, an underwater sightseeing route can be created to allow visitors to experience the feeling of traveling through an algal forest while observing different types of marine life living in these environments e.g., fish, crabs, and sea urchins.

IV. Value in Terms of Raw Materials

Seaweed can be made into food or industrial raw material sources (e.g., Sargassum can made fresh Sargassum, dry Sargassum powder). Moreover, coastal residents frequently use it to feed terrestrial livestock (chickens, pigs, cows, sheep), aquatic livestock (fish, etc.), or as a source of fertilizer or plant food for vegetables.

V. Value in Terms of Health and Biotechnology Beauty Products

Algae is high in protein and carbohydrates, low in fat, rich in minerals and other elements such as iodine, potassium, mannitol, and algin. Therefore, it has great potential to be applied in the health care and food chemistry industries. In the future, health products such as drinks (fucoidan), capsules (oligofucoidan), and probiotics can be developed, as well as biotechnology beauty products like cosmetics (shampoo, shower gel, soap), skin care products (facial masks), etc.

VI. Nutrition Value

Nowadays, genus Pyropia, Gracilaria, and the recently developed Caulerpa lentillifera are the most commonly consumed types of seaweed in Taiwan. Additionally, other edible products can be researched and developed such as Sargassum salt, raw salads (pickled vegetables), alcohol, tea bags, drinks, yogurt, egg rolls, ice cream and steamed buns.

Establishment of Artificial Algal Forest

Restoration or reconstruction of field algal forest by using artificial or semi-artificial planting techniques. Moreover, artificial algal forest formed in the wild can gradually restore marine resources.

Taiwanese Regions and Seaweed Species Suitable for the Development of Artificial Algal forest

Taiwan is surrounded by the ocean; it is an island country that sits at the Coral Triangle—the world's richest marine life hot-spot—with coral reefs also known as the "tropical rainforest of the sea". Thus, Taiwan enjoys abundant marine resources. On the east coast, the Kuroshio Current flows past Taiwan. On the west coast, the Kuroshio Branch Current, the waters of the South China Sea and the Chinese Coastal Current meet each other in the Taiwan Strait, thus forming excellent fishing grounds. In line with the international trend of reducing global greenhouse gas emissions, and to achieve the vision of a Nuclear-Free Homeland. Therefore, the government has actively promoted the green energy policy of offshore wind farms and has carried out large-scale development of offshore wind farms on the west coast of Taiwan. However, the development of offshore wind farms may affect the functions and biological composition of the original fishing grounds, as well as the local fishery activities and revenue. Therefore, artificial algae farms can be built to try to improve or restore habitats, and to reduce the negative impacts of development on the marine ecosystem. According to the Pingtung County Government Summary Report of 2016 (Final Report of Commissioned Service Works [Including the Following Expansion] of Coastal Ocean Space Utilization Planning in Pingtung County), in order to integrate the sustainable development of local fishing villages, and promote the restoration of fishery resources and the rehabilitation of fishing grounds, not only should we focus on building offshore wind farms, but should also prioritize the planning of the three ocean farms in Liuqiu Township, Fangshan Township and Checheng Township. Therefore, the algae farms can also be used to increase coastal resources to achieve the sustainable management of fishery resources.

When choosing a species of algae, the main consideration should be whether it can adapt to the local environment; for example, whether or not it is compatible with the ecosystem's physical and chemical

factors such as light intensity, water temperature, salinity, and nutrients in the seawater. It is also necessary to contemplate how difficult the easy to cultivate and whether or not it can effectively provide a living environment for organisms. Of course, the best choice is to use native local species of algae! Interestingly, the results of on-site investigation showed that Sargassum has all the above-mentioned characteristics, and it is also a native local species; therefore, the National Academy of Marine Research has begun the development of artificial algae bed cultivation technology using local Sargassum. In the future, this technology will be used to expand the restoration of Sargassum in the southwestern waters of Taiwan, and to build a Sargassum marine farm to increase the marine resources along the coast, thereby achieving the goal of sustainable bioresources. The following is a basic overview of Sargassum:

Sargassum is a genus belonging to the family Sargassaceae, order Fucales, Class Phaeophyceae, phylum Ochrophyta, about 539 species recorded in the world. They mainly grow in warm ocean waters around the world. Some species can grow to up to 2-3 meters. Currently, a total of 13 Sargassum species are found in Taiwan waters (including outlying islands), which are common in the region. Sargassum is often mistakenly referred to as "seaweed", but it is actually a group of multi-celled macroalgae that lack roots and instead have holdfast. It is a type of non-vascular algae that does not bloom, bear fruits, or produce seeds. In terms of external morphology, in addition to holdfast, they consist of 5 different parts: stipe, frond, air bladders, and receptacles. They should not be confused with plants, which are organisms with a very different structure.

Production of Sargassum Seedlings and Cultivation Technologies

Sargassum is dioecious, meaning the female gamete and male gamete are released separately; the ovum is fertilized externally by the sperm to produce a zygote, which then forms a new sporophyte seedling. Sargassum can reproduce vegetatively and sexually. In the former, the algae's holdfast has the ability to regenerate and to reproduce vegetatively under suitable conditions and grow new seedlings; in the latter, oogamy occurs during the reproductive season producing fertilized eggs. This is the primary method of producing a large number of seedlings. At present, most of the research on the production and cultivation technology of Sargassum seedlings has been conducted in Taiwan (including Penghu), China, Japan and Republic of Korea. The life cycle of Sargassum is more complicated than other algae, therefore researchers need years to carry out the proper research, improvements and testing. Currently, artificial seedlings can be attached to ropes or reef rocks and be stably stored and grown until the point where they cannot easily detach, then they can be transferred to the sample area for deployment. This shows that significant breakthroughs have been made in artificial cultivation technology. The site for cultivating Sargassum not only requires a large storage space, but also a source of natural, easily accessible seawater, with an appropriate temperature (25-30°C), and sufficient sunlight (over 10,000 Lux). Cultivation works can start once the site has been established. The process is as follows:

I. Harvesting of Wild Sargassum

The growing season of Sargassum is from about October to May of the following year, and it mostly disappears from the wild from June to September. Therefore, in addition to harvesting the algae during the right season, it must be harvested and brought back for storage during the low tide at the intertidal zone.

II. Artificial Fertilization

When the Sargassum breeding season comes, mature algae are harvested in the wild. The artificial shading method is used to stimulate for 2 hours, so that the female and male reproductive receptacles are pressed simultaneously. After putting it in the water artificially, the eggs and sperm will be discharged at the same time for in vitro fertilization.

III. Artificial Techniques for Picking and Attaching Seedlings

Put the fertilized eggs discharged from the female reproductive nursery into a plastic container. The fertilized eggs are collected by artificial strong shaking at the source of seedlings. Then filter the algae fragments with a sieve to obtain seedlings, and attach the seedlings with a brush. Immediately brush attached to the surface of the hollow brick or rope as a substrate for seedling attachment.

IV. Sargassum Seedlings Growth

After the mature female and male Sargassum receptacles are stimulated, they release the ovum and sperm, which fertilize externally to form a zygote. Embryos develop within 24 hours after fertilization; within 48 hours they grow holdfast, to later develop into sprouts, also known as algae seedlings. In conclusion, the life cycle of Sargassum can be divided into 4 stages: seedling, growing, reproduction, and decline, in that order.

Future Challenges and Management

As the previously mentioned examples show, developing marine farms through the implementation of artificial algae farms can bring a lot of benefits, but they can also come with a variety of challenges. For example, algae farms built in the wild may be eaten by algae-eating fish e.g., rabbit fish, small scale black fish, or scorpionfish. These can negatively impact the effectiveness of the artificial algal bed. Therefore, in order to cope with algae-eating fish, local native species of algae with a higher degree of toughness (e.g., Sargassum ilicifolium) can be planted. Another way to combat this issue is to ensure that the artificially cultivated algae have grown to a certain size and density before being transferred into the wild to reduce its chances of being eaten.

In terms of aquaculture, large-scale breeding of a single species may cause diseases or a large amount of deaths due to a limited genetic gene pool, making the species unable to adapt to drastic environmental changes; or a foreign species might be chosen to be cultivated, which may compete or hybridize with the local native species, leading to the replacement of the latter, or even cause an invasive alien species problem. Therefore, if a cultivation center is established locally, it will effectively reduce the problem of native species not adapting to the local environment. In addition, it will make it easier to collect fresh wild algae nearby for breeding, thereby enriching the gene pool and increase seedling's breeding rate.

Additionally, Sargassum is seen as "marine debris." This mostly refers to "devil weed" (Sargassum horneri), which is also part of the family Sargassaceae. This species of warm-temperate algae is unique to the west coasts of the Pacific Ocean; it prefers low temperature environments, and during spring, following the cold water mass, it floats to central and northern Taiwan as well as the coast of Penghu. Unfortunately, a large amount of garbage and dead pufferfish become intertwined in the "devil weed" that washes up on Taiwan's shores, piling up on the coastline and causing trouble and harm. Therefore, when a large mass of "devil weed" washes up on the intertidal zone, it not only needs to be cleared out and disposed of, but also some of it should be released back into the ocean after decomposition, thereby reincorporating it into the ocean food chain's nutrient cycle. Besides, these natural resources can have practical uses in aquaculture, health products, and biomass energy. Consequently, it is essential in artificial algae farms to have an accurate understanding of algae reproduction and Sargassum's growth cycle, to carry out early harvesting in order to reduce the chances of it detaching, or to set up rope interception points to prevent it from floating into the shore. Fishermen can also assist in harvesting, and store algae as frozen vegetables or process it into animal feed or fertilizer to reduce the problem of marine debris.

The National Academy of Marine Research plans to use Sargassum as one of the ways to rehabilitate marine habitats; in the future, they will build algal beds using a variety of methods (e.g., algae attached to bricks or ropes) for different types of habitats, and will simultaneously release economical aquatic animals to create a marine farm with sustainable ecological resources, thus enabling industrial development that benefits all parties.

Maritime Legislation and Delimitation - Practice of Singapore

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Keywords: Maritime Delimitation, Singapore, Territorial Sea, United Nations Convention on the Law of the Sea, Maritime Legislation, Case Concerning Sovereignty over Pedra Branca/Pulau Batu Puteh, Middle Rocks and South Ledge

Singapore's practice regarding law of the sea and maritime delimitation is heavily influenced by the development of the law of the sea at the international level, as well as colonial-era laws and agreements. In addition to announcing maritime claims pursuant to the United Nations Convention on the Law of the Sea and recognizing the Territorial Waters Jurisdiction Act of 1878 enacted by the United Kingdom, Singapore has striven to pursue national interests and resolve maritime disputes with neighboring States. Its efforts in this regard can also be of reference to other States facing similar challenges.

Introduction: Overview of Singapore's Maritime Laws and Regulations

Prior to the adoption of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), Singapore actively participated in the Third United Nations Conference on the Law of the Sea. It paid special attention to issues such as straits used for international navigation and the rights of landlocked and geographic disadvantaged States. Upon the UNCLOS's open for signature, Singapore signed the Convention and ratified it, along with the Agreement relating to the implementation of Part XI of the UNCLOS, on November 17, 1994. Under Singapore's domestic law, the executive branch has the right to conclude treaties with other States, and its Constitution does not require parliamentary approval before submitting instruments of ratification to depositaries. However, treaties to which Singapore is a party would not have domestic legal status unless the parliament adopts legislation to that effect. Thus, rules concerning maritime zones in the UNCLOS do not automatically become domestic rules in Singapore. A survey of existing maritime laws and regulations in Singapore would reveal that the parliament has not adopted any legislation for the purpose of maritime spatial planning or delimitation of maritime zones.

Current maritime laws and regulations generally focus on ports and vessels flying Singaporean flags. Such laws include Maritime and Port Authority of Singapore Act, Prevention of Pollution of the Sea Act, Merchant Shipping (Civil Liability and Compensation for Oil Pollution) Act, and Merchant Shipping (Civil Liability and Compensation for Bunker Oil Pollution) Act. The Maritime and Port Authority is tasked with adopting subsidiary legislation within the scope authorized by the aforementioned laws [1]. In terms of law enforcement, the Police Coast Guard is in charge in the territorial sea, and the Singapore Armed Forces, led by the Minister of Foreign Affairs, are mandated to enforce laws outside of its territorial sea.

Singapore's Territorial Sea Regime and the Territorial Waters Jurisdiction Act

As previously stated, Singapore has not adopted laws on maritime zones. Yet, regarding the width of territorial sea, Singapore's practice via diplomatic channels can provide guidance. During the Third United Nations Conference on the Law of the Sea, Singapore noticed a few important trends of development, including the recognition of 12-n.m. territorial sea and 200-n.m. exclusive economic zone, and the transit passage in straits used for international navigation. On September 15, 1980, Singapore's Ministry of Foreign Affairs issued a press release, proclaiming that Singapore had adopted a 3-n.m. territorial sea since 1878, and "in the light of the said international developments, Singapore will exercise its rights to extend its territorial sea limit up to a maximum of 12 nautical miles [2]." The same

statement also stipulated that if Singapore and its neighboring States have overlapping maritime claims, Singapore would be "negotiate with these countries with a view to arriving at an agreed delimitation in accordance with international law".

In Singapore's submissions to the International Court of Justice after it and Malaysia brought the Case Concerning Sovereignty over Pedra Branca/Pulau Batu Puteh, Middle Rocks and South Ledge to the Court, it reaffirmed its claims concerning the territorial sea. It should also be noted that after the revision of port limits in 2010, the waters outside Singapore's mainland fall largely within the port limits or the traffic separation scheme. The remaining territorial sea is limited in scope [3].

In addition to the maritime laws concerning ports and vessels flying Singaporean flags, the 1878 Territorial Waters Jurisdiction Act remains in force. The Act does not designate the width of territorial sea, it only adopted the term "a certain distance of the Coast" to identify the scope of application of the Act, which is aimed at providing jurisdictional basis for offences which took place with that scope. The provisions include the scope of jurisdiction, restrictions of jurisdiction, procedural matters and exceptional clauses, such as in the case of piracy. Under this Act, all individuals, regardless of nationality, committing the offences are subjected to Singapore's jurisdiction, but jurisdiction over foreign nationals may be restricted under the terms of the Act.

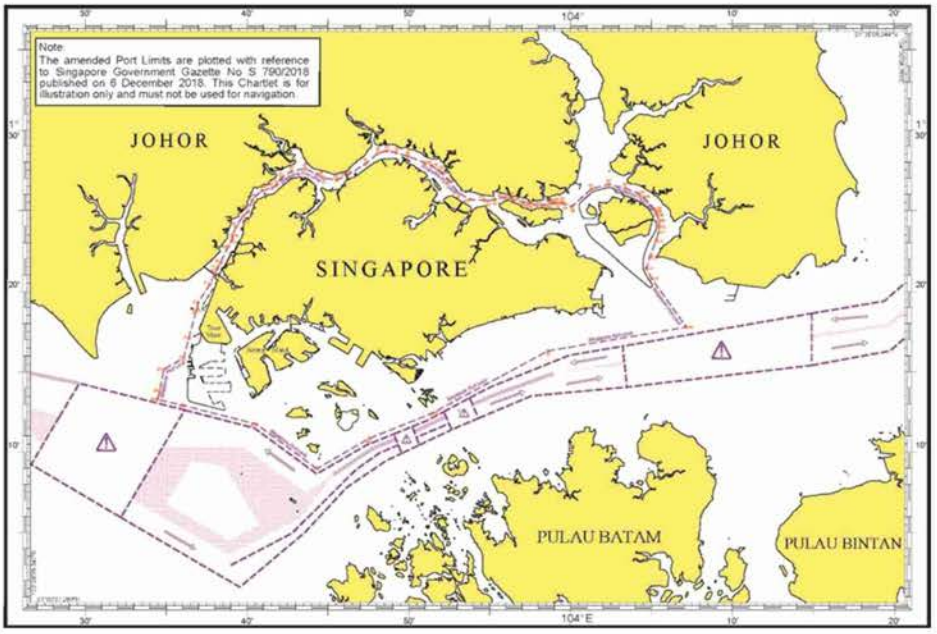

Figure 1/ Singapore's Port Limits (as revised in 2018)
Source/ Singapore's Maritime and Port Authority [4]

Singapore's Practice Regarding Maritime Delimitation

While the domestic law of Singapore does not provide rules concerning the outer limits of maritime zones, in its 1980 statement, the Ministry of Foreign Affairs emphasized its commitment to negotiations. In this regard, Singapore's practice can be observed in its negotiations with Indonesia and Malaysia and the resulting agreements.

Singapore and Indonesia has undergone multiple rounds of negotiation in order to determine the delimitation of the two States' territorial Seas. In 1973, the Treaty between the Republic of Indonesia and the Republic of Singapore relating to the Delimitation of the Territorial Seas of the Two Countries in the Strait of Singapore was concluded. Six points were designated in the 1973 Treaty, and the straight lines connecting the points formed the maritime boundary between the two States. Among the six points, three are equidistant from the baselines of Singapore and Indonesia, and the other three are closer to

Indonesia. Thus the line has been dubbed as "modified equidistance line" [5]. The 1973 Treaty provided solution to only part of the overlapping claims. Therefore, further negotiations between Singapore and Indonesia were needed, and for part of the disputes, Malaysia should also be brought in the negotiation considering the latter's proximity and maritime claims. Singapore's land reclamation activities also brought uncertainties to the agreement reached with Indonesia. Fortunately, both States took the position that such activities would not affect the boundary drawn by the 1973 Treaty. In the following years, the two States concluded delimitation agreements in 2009 and 2014 respectively, and these efforts contributed to a more stable legal order in the Strait of Singapore and clarified the jurisdictional lines for each State.

Figure 2/ Maritime Boundary as Designated by Treaties between Singapore and Indonesia
Source/ Annex B of the 2014 Treaty between the Republic of Singapore and the Republic of Indonesia relating to the Delimitation of the Territorial Seas of the Two Countries in the Eastern Part of the Strait of Singapore

Delimitation talks between Singapore and Malaysia began before the two States' declaration of independence. In 1927, the Straits Settlements and Johore Territorial Waters Agreement was concluded, and it designated "an imaginary line following the center of the deep-water channel in the Johore Strait" as the boundary between the two sides. Such an "imaginary line" lacks the specificity necessary for delimitation. Thus, Singapore and Malaysia began joint hydrographic surveys in 1980 to determine the location of the "deep-water channel" in the Johore Strait. On that basis a treaty was concluded in 1995 to identify the coordinates of 72 points used to draw the boundary. The delimitation of waters surrounding Pedra Branca/Pulau Batu Puteh was not addressed in this Treaty due to its location and sovereignty disputes. In 2008, the International Court of Justice finds that Pedra Branca/Pulau Batu Puteh belongs to Singapore; Middle Rocks belongs to Malaysia and the sovereignty of South Ledge depends on whose territorial sea it is located in. On the basis of the Court's judgment, the two States established a Joint Technical Committee, which oversees their joint survey and prepared materials for delimitation negotiations. The survey was completed in 2013, and under the auspice of the Committee, the efforts continued, and it has been decided in January 2020 that a Sub-Committee on Maritime Boundary Delimitation would commence negotiation [6].

Conclusion

Taking into consideration Singapore's participation in the Third United Nations Conference on the Law of the Sea and its subsequent practice, it can be clearly observed that Singapore pays close attention to the development of the law of the sea. Although it has not adopted legislation or other official acts to comprehensively clarified its claims regarding the width and scope of maritime zones, it nevertheless enacted other maritime laws and regulations to ensure navigation safety and port control. As for disputes with neighboring States regarding overlapping maritime claims, it utilizes diplomatic and legal tools to resolve the differences. Its methodology and attitudes toward issues concerning the law of the sea and international disputes can be of reference to other States facing similar situations and challenges.

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國際海洋資訊 International Ocean Information

9 December 2020
雙月刊 | Bimonthly

發行：海洋委員會

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Published by Ocean Affairs Council

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國際海洋資訊 International Ocean Information

9
December 2020
雙月刊 | Bimonthly

2020年開始營運的新加坡濱海東海水淡化廠（廠房在屋頂公園下方）

中華民國109年12月出版（每雙月出版）
中華民國108年8月創刊
ISSN 2706-638X （紙本）
ISSN 2706-6398 （電子）
中華郵政高雄雜字第236號執照登記為雜誌交寄

海洋委員會 Ocean Affairs Council 發行

台灣經濟研究院 編印

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