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IIRE Journal of Maritime Research and Development

Maritime sector has always been influencing the global economy. Shipping facilitates the bulk transportation of raw material, oil and gas products, food, and manufactured goods across international borders. Shipping is truly global in nature, and it can easily be said that without shipping, the intercontinental trade of commodities would come to a standstill.

Recognizing the importance of research in various aspects of maritime and logistic sector, IIRE through its Journal of Maritime Research and Development (IJMRD) encourages research work and provides a platform for publication of articles, manuscripts, technical notes, papers, *etc.* on a wide range of relevant topics listed below:

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- Port Management, Port Pricing and Privatization
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- Other Current Topics of Interest in Shipping

Editorial

In a world rife with cascading crises – geoeconomic fragmentation, retreating development, and climate change – maritime trade serves as a stabilizing anchor, holding fast against the turbulent currents of disruption. Over four fifths of all trade in the world flows through the high seas. This includes the crucial trade of food, energy, and other essential goods.

As recent trade disruptions, and most notably that of Black Sea food exports due to the war in Ukraine have shown, in our interconnected world, billions of people need open ports and steady ships to eat, keep their lights on, and have their hospitals well-stocked. (UNCTAD Review of Maritime Transport 2023)

The October 2023 Edition of IIRE Journal of Maritime Research and Development paints a picture of the many forces at play reshaping the sector's roles and operating landscape – from Environmental pressures to Skilling to Gender Sensitization.

Undoubtedly, the key challenge for the sector is that the maritime industry must embark on a transformative journey towards decarbonization while sustaining economic growth. Balancing environmental sustainability, regulatory compliance and economic demands is vital for a prosperous, equitable and resilient maritime transport future.

Happy reading!

IIRE Journal of Maritime Research and Development (IJMRD)

Volume 7 Issue 2, October 2023

DESIGN AND IMPLEMENTATION OF SOLAR CHARGING STATION FOR ELECTRIC VEHICLES

Dr S. Thangalakshmi[1], Dr K. Sivasami [2] and Saad Khan[3]

Abstract

With the increasing demand for sustainable transportation solutions, electric vehicles (EVs) have gained significant popularity as an eco-friendly alternative to traditional internal combustion engine vehicles. However, the widespread adoption of EVs is still hindered by limited charging infrastructure and concerns about the environmental impact of electricity generation. This research project focuses on the development of a Solar Charging Station (SCS) tailored specifically for EVs. The primary objective is to design an efficient and environmentally sustainable charging system that utilizes solar energy as its primary power source. The SCS integrates state-of-the-art photovoltaic panels, energy storage systems, and advanced power management techniques to optimize energy capture, storage, and delivery to EVs. The primary objective of this research is to develop a solar charging station inside the IMU Chennai Campus for PHASE 2 of its EV project that maximizes energy utilization, minimizes grid dependency and ensures optimal charging performance for EVs.

Keywords: Solar charging station; electric vehicle; carbon footprint; solar panel and sustainability.

1. INTRODUCTION

The transition to electric vehicles (EVs) is a crucial step towards reducing greenhouse gas emissions and combating climate change. To support this transition and promote sustainable transportation, the development of efficient and environmentally friendly charging infrastructure is imperative. This paper introduces a novel concept of a Solar Charging Station (SCS) for the Electric Vehicle – Minsara Meen, developed by IMU Chennai Campus. This will include renewable energy sources with an effective charging technology to create a sustainable and convenient solution.

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The SCS integrates photovoltaic (PV) solar panels, energy storage systems, and advanced charging equipment into a comprehensive infrastructure [Khan et al., 2018]. The PV panels harness solar energy during daylight hours, converting it into electricity and storing excess power for later use. This stored energy can then be used to charge EVs during the day or night, reducing the strain on the grid and ensuring uninterrupted charging services. This paper presents the SCS as a viable and sustainable solution for the future of EV charging infrastructure. Its environmentally friendly approach, cost-effectiveness, and grid independence make it an attractive option for governments, businesses, and individuals looking to support clean transportation and reduce their carbon footprint. As the world continues to prioritize sustainable transportation, the SCS represents a step forward in aligning EV charging with renewable energy sources, ultimately contributing to a cleaner and more sustainable future for all.

2. ELECTRIC VEHICLE OF IMU CHENNAI CAMPUS

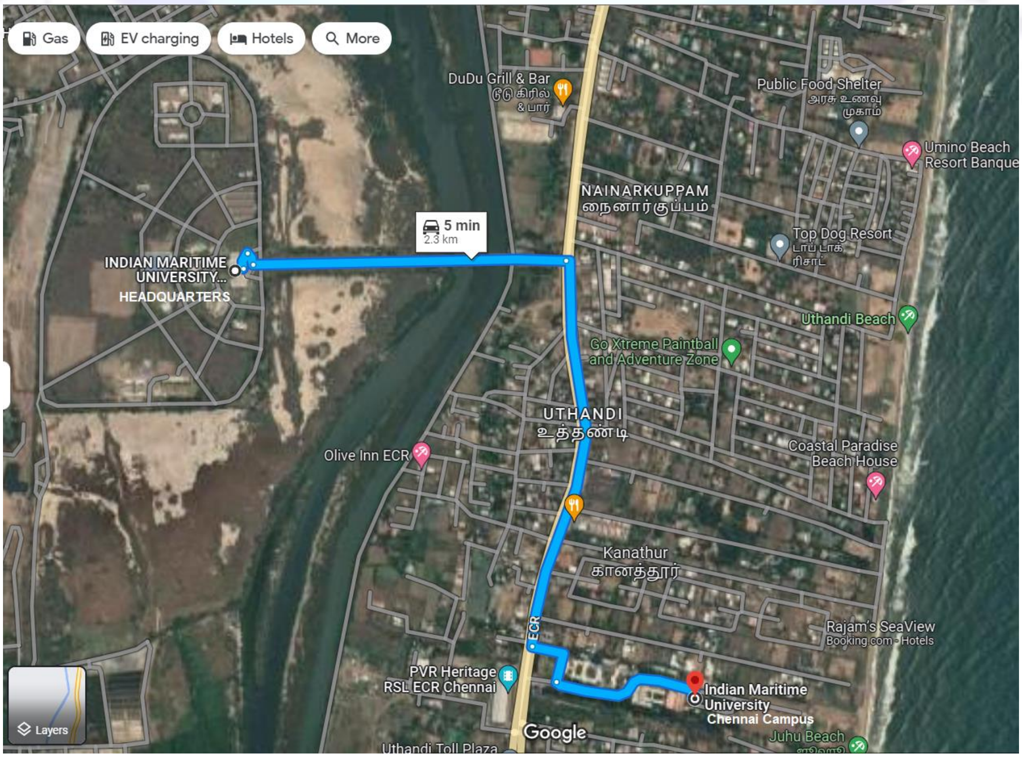
The distance between the Academic and Administrative Block from the Residential Block inside Semmencherry premises is around 1Km and the distance between the Semmencherry premise and the Uthandi premise is around 2.5Km. The EV was developed to reduce the dependence on fossil-fuel burning vehicles to commute and transport which will in turn reduce carbon emissions [Thangalakshmi et al., 2023]. Using an EV for commute will help both in the conservation of university resources and easy means of transport for faculty, staff and cadets. As the development of the EV is completed, planning PHASE 2 which includes development of Solar charging stations at strategic locations in the campus is currently under works. This paper includes the plan of action, calculations, requirements and technical details for the same.

3. OBJECTIVES AND SCOPE

The main objective of the project is to design a solar hybrid charging station for our electric vehicle considering all parameters such as sunlight availability, charging area required for solar panel, battery and power calculation and considering every parameter about charging and equipment. The design should be such as to prevent local grid overload and guarantee a higher percentage of clean energy. A combined system of grid-connected PV modules and battery storage could support the charging station.

Figure 1 - The Electric Vehicle developed by IMU Chennai

Figure 2 - Map Showing Semmencherry and Uthandi Premises of IMU Chennai Campus



The demand for rooftop solar charging stations is expected to increase in the near future as the number of electric cars increases [Alkawsi, Gamal, et al., 2021]. Solar energy can serve as an alternative source of energy and be used to address excess electricity demand. India can use solar energy to generate electricity and store energy in batteries. It can also be used to charge electric cars. This will not only fill the energy generation deficit but will also contribute greatly to green energy generation that will help reduce climate change issues.

Figure 3 - A Simple Sketch of Solar Powered EV Charging Station

4. PROPOSAL AND ACTION PLAN

It is of great importance that the PHASE 2 of the project should be carried out station by station due to both the complexity and the cost required to erect a couple of charging stations across the two campuses of IMU Chennai.

4.1 Proposed Sites for Solar Charging Stations

In consideration of sustainable and convenient solutions for charging electric vehicles, two prime sites have been identified for the installation of solar charging stations:

4.1.1. Semmencherry Premises

The parking lot of IMU HQ is recommended for the erection of the 1st Solar Charging Station due to the following advantages:

- Solar Panels required can be directly installed on the top of the canopy which pre-exists currently on site.

- There is no need to construct anything for shade for the safety of the electric vehicle.
- If the SCS is set up on this site, HQ staff and Faculty Members can charge their own Hybrids or EVs conveniently.
- Only requirement will be to make arrangements for the storage of batteries.
- The site is practically situated at the center point of the premises and hence at an approachable distance from anywhere inside the premises.
- This site guarantees safety and is closest to the main gate situated on ECR road.

4.1.2. Uthandi Premises

The facade of IMU Chennai Campus Main Building is recommended for the erection of the 2nd Solar Charging Station due to the following advantages:

- Solar Panels required can be directly installed on the top of the terrace of Main Building without any extra effort and cost.
- If the SCS is set up on this site, Chennai Campus staff and Faculty Members can charge their own Hybrids or EVs conveniently.
- The site is practically situated at the entrance to the main building hence preventing the passengers to walk unnecessarily.
- This site guarantees safety and is closest to the premise's main gate situated on ECR road.

Figure 4 - Map Showing the proposed site for SCS at Semmencherry Premises

Figure 5 - Map Showing the proposed site for SCS at UTHANDI Premises

5. COMPONENTS OF A SOLAR CHARGING STATION

In the construction of an efficient solar charging station, several key components play a vital role. These components ensure the optimal generation and management of clean energy for electric vehicles. Let's delve into each of these components to understand their significance in the system.

5.1 Solar Panels

The solar panel serves as a charging module for EVs using a renewable energy source, which is solar energy. We planned to install monocrystalline solar panels on top of our electric vehicle. Photovoltaic cells convert sunlight into electricity that can be used to charge an electric car. The same will be used in a solar charging station.

5.2 Charge Controller

A solar charge controller acts as a regulator for your solar battery, preventing it from overcharging and overheating. Batteries are rated for a specific voltage capacity and exceeding this voltage can lead to permanent battery damage and loss of functionality over time.

5.3 Solar Tracker

The use of Solar Tracker systems increases the amount of solar energy received by the solar collector and improves the energy output of the electricity produced. The solar tracker will increase the output of the solar panels by 20-30%, which increases the system economics of the solar panel project.

5.4 Battery

Batteries in photovoltaic systems are subject to frequent charging and discharging. Lithium-ion batteries with deep discharge technology are commonly used for automobiles and for photovoltaic applications.

5.5 Inverter

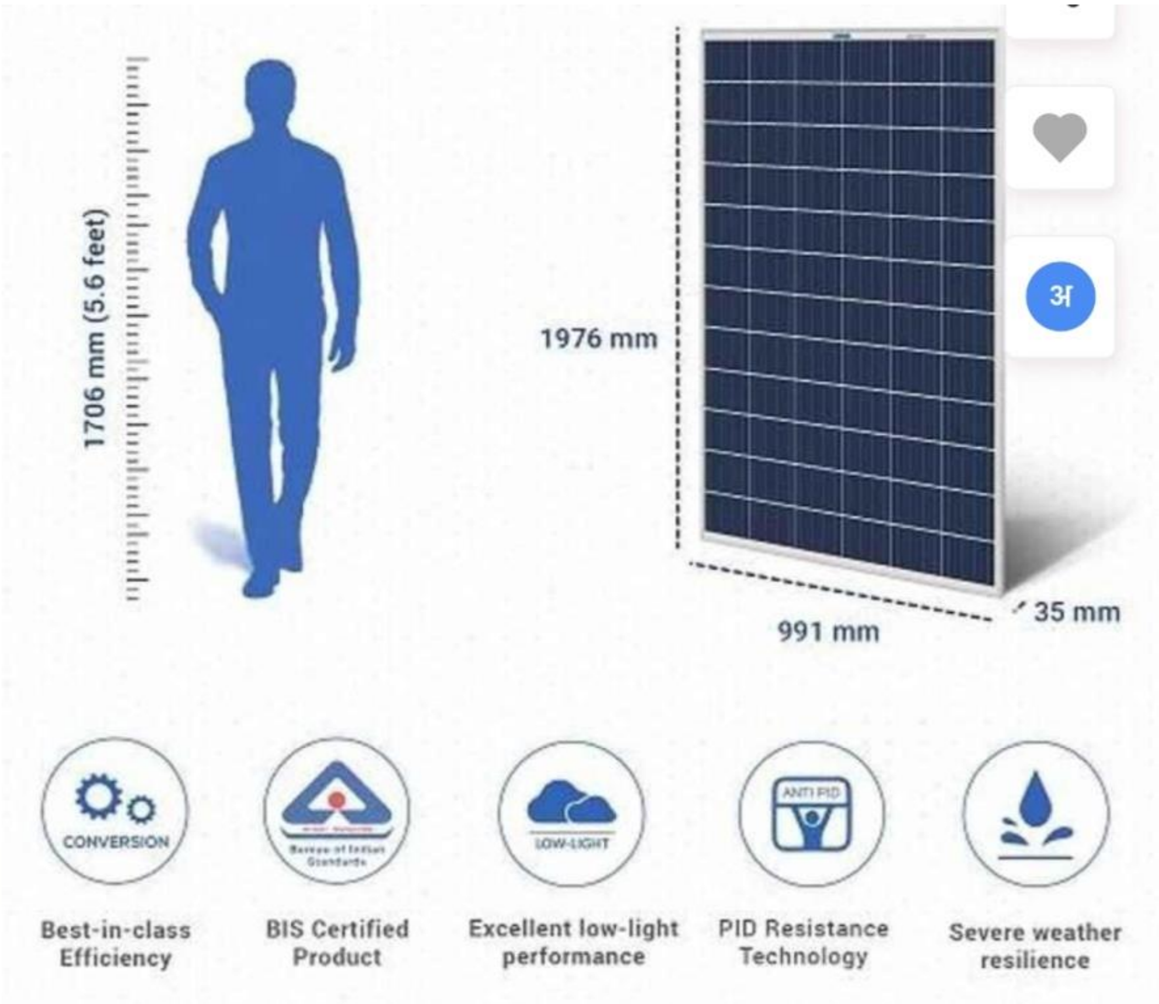
It is a combined solar inverter and EV charger that can be charged directly from rooftop solar panels. Integrating the charger with the solar inverter is a smart solution that eliminates the need for a separate EV charger as well as additional wiring and possible electrical upgrades.

5.6 DC Charger

The battery uses direct current for charging. A DC charger is an external module that converts AC mains power into DC power for charging an electric vehicle. It works in parallel with the solar panel when connected to the charging station and charges the battery.

Figure 6 - Battery and Charger used in the EV

Figure 7 - Recommended Solar Panel (330W 24V POLYCRYSTALLINE)



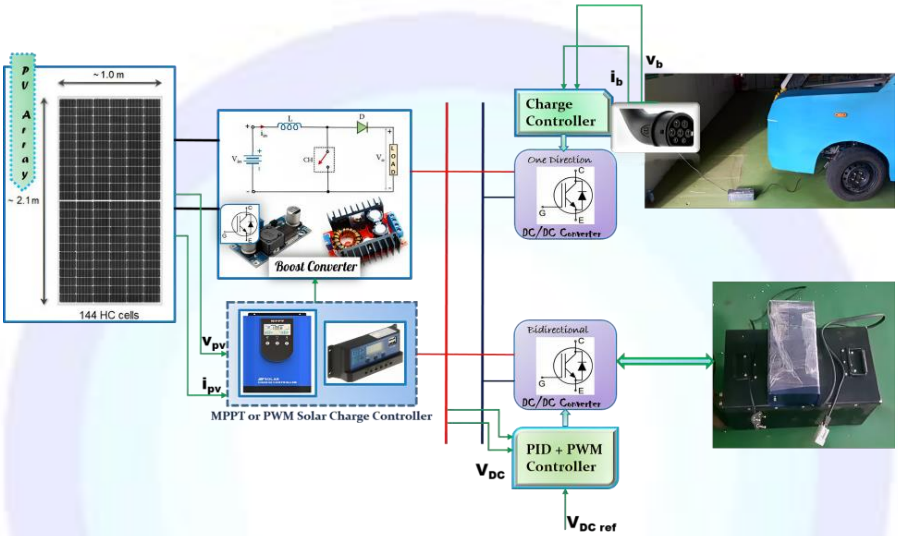
6. DIFFERENT SOLAR CHARGING SCHEME

In the realm of solar charging stations, different charging schemes and systems are employed to efficiently harness renewable energy for electric vehicles. These schemes encompass a variety of innovative approaches, each designed to cater to specific needs and environmental conditions. Let's explore the diverse solar charging schemes and their unique attributes in the following sections.

6.1. PV Grid Charging System

The photovoltaic grid charging system is an advanced future development [Al-Ezzi et Al., 2022]. The given architecture shows the photovoltaic charging system, which studied from different papers. Given architecture shows that there are two stages obtained from DC-to-DC converter and DC to AC converter [Ye et al., 2015]. The dc bus is more importance because it makes the interface the PV array, energy storage battery of electric vehicle including other dc power electronics. Furthermore, the dc bus has a high importance, because it is proposed to interface the PV array, the ESU and the EV battery pack including other dc powered electronics.

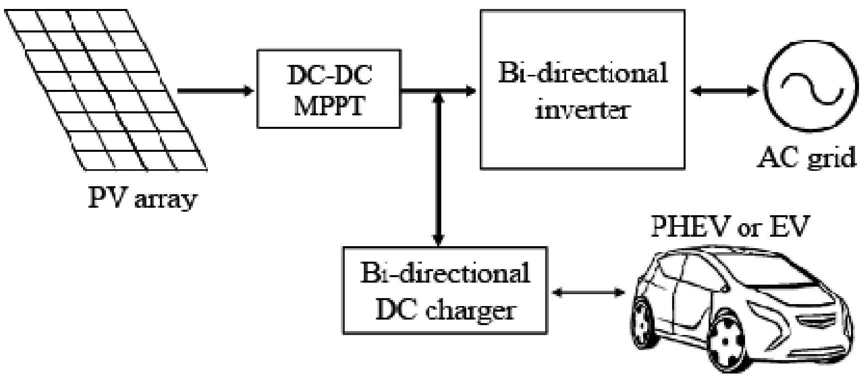
Figure 8 - Proposed Solar EV Charger



6.2. Standalone PV Charging System

Standalone PV charging system: In off grid station, energy is provided to EV's batteries without any connection of grid [Bagher et al., 2015]. The charging system is connected with an Energy Storage Device unit (ESD) for to deliver power continuously to the EV battery during night period [Chen et al., 2016].

Figure 9 - PV Charging System



7. CALCULATIONS

To comprehend the entire system, the following calculations are performed:

Solar system [at 1000W/m^2 of solar irradiance at 25^{0}C]:

Consider, 50 kW of solar system [i.e., daily output]; Average sunshine in India = 5 Hours.

kW = (50 kWhr)/5 hrs = 10 kW

10 kW system will be needed for obtaining 50 kW output per day.

We cannot harness the full power of the sun since its intensity changes throughout the day. Taking into account a solar panel with a peak output of 385 watts

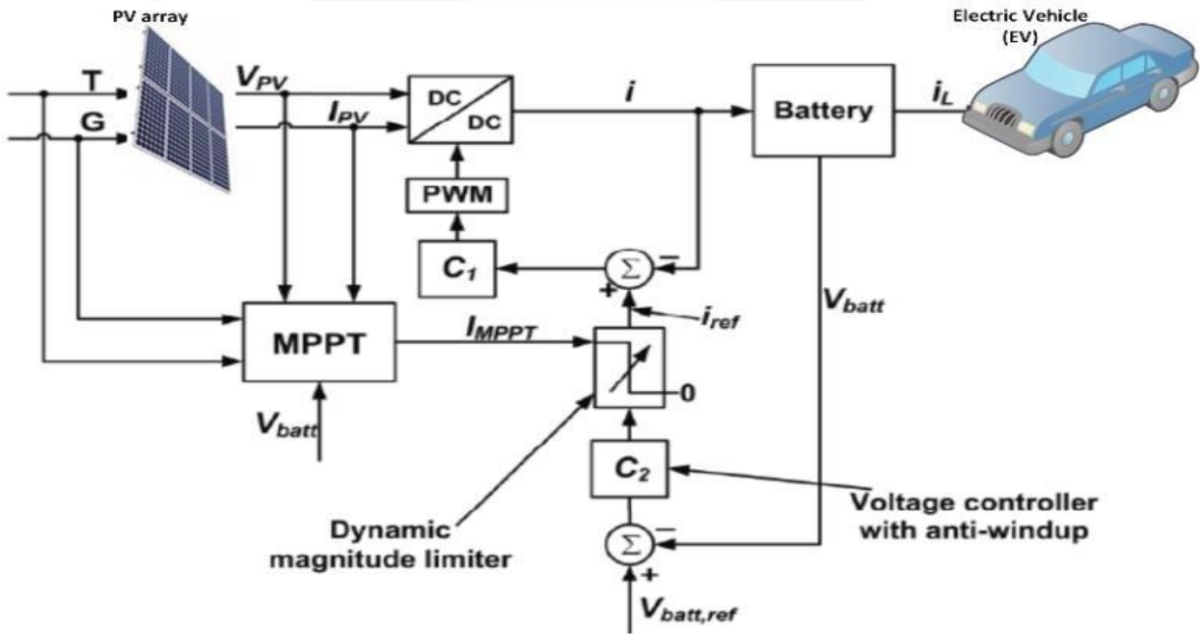
(with V_{peak} = 40.3 V and I_{peak} = 9.56 A; P = V_{peak} * I_{peak}),

∴ No. of panels required for 10 kW system will be:

(10 *10^3 Watts) / 385 Watts = 25.97, or almost 26 panels.

Panels are connected in series to boost voltage output and in parallel to boost current output. The current and voltage requirements determine the series parallel combinations or the arrangement of connecting the panels.

Figure 10 - PV Stand Alone Charging System



Solar panel dimensions are:

Length = 197.6 cm; Width = 99.1 cm; Thickness = 3.5 cm.

∴ Area of Solar Panel = Length * Width = 19582.16 cm^2 = 1.95 m^2.

∴ Total Area for 26 panels = 26 * 1.95 = 51 m^2.

Dimensions of the EV are:

Length = 4.95 m; Width = 1.69 m; ∴ Area of EV = Length * Width = 4.95 * 1.69 = 8.366 m^2.

∴ Minimum Area required for Solar Charging Station is 51m^2.

Calculation for battery to be used for solar electricity storage:

The nominal voltage of Lithium-ion battery is 3.60V/cell and current is 2600mah.

P = V * I = 3.60 * 2.6 = 9.36 Watt (For one cell)

We considered a Lithium polymer battery with following specifications:

Capacity: - 30.2 kWhr and 320 V Lithium polymer battery.

To get the number of cells in a battery pack:

Total output power = 30.2 kW

Output power of one cell = 9.36 Watts.

∴ No. of cells = (30.2 * 10^3 Watts)/9.36 Watts

= 3226.49 cells No. of cells ≈ 3227 cells.

Calculating ampere output of battery

P = V * I = (30.2 * 10^3) = 320 * I

∴ I = 94.375 A.

∴ To calculate no. of cells in series / parallel.

$(P_{Battery})/(P_{cell}) = (V_{Battery})/(V_{Cell}) * (I_{Battery})/(I_{Cell})$

= (320/3.6) * (94.375/2.6 3227)

= 88.88 * 36.29 3227

= 89 * 36

∴ 89 cells are connected in series and 36 cells are connected in parallel to meet the battery capacity.

Operating voltage for batteries:

∴ Lithium-ion will operate safely within the designed operating voltages.

Normal cell voltage = 3.6 V Typical end of discharge

= 2.8V – 3.0V Maximum Charge Voltage

= 4.2 V. As 89 cells are connected in series,

∴ (89 * 4.2 = 373.8 Volt) is the maximum charge voltage of a battery pack. Voltage should not exceed this value; it may lead to temperature rise and battery damage.

∴ (89 * 2.8 = 249.2 Volt) i.e., when voltage reaches 249.2 Volt hence, battery will be in discharged state.

8. MAJOR LOSSES IN SOLAR POWER GENERATION

Converting solar energy to electrical energy involves a number of procedures. Many losses occur during the conversion as a result of the complicated system [Mouli et al., 2016]. The solar energy collected by the PV panel is significantly greater than the electrical energy produced. Because of the numerous components in a PV system, the majority of the energy is wasted as conversion loss in the components or transmission loss in the cables [Steinschaden at al., 2020].

Because no system on the earth is completely efficient, it can only transform a portion of the energy we provide as input into useable energy, and the remainder is lost to the environment. The losses through various sections of solar power scheme are given below:

8.1 Solar panel

A solar PV panel's primary function is to convert sunlight into direct current (DC) electrical energy. Not all of the sun's rays that strike the panels are turned into direct electrical energy; a portion of it is reflected back or dissipated as heat into the surroundings. A one square-meter solar panel (PV) held on the earth's surface collects roughly 1,000 watts of solar energy in the afternoon and under clear skies. It is used to convert a little fraction of a solar panel's efficiency, around 18%, into electrical energy. The remaining 82% of the energy is either reflected back or lost as heat into the environment. This is referred to as energy conversion loss. The solar charge controller protects the battery from overcharging.

8.2 Battery

When the energy from the PV panels is not utilized to charge the car, it is stored in the solar batteries as chemical energy, which may subsequently be used to power the vehicle when there is insufficient sunshine or late at night. Solar cells' primary job is to convert chemical energy into direct current energy, and losses may occur during this electrical conversion. For example, if a battery is 80% efficient, it will transform 80% of the stored chemical energy into direct current electrical energy.

8.3 Inverter

The solar panels convert the energy into DC electrical energy, which is then sent to the inverter. An inverter's primary job is to transform direct current electrical energy into alternating current electrical energy. An inverter, for instance, has a 95% efficiency, which means it can transform 95% of the input DC electrical energy into AC electrical energy while the rest is lost through gearbox losses [Yap et al., 2019].

8.4 Wires

Lead wires, which are conductors, also cause some losses. The distance between the solar system's components should be kept within a particular range. As the distance grows, so will the size of the wire, resulting in more wasted energy. Therefore, a minimum or optimal distance should be maintained between the various components and the electrical load, and the appropriate size of conductors should be chosen.

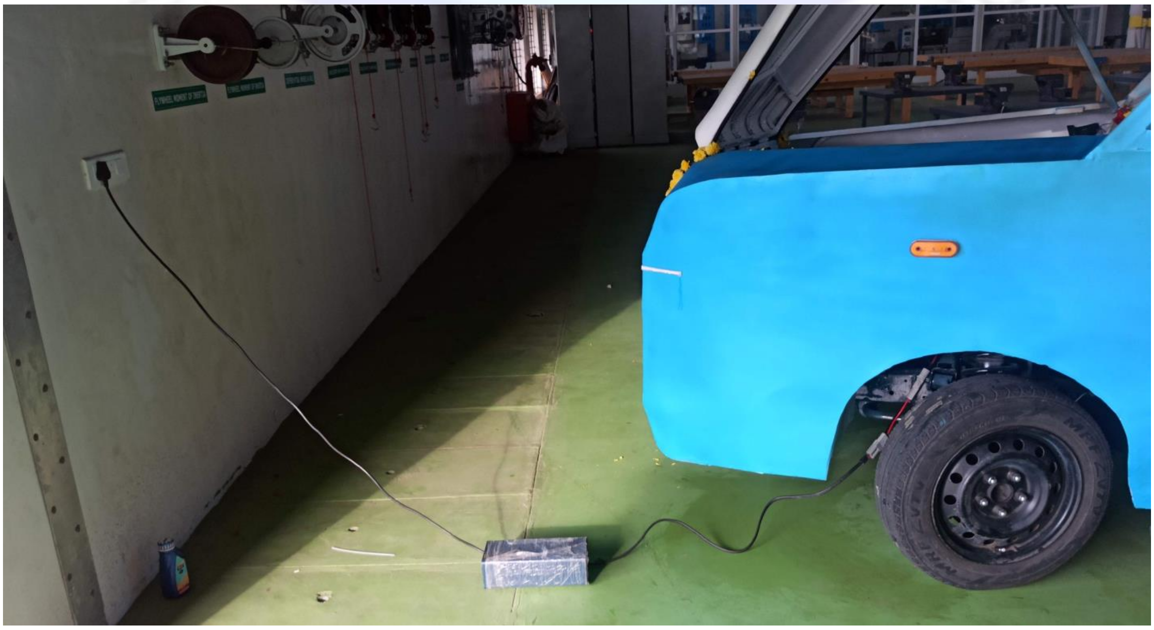
8.5 Loss of design

When the angle of the sun's rays striking the surface of the solar panel is perpendicular, the panels perform optimally. However, due to the Sun's and Earth's relative motion, the sun's beams cannot always be perpendicular to the surface of the solar panel. Solar trackers assist panels in moving from east to west in line with the movement of the sun to capture the most sun rays, however because solar trackers are quite expensive, they cannot be used for tiny units [Tanveer et al., 2022]. Therefore, the best approach to save money and limit the usage of a solar tracker is to identify the ideal tilt and direction of the panels with regard to the sun's rays so that the panels receive the most sunlight during the day. The tilt and orientation are determined by the location of the panels.

8.6 Loss due to aging

Solar PV panels frequently degrade with time, providing less direct current and becoming less efficient. Solar panels' output power will diminish to around 80% of their rated power in the 25th year.

Figure 11 - EV under charging through grid connection.



9. BENEFITS OF SOLAR CHARGING STATION

1) **Sustainability:** By utilizing solar power, the SCS significantly reduces carbon emissions associated with EV charging. It harnesses clean, renewable energy, thereby contributing to a greener transportation ecosystem.
2) **Cost-Effective:** Over time, the SCS offers cost savings compared to traditional charging stations, as it generates its own electricity and reduces reliance on grid power. Additionally, it benefits from government incentives and tax credits for renewable energy installations.
3) **Grid Independence:** The inclusion of energy storage systems allows the SCS to operate independently from the grid, providing reliable charging services even in remote locations or during power outages.
4) **Scalability:** The modular design of the SCS allows for easy scalability, enabling the addition of more PV panels and charging stations to meet growing demand.
5) **Smart Management:** The SCS incorporates advanced monitoring and management systems, allowing operators to optimize energy use, track station performance, and provide real-time data to users through smartphone apps or online platforms.

10. CONCLUSION

According to reports, India has 21 of the world's 30 most polluted cities, and the country is rated fifth on the list of most polluted countries. The electricity generating industry is now India's greatest carbon emitter. Furthermore, carbon particle emissions from the automobile industry are fast increasing as the number of gasoline-powered cars increases. The highest accomplishment of pollution control goals is related with effective pollution management from these two expanding industries. Thus, this paper attempts to build a model that combines solar charging stations for electric cars and the usage of EVs to reduce pollution from both the power generating and automotive sectors at the same time. The SCS for Electric Vehicles is a viable approach for improving EV charging infrastructure accessibility and sustainability. This technology, by using solar power, not only diminishes the environmental effect but also adds to the general expansion of electric mobility, encouraging a more sustainable and cleaner transportation for future automotive sectors.

To summarize, EV SCS are a sustainable and forward-thinking solution to the issues of modern transportation. They lower emissions, increase charging accessibility, improve energy efficiency, and give economic incentives, all of which contribute to a more ecologically benign and economically viable future for electric transportation. As technology progresses and solar energy becomes more widely available, these stations will play a critical role in hastening the transition to a cleaner, more sustainable transportation system.

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Cadet. Sadd Khan, Cadet of Batch-08 (2019-2023) of B. Tech Marine Engineering at Indian Maritime University, Chennai Campus has signed a contract with MSI and is serving as a Trainee Marine Engineer in oil tanker.

SKILLING THE MARITIME SECTOR IN THE WORLD OF DIGITALIZATION

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Abstract

The transition towards digitalization and automation of processes and operations to enhance efficiency, increase competitiveness, and spur industries towards the decarbonization path of net-zero emissions have initiated the emergence of the Maritime Autonomous Surface Ship (MASS) in shipping operations. The rapid pace of digital transformation and technological advancement requires training and retraining of seafarers for adaptability. To accommodate this changing phase of the application of digital technologies in maritime operations and enable smooth transition, the Company of Master Mariners of India organized a focused group seminar to explore and identify potential competency requirements and necessary learning and training for seafarers to stay updated in the changing norm. This White paper distils the proceedings from the focused group seminar and validates it against the extant literature review from the world-class research documented in high-impact journals and then presents an analysis of relevant issues. Systematically commencing from the identification of 4 levels of MASS operation, analysing the key emerging technologies being used, thence analysing the Tasks and Competencies, to assessing the specific training needs, the paper culminates with defining a competency matrix that could be adopted for formulating and developing training and learning for seafarers in MASS operations. CMMI wishes to acknowledge and express its gratitude to the participating organizations, The Directorate General of Shipping, the Indian Maritime University, Warsash Maritime Academy, UK, and the organizing Seminar Committee of the CMMI.

Keywords: Maritime Autonomous Surface Ship (MASS), Digitalization, Automation, Training, Seafarers, Competency Requirements, Learning, Technological Advancement, Decarbonization, Net-zero Emissions.

1. INTRODUCTION

In December 2018, in the 100th session of Maritime Safety Committee meeting (MSC100), MASS was officially defined from the view of legislation as a ship that can operate independently of human-machine interaction in some extent. According to the automation level, MASS was divided into four levels.

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See figure 1 below “Automation level (AL) of MASS”.

Figure 1 - Automation levels of MASS (IMO, 2018)

	Level of autonomy	Human presence	Operational control	Human role
Degree 1	Ship with automated processes and decision support	Yes	Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control	Supervision and operation
Degree 2	Remotely-controlled with seafarers on board	Yes	The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions	Backup to manoeuvre, supervise the systems
Degree 3	Remotely-controlled without seafarers on board	No	The ship is controlled and operated from another location. There are no seafarers on board	Monitoring and remote control
Degree 4	Fully autonomous	No	The operating system of the ship is able to make decisions and determines actions by itself	Monitoring and emergency management

2. ANALYSIS OF KEY TECHNOLOGIES TO BE USED ON MASS

Based on the features of MASS, MASS involves the integrated application of technologies such as cyber-physical systems, Integrated Bridge Systems, environmental information perception, collision avoidance path planning, track control, internet of things, cloud computing, big data, automation, network information security, remote control, satellite and communication, fault diagnosis technologies for equipment and systems and hull condition monitoring etc. Analysis of Key technologies for MASS is as below.

2.1 Cyber-physical Systems

Cyber-physical systems (CPS) are the integration and interaction between computing processes and physical processes. In other words, it can detect and control the physical process through embedded computer and network and realize the influence of physical process on calculation process through feedback loop.

Different from the traditional concepts of computing system and physical system, it combines the information world with the physical world through self-adaptive and feedback closed-loop control, and mainly considers the performance optimization in function. It is an intelligent technology integrating computing, communication, and control technology (3C), which has the characteristics of real time, security, reliability, and high performance.

Autonomous ship is a complex, heterogeneous, and highly reliable application system that meets the requirements of CPS. The realization of intelligent needs the support of multi-source isomerism information, such as the vessel's own navigation status, surrounding environment, equipment status, and inter-vessels, vessel-to-shore interaction.

A. Integrated Bridge System

The Integrated Bridge System IBS is an integrated system, which is reflected in various functions such as perfect navigation, driving control, collision avoidance, information centralized display, alarm monitoring, communication, shore station support, navigation management and control automation.

It is convenient for the driver and shore-based personnel to observe and manipulate and optimize the information of each equipment at the same time, so that the Integrated Bridge System can play a greater role in ensuring the safe navigation of the vessel and reducing the personnel cost than when the equipment is used alone.

The current IBS has entered the stage of artificial intelligence and mobile internet development, and the new generation of IBS will undergo a major change under the guidance of information technology, network technology, communication technology and computer technology.

B. Environmental information perception

At present, information of the fairway, surrounding traffic, other vessels, and own vessel navigation status can be obtained by means of the existing navigation equipment such as radar, AIS, electronic chart and GPS, etc. The water depth, water flow velocity, wind speed and wind direction are obtained by means of hydrological sensors such as depth sounder, ocean current meter and anemometer etc.

For non-vessel obstacles, laser scanners and radar can also be used for fusion recognition. In the process of environmental perception, the information of different sensors or devices may be redundant, conflicting, and missing. It is necessary to realize the reliable identification of the environment by means of information fusion theory.

C. Collision avoidance path planning

When the vessel is sailing, it is necessary to follow the vessel collision avoidance rules. Considering the safety of the collision avoidance path, it is also necessary to consider making the route shorter, more energy efficient and more timesaving. In the early stage, the collision avoidance path planning method based on expert system was widely used.

After the 1990s, with the rapid development of intelligent algorithms, fuzzy control, neural networks, and artificial potential fields have been used in the field of vessel collision avoidance path planning.

However, different intelligent algorithms have their own advantages and disadvantages. The application of multiple intelligent algorithms to avoid collisions has become the development trend of current vessel collision avoidance path planning.

D. Track control

The traditional vessel track control adopts the track automatic rudder method and has experienced four stages: mechanical automatic rudder, PID automatic rudder, adaptive automatic rudder, and intelligent automatic rudder.

In response to these demands, some advanced control algorithms have begun to be applied to vessel track control, such as Line of Sight (LOS) navigation based on state feedback, Model Predictive Control (MPC) based on optimal control theory method, etc.

E. Internet of Things

Based on the communication network such as the internet and mobile communication networks, the Internet of Things uses the intelligent objects with sensing, communication, and computing capabilities to automatically acquire various information of the physical world. It interconnects all physical objects that can be independently addressed, realizes comprehensive sensing, reliable transmission, and intelligent analysis and processing, and constructs an intelligent information service system in which people and things, things and things are interconnected.

In the field of navigation, the application of Global Positioning System (GPS), ARPA (Automatic Radar Plotting Aid) radar, AIS, electronic chart display and information system, integrated bridge system, radio frequency identification (RFID), video surveillance and other technical means has made the vessel develop rapidly in the direction of informatization and intelligence. The emergence of the Internet of Things has provided new ideas for the development of autonomous vessels.

F. Cloud computing

Cloud computing is the development of distributed computing, parallel computing, and grid computing. Real-time and dynamic analysis of the massive amount of information collected by a large number of sensing devices at different times during vessel navigation, and the aggregation, splitting, statistics, and backup of such information require cloud computing with elastic growth storage resources and massive parallel computing capabilities as a support.

G. Big data

The application of big data is the process of using the results of big data analysis to provide users with decision-making and mining potential value. Regional or dedicated data monitoring centres have emerged in the shipping industry.

For example, international shipping companies such as China Ocean shipping Group have realized the operation status of their vessels on a global scale. Europe's information collaboration service concept for supporting inland navigation, traffic management, transportation management and multi-modal transport - Harmonized River Information Services (RIS) provides users with static information such as electronic maps, laws and regulations, and dynamic information such as vessel registration and vessel position, cargo information, and estimated arrival time.

The application of those technologies above on ships is the guarantees to realize the development of different levels of MASS. (Wang Deling, 2020)

3. ANALYSIS OF TASKS AND RELATED COMPETENCIES

The table 1 below shows a limited summary of task descriptions onboard MASS, especially the ROC (Remote Operation Control).

The evolving pace of the maritime industry requires training and qualification in both core and soft skills to meet the complexity of MASS operations. Below is a table 2 showing some of these necessary competencies and skills for MASS Operation:

Table 1 - Task description for MASS

S/N	Task	Description
1	Operational support, monitoring, and navigation	Control all MASS systems, maintain safety at all times, and operate MASS based on regulatory requirements.
2	Operational prediction and optimization of systems	Planning the most efficient route and choice of action.
3	Path tracking, mission planning, and decision-making	Conduct mission planning for MASS operations according to the area, type, and vessel.
4	System maintenance	Servicing and repair (including fault finding), maintenance, pre-launch checks, and overhaul of components of the system.
5	Risks assessment	Conduct a general risk assessment for MASS operations, including deployment, intervention, and recovery.
6	System management and communication	Understand and manage all vessel control and interactions and awareness of the specifics of remote operations.
7	Hosting of server systems	Hosting and managing host server systems.

Table 2 - Competencies for MASS

S/N	Core Competencies	Soft Skills
1	Digital competency (e.g., digital operations of physical systems, software and computer engineering, coding and computer programming, cyber security, data analytics)	Leadership.
2	Classical maritime competencies	Teamwork and communication
3	Automation engineering	Critical thinking, analytical skill and reasoning
4	Maritime law in autonomous maritime operations	Creative problem-solving
5	Maritime economics and logistics (i.e., how global trends impact businesses and business models	Adaptability and agility
6	Remote monitoring operations	Innovativeness
7	Environmental sustainability on evolving technologies	Continuous learning ability

4. ANALYSES OF KNOWLEDGE AND SKILLS NEEDED TO MANAGE AND OPERATE MASS

The current STCW convention and code stipulates the requirements of the training, certification, watch-keeping, and competence for seafarer. MET in most countries in the world are basically conducted in accordance with the requirements of STCW convention and code.

As to the positions on board ships, seafarers are divided in STCW code into three levels: management level, operation level and support level, and the table of KUP (Knowledge, Understanding, Proficiency) in STCW code specifies the competence requirements of the three levels.

The application of new knowledge and new technology on MASS is bound to produce new requirements for the competence of seafarers. The requirements of the current STCW convention and code will not meet the development of MASS in no doubt. In order to further analyse the specific influence of MASS on seafarers' MET, - according to the development trend of MASS, the knowledge and skills needed by navigators in the future to manage and operate MASS is divided into three aspects: Ability, Knowledge and Technology. Each aspect includes several elements (see figure 2 below). However, In the existing traditional MET curriculum, the new knowledge and technology related to MASS are not included, which will not meet the needs of MASS development, making it urgent to reform in MET. See figure 2 below "Knowledge and skills needed to manage and operate MASS in the future".

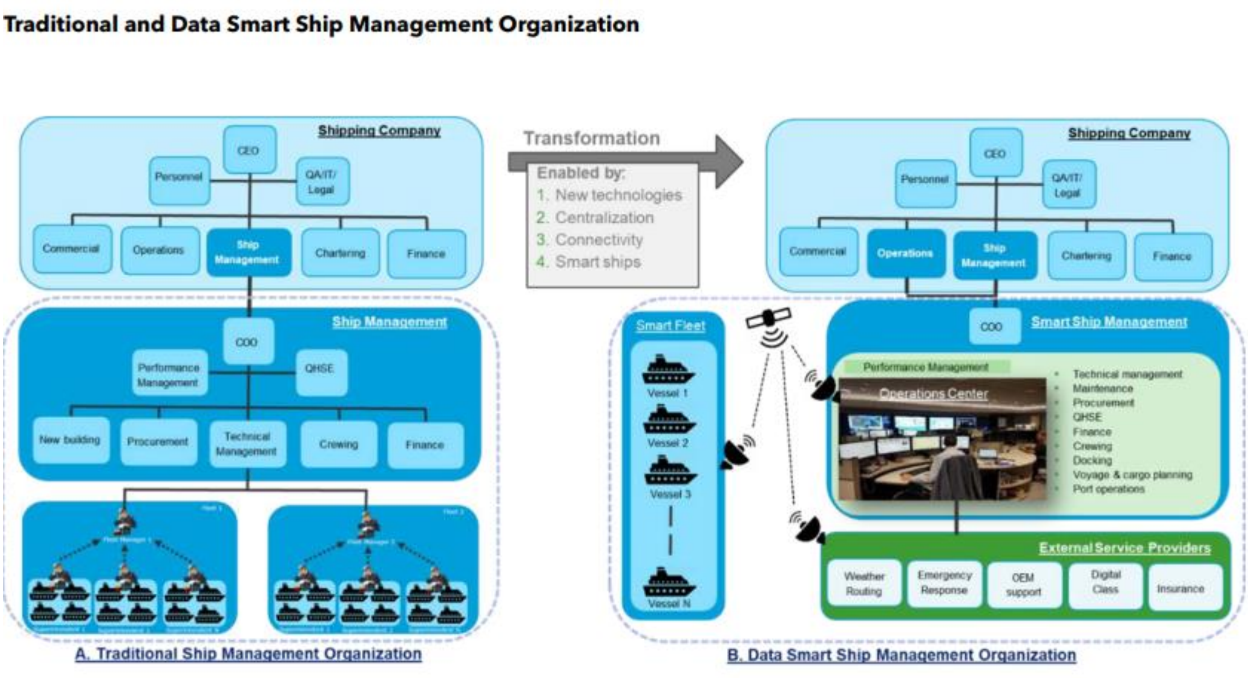
Figure 2 - Knowledge and skills for MASS (Onwuamadike, 2022)

Classification of Knowledge and skills in relation to MASS	**Knowledge and skills**	**Whether included in the existing MET curriculum?**
Aspect of ability	Leadership and communication	Yes,
	Obedience and execution	Yes
	Psychological stress resistance	Not exactly, as the number of ship manning decreases, problems of "psychological stress" will become more prominent.
Aspect of knowledge	Traditional nautical knowledge	Yes
	Network communication knowledge	Not exactly, this knowledge is only reflected in GMDSS courses.
	Automatic control knowledge	Not exactly, there are only some automation knowledge in ships' bridge and engine room control in existing MET.
	Data mining knowledge	No
	Artificial intelligence knowledge	No
Aspect of technology	Autonomous navigation	No
	Fault diagnosis	No
	Remote control	No
	Environmental information perception	No
	Internet of Things	No

Note: The word "navigator" is used here instead of "seafarer", because "seafarer" refers to persons manned on board ships to management and navigate the ship. However, when

MASS develops to a certain stage in the future, the ship will no longer be manned, and it would be inappropriate to use the word of "seafarer" while there is no seafarer on board. The transition is well captured the Figure 3 below:

Figure 3 - Traditional and Data Smart Ship Organization



Being more specific, a limited summary of Specific Training Needs in MASS Operations is as below (UK, 2018). Those knowledge and skills listed in figure above are essential and minimum requirements for navigators in future to manage and operate MASS. The mastery degree of the knowledge or skills required by navigators varies according to position of navigator and the level of MASS.

5. IMPACTS OF MASS ON THE SHIP'S MANNING

The division of four levels of autonomy, in essence, is that the ship's navigation behaviour depends on the division of the level of the ship's crew on board, from no longer entirely depending on the shipboard crew to completely getting rid of crew on board ships.

Figure 4 - Specific Training Needs for MASS

Key Training areas	Explanation
Principles of Autonomous Systems	Understanding of the levels of automation and specifically the level of operator's interaction with the MASS
MASS Regulations, permissions, notifications, requirements	Understand and produce the required notifications, permissions and requirements for the operation of MASS in the given area
MASS Safety Principles including Machine Application of Regulations	Understand the safe operation of the MASS and any limitations in the application of regulations within the system
MASS Command Control and Communications to include Security	Operate and control communications with the MASS, awareness of security aspects (e.g. cyber) and responses when communications are lost
MASS Deployment and Recovery	Control the launch and Recovery of vessels from land or other vessels
MASS Responsibilities (Owner, operator, insurer, accreditor, certifier)	Understand the responsibilities of all parties involved with a MASS operation
MASS Operations Risk Assessment	Conduct Risk assessment for MASS operations including deployment and recovery
MASS Vessel Specifics	Control the specific MASS and understand all operational requirements according to the MASS vessel in operation.
System Maintenance & Checks	Training on the servicing, repair to (including fault finding), maintenance, pre-launch checks & overhaul of all appropriate components of the whole system
Operator Facilities and interactions	Understand all vessel controls and interactions available to the operator and awareness of the specifics of operating a vessel at distance
Limits of Operation	Understand the limitations of the vessel
Sea Awareness and Handling	Demonstrate awareness of the performance of the MASS under different conditions and any specific handling limitations
Operations	Control all MASS system operations, maintaining safety at all times and meeting regulatory requirements
Emergencies contingencies and Faults	Control the vessel or take appropriate action in the event of emergencies including loss of communications with the MASS
Mission Planning	Conduct mission planning for the MASS Operation according to the area, type and vessel solutions

In the first level of MASS, the ships' manning is decreased. In the level of remote-controlled ships, the future "seafarers" will be divided into two types: "shore-based operator" and "seafarers on board ships". In the full autonomous level, the ships will sail autonomously, under which condition there will be no seafarers on board ships. Thus, it can be seen that the reduction of ship manning is a general trend, and the enrolment scale of navigation major will be reduced with the development of MASS.

In terms of horizontal structure, the development of MASS will bring about the adjustment of seafarer type structure. In accordance with the STCW convention and code, seafarers are basically divided into three types: deck crew members in charge of ship navigation and cargo transportation (Major of nautical technology); engine room crew members responsible for ship propulsion and machinery system (Major of marine engineering); and electrical, electronic and control personnel (Major of electrical, electronic and control engineering) responsible for the electrical, electronic installation and control system of the ships. While in higher levels of MASS, the seafarers will not be classified according to the workplaces, and ship control personnel will be divided into two types: "shore-based" personnel and "shipboard crew". The shore-based personnel will be responsible for the navigation of ships by remote control, and the shipboard crew will undertake multiple tasks such as navigation and machine maintenance.

In terms of longitudinal structure, the development of MASS will bring about the adjustment of the hierarchical structure of maritime talents. At present, the cultivation of the maritime talents has three levels: technical secondary, high-vocational education and undergraduate. Whether from view of human capital or from the view of technological development, this occupation requires higher technical conditions, and the society needs more high-quality talents. The development of MASS needs more skilled maritime talents, so the proportion of maritime talents at the levels of technical secondary will continue to shrink, and those of high-vocational and undergraduate level will occupy the mainstream.

6. IMPACTS OF MASS IN DIFFERENT LEVEL ON THE REQUIREMENT OF MET

Through the study on the technologies required by MASS and the content in figures above, different levels of MASS have different impacts on the future maritime education and training.

Impacts of ships with process automation and decision support on MET

Ships with process automation and decision support are equipped with some systems or equipment that can help seafarers to achieve the process automation and decision support of navigation tasks. The navigation decision-making of ships is entirely made by the seafarers themselves, and the information obtained from outside only plays a supplementary role in the decision-making of seafarers. The operation of ship with process automation and decision-support remains largely dependent on the operation and management of seafarers. MASS in this level has limited impacts on modern maritime education and training. However, as the automatic control system and decision support system are widely applied in this type of ship, new requirements will be put forward for the knowledge system and training method of education training.

A. Impacts of Remote-control ships with crew on MET

When the marine autonomous surface ships develop to the second level, i.e. the Remote-control ships with crew, the personnel allocation of the ships will be greatly changed compared with that of traditional ships: shore-based Remote-control personnel will appear, the number of the personnel on board reduced, and the working mode and division of labour will greatly be changed. Marine navigators will need to complete the learning or practice of relevant knowledge and skill in accordance with the requirements in table 2 and meet the corresponding standards of competency. As can be seen from table 2, the knowledge structure required by maritime navigators on Remote-control ships with crew members is changed greatly. In addition to the corresponding traditional maritime knowledge, marine navigators should master new knowledge and technology related to marine autonomous surface ship or apply them in practice to different degrees, such as network information knowledge, automation knowledge, information physical system knowledge, big data knowledge, autonomous navigation and collision avoidance technology, remote control knowledge etc, which will have a considerable impact on the future maritime education and training, requiring the future maritime education and training to include the above new knowledge and technology in addition to the traditional maritime knowledge.

B. Impacts of Remote-control ships without crew on MET

Ships with this stage are equipped with remote control system or facilities that can help personnel being not on board such as remote-control navigators on shore or on other facilities to fulfil navigation tasks. Decisions will basically be made by personnel being not on board and the ship will be unmanned. Compared with the Remote-controlled ships with crew, the Remote-control ships without crew are completely dependent on the operation of the qualified personnel on shore. Therefore, the qualified personnel on shore need to have a deeper understanding of the knowledge of network information technology and automation technology, as well as an extensive knowledge reserve to cope with the remote and changeable marine navigation environment.

C. Impacts of full autonomous ships on MET

Ships in this level are equipped with the system or equipment that can enable it to accomplish the tasks of navigation autonomously. The decision-makings for ship operations are completed autonomously. There is no crew on the ship. Control personnel on shore mainly play the role of monitoring the ship's navigation performance, when necessary, can get involved in controlling the ship. Higher requirements have been put forward for suitable personnel of full autonomous ships. The supervisors need to be proficient in all the knowledge and skills listed in paragraph 1 above detailing Key Technologies for MASS.

7. WHAT TYPES OF SKILLS AND COMPETENCIES ARE REQUIRED TO PERFORM SHORE-BASED OPERATIONS OF UNMANNED AND AUTONOMOUS SHIPS?

Definitely one would say that there should be a training on ICT, about machinery operation. They should know basics about artificial intelligence and troubleshooting skills.

They will have to be ex-seafarers. They should be like master’s licence holders at the minimum because they need to know exactly, just like you are controlling the ship, they need to know when to take over. They should be just like a master taking over the manoeuvring.

It will be critical to diminish the focus on mechanical and electrical training and focus more on electronics in the short term and on artificial intelligence and machine learning in the future, that is the real future.

They will still need the traditional seafaring skills. In addition, they will need the basic skills of how to operate a computer, computing skills, gaming skills. Also, they will need to understand the environment, they will need to understand cargo and stability, they will need to understand all of the engineering. Future operators in shore-based will need to have high cognitive skills, which will allow them to deal large amount of information on the screen displayed in shore-based stations. They should be very sound, theoretically.

Leadership, communication, decision-making, information management, risk analysis and task allocation are also among the soft skills that will be needed by shore-based operators in order to effectively do their job. Only ex-seafarers should be trained to operate autonomous and unmanned ships – is quite established. With regard to the specific certification that future shore-based operators should hold. It is suggested that a smart ship's (i.e., autonomous/unmanned ships') licence could be added above the traditional licence. Maybe we can call it like a smart ship operator's licence.

Adapted competency matrix for MASS and conventional ships as per figure below: -

Figure 5 - Competency Matrix for MASS and Conventional ships (Cicek & Akyuz, 2019)

MASS Competency Matrix

Persons	Vessel/ Shore	Ship (MASS) Digital System Understanding and Technical Knowledge	Operations monitoring and analysis (remote operations)	Equipment operations and control	Equipment maintenance and repair	Automation engineering	Trouble shooting	Data engineering (data processing and analytics)	Electrical/ electronics engineering	Autonomous maritime law and regulations	Programming	Cybersecurity	Maritime economics and logistics
Traditional Seafareres	Conventional ships		0	0	0	0	2	0	0	0	0	1	1
Seafarers with Advanced Technology Skills	MASS (autonomy levels - 1 & 2); IMO		2	2	2	2	2	2	2	2	2	2	2
Remote Operator	MASS (SCC/ROC - autonomy levels - 3 & 4); IMO		2	2	2	2	2	2	2	2	2	2	2

Persons	Vessel/ Shore	Classical Maritime Competency - Deck/ Engine (STCW i - viii)	Navigation/ marine engineering	Cargo handling and stowage/ maintenance and repair	Ship operations/ Electrical, electronics and control engineering	Maritime law and regulations	Security Duties	Good seamanship
Traditional Seafareres	Conventional ships		2	2	2	2	2	2
Seafarers with Advanced Technology Skills	MASS (autonomy levels - 1 & 2); IMO		2	2	2	2	2	2
Remote Operator	MASS (SCC/ROC - autonomy levels - 3 & 4); IMO		2	2	2	2	2	2

Persons	Vessel/ Shore	Soft Skills	IT and technology affinity	Leadership and teamwork	Good reasoning and decision making	Critical thinking and problem solving	Efficiency orientation	Good communication	Managing complexity	Cognitive ability and analytical skills	Innovativeness	Flexibility and adaptability	Continous learning - motivation to learn, learning & resaerch	Environmental awarenes and sustenability mindset
Traditional Seafareres	Conventional ships		1	2	2	2	2	2	2	2	2	2	2	2
Seafarers with Advanced Technology Skills	MASS (autonomy levels - 1 & 2); IMO		2	2	2	2	2	2	2	2	2	2	2	2
Remote Operator	MASS (SCC/ROC - autonomy levels - 3 & 4); IMO		2	2	2	2	2	2	2	2	2	2	2	2

Definitions:
0 - Not necessary
1 - Should have basic knowledge/skills
2 - Should have good knowledge/skill (theory &practical)

Comments: These competencies and task descriptions are summarily explained in (Chapters 2.8, 2.9, Tables 5 & 6, and figure 10 in chapter 5.1). The matrix is in generalty to seafaring, both traditional and MASS operations.

8. RETENTION, ATTRACTION, AND OPPORTUNITIES

Retention and attraction are crucial in the maritime industry, with many seafarers facing limited opportunities for career advancement and development. Lack of a career path and poor compensation can lead to a loss of experienced and talented workers, creating a skills gap in the industry which is already under strain. This is likely to be more impactful if seafarers are trained in highly specialized areas, likely to prevail in the decade of transformation when digitalization and new technologies emerge.

It is recommended that Shipowners/operators/managers should closely manage the progression opportunities of seafarers from both a retention/attraction and operational capability standpoint. Career development opportunities brought about by digitalization and decarbonization should be leveraged to retain and attract people to seafaring jobs.

Most seafarers would prefer to perform their current onboard role if it could be shore-based. This brings new opportunities for seafarers using their existing skill sets in shore-based control and monitoring facilities such as Shore Control Centres. In addition, shore-based jobs will remove many negative connotations associated with a seafaring career, bringing about significant benefits to seafarers and their families (DNV 2023).

Shipowners/operators/managers should harness the unique and desirable skill sets of seafarers and provide them with opportunities for complementary shore-based roles such as vessel control and monitoring facilities (shore control centres), which will likely become more prevalent later in the current decade and beyond.

9. CONCLUSION

In the future, ships may be controlled and operated autonomously without intervention of human if MASS can reach the level of unmanned control. It is in no doubt that the wider application of MASS will bring great changes to the shipping industry and pose great challenges to seafarers' knowledge structure and maritime talent cultivation, thus posing great challenges on the Maritime Education and Training.

As is analysed above, basically those challenges on MET are reflected on the following two aspects:

1) Application of new technologies on MASS requires higher-standard maritime talents

Shipping is now stepping into the first level of MASS, i.e., ships with the process automation and decision support. MASS in this stage is mainly dependent on operation and management of crew, which has a limited impact on modern maritime education and training. As the automatic control system and decision support system gets applied widely, new knowledge and skill needs to be increased in the existing education training. However, in terms of the current growth momentum of technologies, ships will rapidly develop into a higher level in the coming decades, and by then traditional knowledge and skills of ship navigation will not meet the requirements for MASS operation. In addition to the traditional maritime knowledge, ships' navigators are to be required to master new knowledge and technology related to MASS such as network information knowledge, automation knowledge, information physical system knowledge, big data knowledge, autonomous navigation and collision avoidance technology, remote control knowledge, etc.

Maritime universities, colleges, training institutions and maritime authorities are suggested to closely track the development of MASS and provide relative new knowledge and improve modes of maritime education in order to produce talents suitable for the development of navigation technology.

2) Mode of MET need to be adjusted to adapt to different levels of MASS

The division of four levels of autonomy, in essence, is that the ship's navigation behaviour depends on the ship's manning, in other words, operation of ships evolves gradually from entirely depending on the shipboard crew to completely getting rid of crew. The development of MASS is to bring about the adjustment of seafarer type and the hierarchical structure of maritime talents.

Different from traditional ship manning mode, in higher levels of MASS, ship navigators will be divided into two types: "shore-based" personnel and "shipboard crew". The shore-based personnel will be responsible for the navigation of ships by remote control, and the shipboard crew will undertake multiple tasks such as navigation and machine maintenance. Therefore, design of maritime curriculum system shall be adjusted to include new skills and knowledge required by MASS.

What's more, the development of MASS needs more higher standards maritime talents, so the proportion of maritime talents at the levels of technical secondary will continue to shrink, and those of high-vocational and undergraduate level will occupy the mainstream. Therefore, it is suggested that MET should closely track and follow the development of MASS, forecast the supply and demand for seafarers, dynamically control the scale of maritime talent education, reshape the curriculum system, renew the teaching content, promote innovation of the education mode, and improve the educational quality of maritime talents to adapt to the development of MASS.

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ANALYSIS OF NAVIGATIONAL KNOWLEDGE, SKILLS, AND PROCEDURE COMPLIANCE OF THE DEEP-SEA FISHERS OF THOOTHUR ZONE, SOUTHWEST COAST OF INDIA.

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Abstract

Growing number of accidents involving fishing vessels at sea particularly collision between vessels and loss of vessels due to heavy weather is a serios concern. Poor navigation being the main reason, a study was conducted on the Navigational Knowledge, Skills and Procedure Compliance of the deep-sea fishers (125 respondents) of Thoothur zone, Southwest coast of India during 2022-2023 which revealed Navigational knowledge index of the fishers as 4.29. Further their Navigational skill index was estimated at 7.90 and the Navigational procedure compliance being 6.73. The low Navigational knowledge index indicated inadequate knowledge level and could be attributed to the low educational level with the mean schooling years of 6. Relatively better Navigational skill index could be attributed to higher level of interpersonal skills (Interpersonal skill index 9.06) besides terrestrial and celestial navigational skills (Index value 9.02). The reason for the relatively lesser adoption of Navigational procedure compliance observed in the study could be due to the fact that the fishing vessel design itself did not comply with the standard design and without basic navigational facilities. The study warranted need for the up gradation of navigational knowledge level of the deep-sea fishers of Thoothur zone through trainings. Further, the Navigational equipment operational skills and cognitive skills are to be improved through practical demonstration and awareness trainings respectively. The design of the deep-sea fishing vessels also needs to be standardised besides equipping the vessels with adequate modern navigational equipment such as RADAR (Radio Detection and Ranging), NavIC, Automatic Identification System (AIS) and Electronic Navigational Chart which are required for safe navigation in deep-sea fishing vessels.

Keywords: Thoothur zone, deep-sea fishers, Navigational knowledge, skill and procedure compliance index.

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1. INTRODUCTION

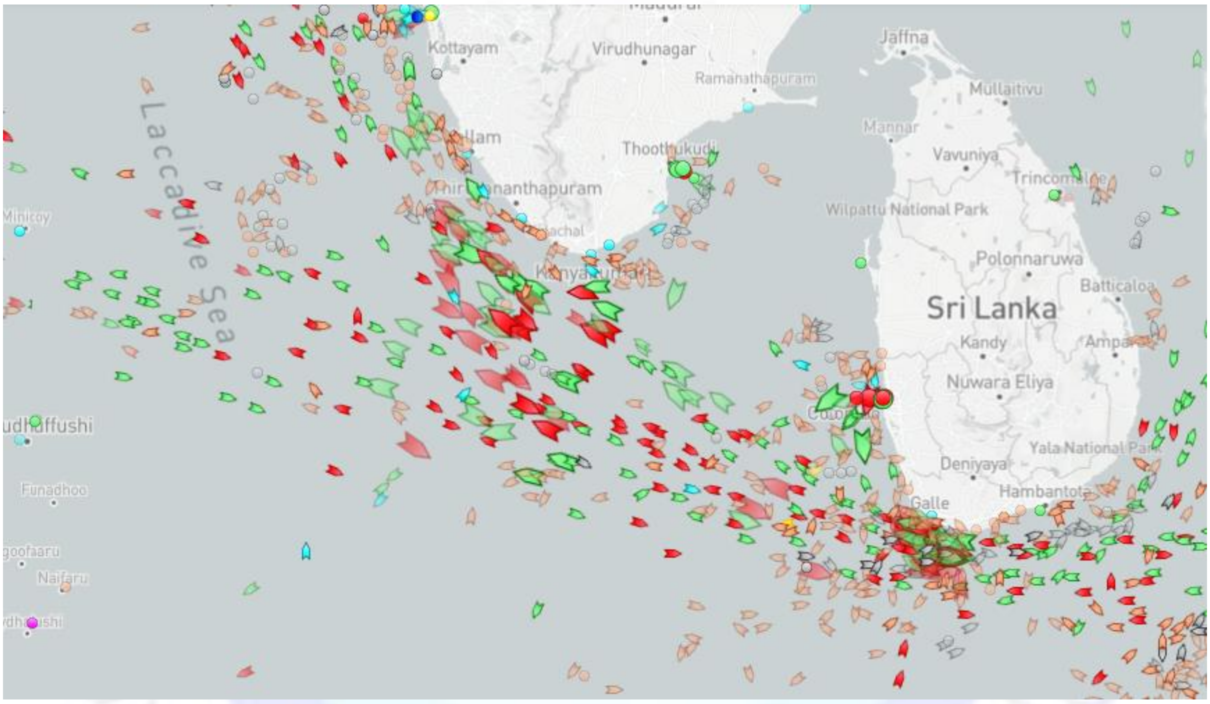
Fishing vessels have been facing navigation related incidents quite often during navigating and fishing at sea. Marine insurance company GARD had claims from 49 collision incidents involving fishing vessel between 2015 and 2020 with loss of life to 54 fishers besides major injury to 15 fishers. Grounding (30%) and collision (9%)were the 2nd and 4th most accidents accounted for Canadian fishing vessel from 2011 to 2021(TSB, 2021). For the year 2014-2021, out of 177 vessels lost at sea, 61% belongs to fishing vessel category in European Union(EMSA, 2022). In UK, out of 90 vessels, 5 vessels were lost due to collision and 2 due to contact for the year 2012-2020(MAIB, 2021).

In Indian during Ockhi cyclone, the fishermen dead and missing in Tamil Nadu were 218 and in Kerala 143. In Kerala from Thiruvananthapuram district alone 91 fishers were found missing during the Ockhi cyclone(FAO, 2019). For the year 2020, In Indian ocean region 60% and 35% of the incidents were collision and grounding respectively involving small vessels including fishing vessels and the capsizing incident was found to be 125 in which 90% accounted for small craft including fishing vessels(MMSU, 2020). 15 fishing vessels had capsized at mid-sea off Gir Soamnath Nava Bandar port due to neglect of the weather warning issued by Indian Meteorological Department (IMD) for the strong wind (Methri, 2021). National Federation of Fishers Cooperatives (FISHCOPFED) found that on an average, they received reports of 100-200 fishermen deaths every year – with “more deaths on the east coast than on the west coast” during the year 2021. From April 2013 to Dec 2021, 278 incidents had occurred at sea involving fishing vessels (IFC-IOR) which included 26 collisions and 13 grounding.

During the year 2012, there was a sharp rise in the number accidents to the fishing vessels at sea in the state of Kerala, as evidenced through 433 rescue operations against 176 during the year 2010. There were 3 collision accidents occurred between fishing vessels and merchant vessels in the year 2016. It rose to 10 for the next two years which claimed several lives (Neethu, 2019). Kerala fishermen welfare fund board found that 327 fishermen were dead due to accidents at sea in the past 5 years (2016 to 2021 Nov) across Kerala, of which 145 died in Thiruvananthapuram district followed by 68 in Kollam district. In these incidents capsizing accounted to 19 followed by 8 collisions, 8 grounding incidents and 6 engine failures incidents. During the year 2021, there were 2 collision accidents between fishing vessels and merchant vessels in the southwest coast of

India. The accidents involving fishing vessels in Indian waters are a great concern as it leads to loss lives besides loss of property. The reason for so much of navigational related indents could be due to their poor navigational activities. This study was conducted at Southwest coast of India with the objectives of finding Navigational knowledge, skills, procedure compliance of the deep-sea fishers and to recommend necessary corrective measures.

Figure 1 - Marine Traffic condition near Southwest coast of India



2. MATERIALS AND METHODS

The study was conducted covering 125 Thoothur zone deep-sea fishers involved in navigation of the vessel during 2022-2023. Thoothur zone is located in Tamil Nadu, Southwest coast of Indian, close to international maritime traffic route and consists of 8 fishing villages namely Chinnadurai, Vallavilai, Eraviputhenthurai, Poothurai, Erayumanthurai, Marthandanthurai, Neerodi and Thoothur. A detailed survey was made with structured interview schedule. Simple random sampling method was employed, and perception analysis was carried out during the data collection. Descriptive analysis and regression analysis were used to analysis the data to test the hypothesis and finding Navigational knowledge, skill and procedure compliance indices.

Socio democratic characteristics such as age(X1), educational status(X2), experience at sea(X3), fishing vessel type (X4), length of fishing vessel worked (X5), fishing distance (X6), duration of voyage (X7), fishermen income (X8), number of trips per year (X9), trainings attended (X10), innovativeness (X11), self-confidence (X12), scientific orientation (X13), risk orientation (X14), economic motivation (X15) and safety orientation (X16) were kept as independent variables and Navigational knowledge, Navigational skill and Navigational procedure compliance were kept as dependent variable and regression analysis was carried out for each dependent variables to measure the correlation among them.

Navigational knowledge is defined as information and understanding about moving the vessel from one place to another place by plotting the track, knowing position, speed and directing the vessel along the track. The Navigational knowledge level of the deep-sea fishers was measured by interviewing them with 10 Navigational knowledge related questions. The correct answer was given one mark and Navigational knowledge index was arrived based on the below formula.

$$\boldsymbol{Navigational\ knowledge\ index} = \frac{\sum_{i=1}^{n}(\mathrm{K}i)}{n}$$

K*i – Marks obtained by the* i^{th} *respondent*

n= Total number of respondents (n=125)

Navigational skill is defined as the ability to use one's Navigational knowledge effectively and readily in execution or performance of the navigation of the vessel. Navigational ability can be classified under two broad categories, i.e. Technical skills and Non-technical skills. The technical skills were further subdivided into terrestrial, celestial navigational skill and equipment operational skill. The non-technical skills were also sub divided into cognitive skill and interpersonal skill. The sub divided 4 skills were assessed through 10 questions each and each answer was assigned score in ordinal scale with 4 as the maximum score. The Navigational skill index was arrived based on the below formula.

$$\boldsymbol{Navigational\ skill\ index} = \frac{\sum_{i=1}^{n}(TCi + NEi + Ci + IPi)}{Ks\ x\ n}$$

TCi = Marks obtained by the i^{th} respondent on terrestrial, celestial navigational skill

*NE*i = Marks obtained by the i^{th} respondent on navigational equipment operational skill

*C*i = Marks obtained by the i^{th} respondent on cognitive skill

IPi = Marks obtained by the ith respondent on interpersonal skill

n= total number of respondents (n=125)

$$Ks \;= \frac{\text{Max. marks for one question x Total number of questions on navigational skills}}{10}$$

Procedures are a series of steps followed in a regular definite order. Navigational procedures are being followed on vessels for a safe and efficient navigation of the vessel from harbour to the deep-seas and back. Ordinal scaling technique (maximum marks of 4) was employed to measure Navigational procedure compliance with 10 questions. The navigational procedure compliance index was arrived based on the below formula.

$$\boldsymbol{Navigational\ Procedure\ compliance\ index} = \frac{\sum_{i=1}^{n}(\text{PC}i)}{Kp\ x\ n}$$

PCi = Marks obtained by the ith respondent on procedure compliance skill

n= total number of respondents (n=125)

$$Kp \;= \frac{\text{Max. mark for one question x} \\ \text{Total number of questions on navigational procedure compliance}}{10}$$

Psychological factors such as innovativeness, self-confidence, scientific orientation, risk orientation, economic motivation and safety orientation were measured with 5 questions each and assigned mark from 1 to 3 for each question. Each psychological factor mark was arrived after adding all the marks and mean of all the 6 factors were calculated to classify them into the following 3 categories.

Low: <= mean of psychological factors -1

Medium: = mean of psychological factor ±1

High: >= mean of psychological factor + 1

3. RESULT AND DISCUSSION

In the exploration of deep-sea fisher socio-democratic characteristics and their profound impact on navigational knowledge, skill, and procedural compliance, this section unveils the study's critical findings and offers insightful discussions. It delves into the diverse aspects of the respondents' characteristics and how these factors influence their knowledge, skills, and adherence to navigational procedures. Let's delve into the detailed results and engage in a thoughtful discussion of these significant findings.

3.1 Socio-Democratic Characteristics

The respondents had a mean age of 42.9 years with education level of 7th standard and professional experience of 27 years. Majority of them worked on two types of fishing vessels and average length of the vessel being 59. 7ft.

The fishers travelled up to an average distance of 773 nm from the coast. Their average voyage days extended to 26 days with an income of Rs.20,000 per voyage. Due to their long-distance voyages, most of them could make only 9 voyages per year.

Only 17 (13.6%) of the respondents underwent any kind of training for navigation of the vessel. Their psychological factors for the fishers such as innovativeness (12.56) found to be medium, self-confidence (13.88) high, scientific orientation (7.26) low, risk orientation (10.70) medium, economic motivation (13.98) high and safety orientation (11.81) medium.

3.2 Navigational Knowledge

The study revealed that Navigational knowledge index of the Thoothur zone deep-sea fishers was 4.29. The lower navigational knowledge index could be due to their lower educational level with mean schooling years of 6 and the navigational knowledge acquired was through tradition and personal experience alone.

This is evident through the socio democratic characteristics X5 (length of the vessel worked) alone having positive correlation with navigational knowledge of the deep-sea fishers and Income of the fishermen (X8) and scientific orientation (X13) being negatively correlated at 5% significant level. Age, education and experience did not have any significant correlation with the navigational knowledge of the deep-sea fishers of Thoothur zone.

(Gopal et al., 2018) has also confirmed in his study on traditional knowledge of Kerala fishermen that they were using wind, current, stars, constellations, lunar cycles and weather conditions for the navigation of the vessel into sea for fishing.

3.3 Navigational Skill

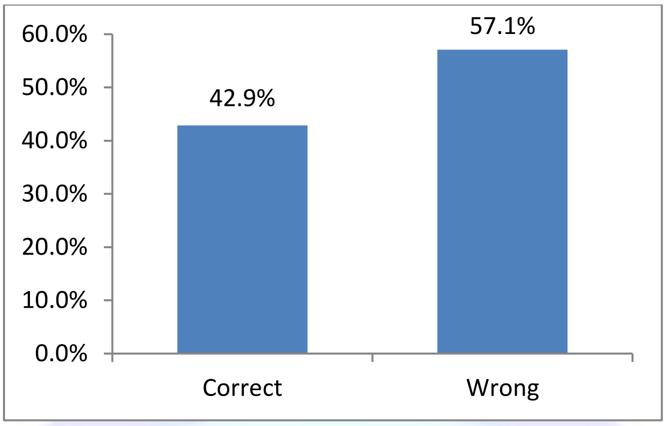
Navigational skill index of the deep-sea fishers of Thoothur zone was calculated as 7.90. It is evident from the study that age (X1), Participation in training (X10) and Safety orientation (X16) had positive correlation with Navigational skills at 5% significant level.

Table 1 - Correlation between the socio democratic characteristics of the Deep-sea fisher and Navigational knowledge, Navigational skill and Navigational procedure compliance

Variable code	Variable	Correlation coefficient		
		Navigational Knowledge	Navigational skill	Navigational procedure compliance
X1	Age	-0.023 NS	0.078*	0.048 NS
X2	Education status	-0.028 NS	-0.015 NS	-0.082 NS
X3	Experience at sea	0.009 NS	-0.066 NS	-0.060 NS
X4	Fishing vessel type	-0.012 NS	0.617 NS	0.284 NS
X5	Length of the vessel worked	0.027*	0.001 NS	0.011 NS
X6	Fishing distance	0.0002 NS	0.002**	0.003**
X7	Duration of voyage	-0.019 NS	-0.014 NS	-0.102**
X8	Income of the fishermen	-.00002*	0.000 NS	0.000 NS
X9	Number of fishing trip	-0.003 NS	0.005 NS	-0.011*
X10	Participation in training	0.401 NS	0.823*	0.261 NS
X11	Innovativeness	0.0240 NS	0.097 NS	-0.211 NS
X12	Self confidence	0.198 NS	0.514**	0.672**
X13	Scientific orientation	-0.202*	-0.093 NS	-0.314*
X14	Risk orientation	-0.151 NS	0.311**	0.055 NS
X15	Economic motivation	-0.005 NS	0.628**	0.527**
X16	Safety orientation	0.038 NS	0.283*	0.296 NS

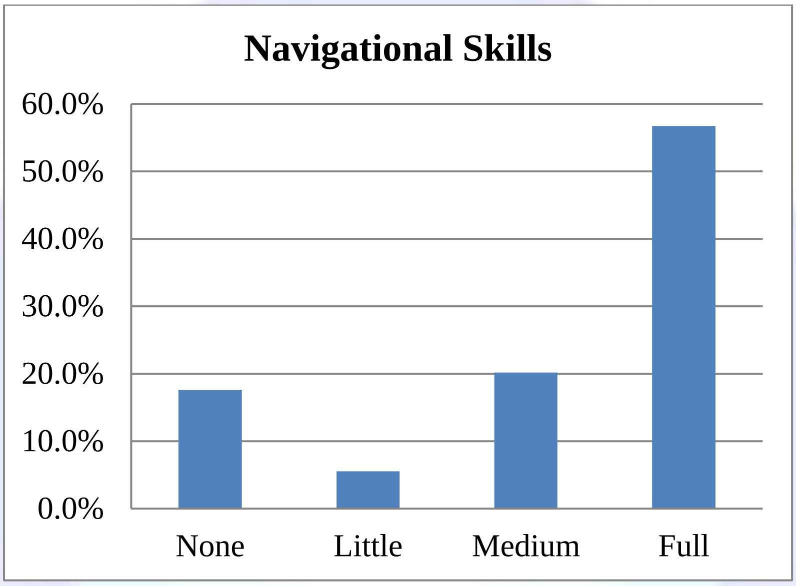
*Note: * - Significant at 5% level, ** - Significant at 1% level, NS – Non-significant*

Figure 2 - Navigational knowledge of the fishers – number of correct and wrong answers



However, Fishing distance (X6), Self-confidence (X12), Risk orientation (X14) and Economic motivation (X15) had positive correlation with Navigational skills at 1 % significant level. It is evident from the study that self-confident of the deep-sea fishers could have played a major role in developing these skills. However, the lack in the skills could have been caused due to the lack in formal training. They could develop the skills on their own to the limit of their exposure to the sea. Similar finding was seen when (Yi, 2015) in his study on collision between fishing vessels and merchant vessels in China, reported that deficiency in training led to unawareness of the danger involved in marine navigation to the fishing vessel personnel. This was also caused due to their poor education level. The study further reveals that their terrestrial, celestial navigational skill is high (9.02) and it could be due to the routine practice of arrival and departure from the same fishing harbour. Less equipment operational skill (5.69) indicated that even though the fishing vessel were fitted with modern electronic equipment which made their navigation more safe and efficient, navigational decision making lacked due to unavailability of the modern meteorological, communication equipment such as NavIC messaging system onboard deep-sea fishing vessel to predict the weather conditions well in advance(Thara, 2018)(Suresh et al., 2018) and to avoid Ockhi cyclones (P. Punya et al., 2021). This study is in confirmation with the study conducted on the need for navigational decision making for avoiding maritime environmental factors such as unpredictable weather conditions, navigational errors and human factors(Roberts et al., 2010) and impact of hydro meteorological conditions in safety of fishing vessel in polish fisheries (Pleskacz, 2015). The study further revealed that cognitive skill (7.84) was considerably less among Thoothur fishers. Poor cognitive skill could lead to poor situational awareness. This is in line with the study conducted by (Baker & McCafferty, 2005) that human failures caused nearly 80% of the maritime accidents at sea. High Interpersonal index (9.05) indicated that onboard management, teamwork and leadership skills were better. This could be due to the fact that onboard working culture in Thoothur zone boats were practically designed to continuously improve and directly related to the catch output. The small lagging in index could be due to non-availability of the formal awareness training to the deep-sea fishers in crew resource management. (Pietrzykowski, et al., 2017) concluded that conversion of navigational information system into decision support system would reduce human errors and thus accidents at sea.

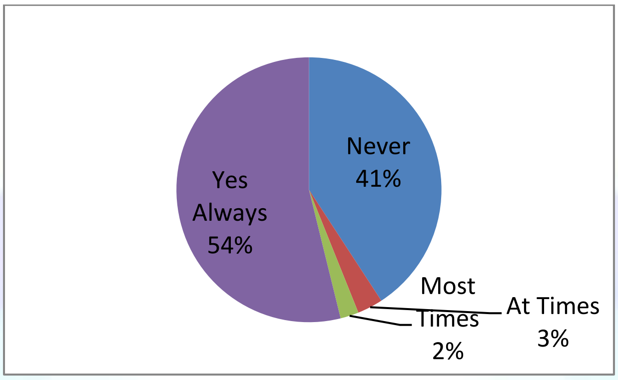
Figure 3 - Navigational skill of the Thoothur fishers – ability of the fishers



3.4 Navigational Procedures

Deep-sea fishers of Thoothur zone had procedure compliance index of 6.73. It is evident from the study that compliance with the collision regulations and watch keeping procedures were less. Fishing distance (X6), Duration of voyage (X7), self-confidence (X12) and economic orientation (X15) had correlation at 1% significant level. Number of fishing trips (X9) and scientific orientation (X13) had correlation at 5% significant level. The poor procedure compliance is evident through their practice of keeping the navigational bridge unmanned during night and in some cases lights off to save batteries. This was in line with the study conducted by (Shankar et al., 2014) on knowledge level of fishers on marine policies and regulatory measures and reported that 61.34% of the fishers knowledge level was medium. (Yi, 2015) had reported that poor lookout and unaware of the collision regulations caused many accidents in Chinese coastal waters. Many accidents and close quarter situations were encountered by these fishing vessels in the past. This could be due to less manpower and excessive workload demanded the whole crew of the vessel involved in fishing operations keeping the bridge watch in the darkness. In addition, this excessive work load caused fatigue and led to the crew to fall asleep when kept for keeping watch. (Kongsvik et al., 2012) studied the impact of different watch keeping regimes at sea on sleep, fatigue and safety and concluded 8-8-4-4 system of watch keeping had better sleep efficiency.

Figure 4 - Navigational procedure compliance of the Thoothur fisher



4. CONCLUSION

Thoothur zone fishers were doing a successful fishing at sea through sailing to very long distance in Indian Ocean and stay for long period of time at sea. They had acquired their navigation related knowledge through their own experience and developed the navigational skills by themselves and passed on to the next generation. The Navigational knowledge was low as they could not get any training to enhance their knowledge. It was always thought by the fishers that as long as they did not involve in collision incidents and there were no loss of fishing gears or damaged to fishing gear by other vessels, they were perfect and safe in navigation of the vessel. However, recent accidents involving fishing vessels in the south west coast of India indicates the need for bringing the deep-sea fishing vessel operations and knowledge of the fishing vessel personnel on par with the internationals standard. The navigational skills were little better as they could develop the skills through their day to day activities. However, this lacked as there is no formal training was given to enhance their skills on par with the international standard as shown in STCW-F. Navigational procedures are set of procedures followed by the vessels on the bridge in watch keeping at sea and compliance of collision regulations. Collision regulation classify the vessels into power driven vessel, vessel engaged in fishing etc(COLREG, 1972) and the regulation is common to all the vessels at sea. Poor understanding of the collision regulations and less observance of the watch keeping procedures on fishing vessels led to many navigational related accidents in Indian fishing vessels. This brings a need to enhance the knowledge and procedures followed by the fishers to come on par with the other vessels being operated at sea.

5. RECOMMENDATION

The low Navigational knowledge index demands the need for uplifting their knowledge level in par with the international standard. This could be possible only through education and training. Standardisation of the Training, Certification and watch-keeping for fishing vessel (STCW-F) convention is in force and stipulates training standards for fisheries personnel(STCW-F, 1995). Even though India did not ratify the convention, training structures which is similar to the STCW-F and suitable to the Indian marine fishing industry can enhance the knowledge and technical skills of the deep-sea fishers. Awareness program can be conducted to enhance the non-technical skills of the fishers. The design of the vessels also needs to be upgraded to be COLREG compliant and fitted with modern electronic navigational equipment. The fishing vessels need to be fitted with light and mast for displaying various signals as required by the COLREG. Further modern electronic communication and navigational equipment can be fitted onboard for effective decision making. Moreover, the vessels need to be manned with sufficient licensed personnel for navigational activities besides fishing personnel.

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SAILING TOWARDS GENDER EQUALITY AND INCLUSIVITY IN MERCHANT NAVY

Dr Poonam Kapoor[1].

Abstract

This paper addresses the paradigm shift towards gender equality in the Merchant Navy, focusing on initiatives like the 'Women in Maritime' program by the International Maritime Organization. Despite progress, challenges persist, with only 9% of executive leadership comprising women, highlighting the need for more inclusive policies and increased awareness. The advantages for women in the Merchant Navy, such as equal pay and global experiences, align with the industry's gains in diversity and innovation. To overcome barriers like biases and demanding work conditions, the paper advocates for strategies including increased role models, inclusive policies, and enhanced awareness and education. While acknowledging positive strides, the conclusion stresses sustained efforts for a truly inclusive future in the maritime sector.

Keywords: Gender equality, Maritime industry, Women seafarers, Challenges, Opportunities, Diversity, Inclusion, Equal pay, Career advancement.

1. INTRODUCTION

Merchant Navy has traditionally been a male-dominated profession, but recent years have seen a significant shift towards gender equality and inclusivity in the industry. Women are now being welcomed into the profession, and more efforts are being made to make the industry more welcoming and inclusive for all. The International Maritime Organization (IMO) has recognized the importance of gender equality and inclusivity in the maritime industry and has been working towards achieving it. According to the IMO, the maritime industry has recognized that there is a need to increase the number of women in the industry, as this can improve the industry's overall competitiveness and sustainability. Additionally, gender equality can lead to better economic

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growth in countries, and companies with more women leaders perform better, according to a study by Catalyst. The IMO has adopted the Women in Maritime program, which aims to promote gender equality and empower women in the maritime sector. It also provides training opportunities for women in the industry.

According to the International Maritime Organisation (IMO), there are around 2% of women seafarers in the shipping industry worldwide and 1% in India, and most of them work in the cruise industry or in administrative positions. However, the trend towards increasing the number of women in the maritime industry is on the rise. In 2019, the International Maritime Organization (IMO) launched its ‘Women in Maritime’ program to promote gender diversity and empower women in the maritime sector. The program aims to increase the number of women in maritime-related fields to 30 per cent by 2030.

In recent years, many countries have taken steps to promote gender equality in the maritime industry. For example, in India, the government has launched several initiatives to increase the number of women in the maritime sector. The maritime industry has been making efforts to attract women to the profession by promoting gender diversity and inclusivity. The industry has started to recognize the value that women can bring to the profession. Women bring unique skills and perspectives to the industry, which can help to improve the industry.

The industry is also making efforts to create a more inclusive work environment. This includes addressing issues such as sexual harassment and discrimination, which have been a problem in the industry. The industry is now taking steps to ensure that all employees are treated with respect and dignity.

The Maritime Labour Convention (MLC) has been adopted by the International Labour Organization to ensure that seafarers are protected from discrimination and harassment. The MLC provides specific guidelines on the treatment of seafarers, including the provision of equal opportunities and the prevention of discrimination.

The industry has also been working towards creating a more supportive environment for women in the profession. This includes providing access to maternity leave and flexible working hours. The industry is also providing mentoring and training opportunities for women in the profession.

2. STATUS OF GENDER DIVERSITY

Gender equality and inclusivity in merchant navy is a topic that deserves more attention and action from all stakeholders in the maritime sector. As discussed earlier, there are many challenges and opportunities for women in merchant navy, both onboard and ashore. However, the female population is still very low, especially in senior and leadership positions. According to a report by Spinnaker, only 9 per cent of the executive leadership team members in maritime companies are women. This indicates that gender diversity in maritime is taking a long time to achieve. Some of the possible reasons for this slow progress are:

Lack of awareness and exposure: Large population is not aware of the career opportunities merchant navy offers. People in general not aware about the scope and benefits of working in merchant navy, there is a lack of knowledge about career for women on board a ship. There may also be a lack of awareness and education among men about the value and importance of gender diversity and inclusion in the maritime sector.

Barriers: Misconceptions about the nature, requirements of the job and life on board a ship creates social and cultural barriers that discourage women from choosing this field.

Gender bias and stereotypes: Women may face discrimination and harassment from their male counterparts or superiors who may doubt their abilities or suitability for the job. They may also face challenges in balancing their personal and professional lives, especially if they have family responsibilities or plan to start a family.

Physical and mental stress: Working in merchant navy involves long hours, harsh weather conditions, isolation from family and friends, and constant adaptation to different cultures and environments. It is preconceived notion that women may find it difficult to cope with these factors.

Lack of role models and mentors: Women do not have enough exposure to successful women leaders in the maritime sector who can inspire them, guide them, and support them in their career aspirations. They is a dearth of guides and mentors who can provide young women encouragement, knowledge, advice, and opportunities for growth and development in this field.

Lack of policies and practices: Industry needs adequate policies and practices to facilitate the entry and retention of women. These may include flexible work arrangements, maternity and paternity leave, childcare facilities, anti-harassment measures, equal pay audits, gender-sensitive recruitment and promotion processes, etc.

2.1 Advantages for Women in Merchant Navy:

There are many advantages and incentives for women to join merchant navy, such as:

- **Equal pay and opportunities:** Women in merchant navy are paid equally as men for the same rank and position. They also have equal opportunities for promotion and career advancement based on their performance and qualifications.
- **Travel and adventure:** Women in merchant navy get to travel around the world and experience different cultures enriching their personal and professional lives.
- **Braking Barriers:** Women get an opportunity to prove their worth and potential in a male-dominated industry. Their career choice can inspire other women. They can also receive recognition and appreciation from their employers, clients, colleagues, and society for their contributions to the maritime sector.

2.2 Advantages for the industry for having women seafarers:

The industry can also benefit from including more women onboard ships, such as: Diversity and innovation: Women can bring different perspectives, ideas, skills, and experiences to the maritime sector. Their presence can foster a more inclusive, collaborative, and creative work environment that can enhance productivity, efficiency, and quality.

Safety and sustainability: Presence of women on board a ship can help improve the safety and sustainability of the maritime operations by promoting a culture of compliance, responsibility, accountability, and respect.

Reputation and competitiveness: Women can help improve the reputation and competitiveness of the maritime sector by showcasing its attractiveness, professionalism, and social responsibility. They can also help attract more talent, customers, investors, and partners to the industry.

Therefore, it is important to encourage more women to join merchant navy by creating awareness, providing education, training, mentoring, scholarships, incentives, policies, facilities, support systems, networks, role models, etc. that can help them overcome the challenges and leverage the opportunities in this field. It is also important to create a culture of respect, equality, diversity, inclusion, empowerment, recognition etc. that can help them thrive and succeed in this field. By doing so, both women and the industry can benefit from each other's strengths and potentials. It is important to address these issues and create a conducive environment for women to join and advance in the maritime sector. Some of the possible actions that can be taken are:

Increasing role models and mentors: Women need more visibility and recognition of their achievements and contributions to the maritime sector. They also need more opportunities to network with other women leaders and professionals who can share their experiences, challenges, and best practices. They also need more mentors who can provide them with guidance, support, and sponsorship for their career development.

Implementing policies and practices: Women need more policies and practices that can enable them to balance their personal and professional lives, protect them from discrimination and harassment, ensure them fair compensation and benefits, and provide them with equal opportunities for career advancement. These policies and practices should be aligned with international standards and best practices, such as those recommended by IMO.

Enhancing awareness and education: Women need more awareness and education about the scope and benefits of working in the maritime sector, as well as the skills and qualifications required for the job. They also need more access to quality training and education programs that can equip them with the necessary competencies and credentials for the job. Men also need more awareness and education about the value and importance of gender diversity and inclusion in the maritime sector, as well as the skills and attitudes required for working effectively with women. By taking these actions, both women and men can benefit from a more diverse and inclusive maritime sector that can enhance its performance, competitiveness, sustainability, reputation, etc.

3. CONCLUSION

The efforts towards gender equality and inclusivity in the maritime industry have already started to yield positive results. Women are now being welcomed into the profession, and there are more opportunities available for them. The industry is also benefiting from the unique skills and perspectives that women bring to the profession. The maritime industry is sailing towards gender equality and inclusivity. There is a growing trend towards increasing the number of women in the maritime industry. The IMO and various countries are taking steps to promote gender equality in the industry, which will hopefully lead to more women sailors in the future. The efforts being made by the industry towards achieving this goal are commendable. However, there is still a lot of work to be done to ensure that the industry is truly inclusive for all. The industry must continue to promote gender diversity and inclusivity to create a better future for all seafarers.

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MARINE POLLUTION AND SDG 14 IMPLEMENTATION DEGREE OF CHALLENGES AND COMBAT STRATEGIES

Dr Jai Acharya[1]

Abstract

This literature review aims to highlight on current scenario and identify research needs related to the Sustainable Development Goals (SDGs) and to explore options for making structural changes in research policy and creating more resources to foster progress on the SDGs related to environmental issues, climate change, marine plastic litter and debris, ocean acidification, eutrophication and specifically Goal 14: Life Below Water. Marine pollution can have a wide range of impacts on ocean ecosystems, including damage to marine life, habitats, and food webs. The ocean provides important ecosystem services to society, but its health is in crisis due to the impacts of human activities. Ocean sustainability requires ambitious levels of scientific evidence to support governance and management of human activities that impact the ocean. However, due to the size, complexity and connectivity of the ocean, monitoring and data collection pre-supposes high investments, and nations need to cooperate to deliver the ambitious, costly science that is required to inform decisions (Ref: Atlantic Ocean Science Diplomacy in action - Andrei Polejack, Sigi Gruber et al.).

New challenges, including climate change and sea-level rise, plastics and microplastics, anthropogenic underwater noise, ocean warming, and ocean acidification, are more prominent. Plastics and microplastics in the marine environment have increased dramatically and are a serious threat with complex eco-toxicological effects (Avio et al., 2017). Carbon pollution is changing the ocean's chemistry making it more acidic. Ocean warming and acidification, although different phenomena, interact to the detriment of marine ecosystems, affecting primary productivity, nutrient cycles, and ultimately the survival of marine species. Anthropogenic underwater noise production has serious detrimental effects on ocean biodiversity (Williams et al., 2015). In 2015, the UN General Assembly adopted 17 Sustainable Development Goals (SDGs) as part of the 2030 Agenda. Most notably the SDG-14 - Life Below Water and Target 14.1 entails that by 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris & nutrient pollution.

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Overall, marine pollution is closely linked to achievements of targets of SDG 14 and related to plastic waste and marine litter management across the sectors. Target 14.1 and associated indicators stress in particular the problem of plastic debris and nutrition pollution, linked to eutrophication.

SDG 14 targets seek to prevent and reduce marine pollution; further the sustainable management and protection of marine and coastal ecosystems; address the impacts of ocean acidification; regulate harvesting and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices; conserve coastal and marine areas; increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources; and strengthen the means of implementation, including increasing scientific knowledge, the transfer of marine technology and implementation of IMO Conventions on marine pollution prevention (MARPOL) and international law as reflected in the UN Convention on the Law of the Sea (UNCLOS) 1982. (Ref: Miguel De Serpa Soares https://un.org/en/chronicle/article).

While there are many uncertainties both in the scientific and policy realms, reality in the ocean is much more certain and paints a bleak picture that calls for urgent action. The evolution in ocean governance from Stockholm to SDG 14 has not altered the stakes, which remain as high as they can be - Ocean Health is Intimately Tied to Our Survival. To address this gap, a global overview on current progress in terms of achieving the success in implementation of SDG 14 and the degree of challenges due to marine pollutions has to be linked with precise strategies to combat the challenges.

Keywords: Marine Pollution, Marine Resources, Sustainable Development Goals, SDG, SDG 14, SDG 14 Targets, IMO, IUU, MARPOL, UNCLOS, UNEP, Life Below Water, Plastic Pollution, Ocean Statistics, Coastal eutrophication, Combat Strategies, Climate Change, Marine Protected Areas (MPAs), IUCN, UNFCCC.

1. INTRODUCTION

Several of the interlinked SDGs are essential in relation to the ocean and seas and contain specific targets and timetables for achieving them. Goal 14 - 'Life Below Water'- addresses marine issues specifically SDG 14. This goal provides opportunities to both facilitate concrete actions for ocean sustainability and foster greater integration in ocean governance. Since the adoption of United Nations Sustainable Development Goals (SDGs) in 2015 global agenda. At the national level, the ocean has received increasing consideration, with many coastal states and islands adopting blue economy strategies and frameworks and putting the ocean at the centre of development.

SDG 14: Life Below Water includes ten targets, four of which (14.2, 14.4, 14.5 and 14.6) expired in 2020. It remains very high in the international agenda aligning with the UN Decade of Ocean

Science for Sustainable Development. As research has shown, the achievement of SDG 14 is a prerequisite to the achievement of other Sustainable Development Goals (SDGs). Globally, it has been found that SDG 14 is one of the most difficult goals to achieve (Salvia et al., 2019).

Despite the critical role of SDG 14, funding and research towards SDG 14 has also been limited (Johansen and Vestvik, 2020). Considering the current high profile of SDG 14 (UNEP, 2021), more research is needed to provide insights for decision-makers on how to effectively move forward in the next 10 years.

Challenges and limitations do exist on the method of the literature review as the SDG 14 targets are very broad and cover vast areas of knowledge and international negotiation. Secondly, despite their breadth, the SDG 14 targets are of intergovernmental, transboundary and areas beyond national jurisdiction, which means they may not always reflect local or national sustainable development priorities and problems, and there may be visible gaps from local and national perspectives. Another challenge is to have access to relevant literature review text for different targets and ensuring there is enough scientific substance for the analysis to be of interest for researchers in the field.

The challenging question is - to what degree have we achieved the 2020 targets for our oceans?

1.1 Marine Pollution Impacts - Current Scenario and Combat Strategies

Whether deliberately discharged or unintentionally introduced, plastic waste, oil, pharmaceuticals, toxic heavy metals, insecticides and other chemicals have found their way to every corner of the oceans. The consequences are catastrophic and often lethal, especially for marine organisms.

The only good news is that international prohibitions of some pollutants are beginning to have an effect. Without radical changes in industry and commerce, however, the pollution crisis in the oceans cannot be overcome. According to a report by the United Nations, there are now an estimated 5.25 trillion pieces of plastic debris in the ocean, with about 8 million tons of plastic being added every year. In the staggering numbers of 5.25 million pieces, the mass of 269,000-ton float on the surface, while some 4 billion plastic microfibres per square kilometre litter the deep sea. (Ref: National Geographic, January 2015).

Plastic Pollution can harm marine life through ingestion or entanglement and can also have broader impacts on ecosystems by altering water quality and blocking sunlight. Besides the plastic pollution, here are some of the latest data on the impacts of marine pollution which include oil spills, chemical pollution, noise pollution and pollution due to climate change.

Oil Spills can have devastating impacts on marine ecosystems, killing fish, birds, and other wildlife, and damaging habitats. The 2010 Deepwater Horizon oil spill in the Gulf of Mexico, for example, is estimated to have killed millions of animals and caused long-term damage to the ecosystem.

Chemical Pollutants such as pesticides, herbicides, and industrial chemicals can also have harmful impacts on marine ecosystems, including disrupting the reproductive and immune systems of marine life, and altering the composition of marine food webs.

Noise pollution Human activities such as shipping, drilling, and sonar use can produce underwater noise that can disrupt marine life, including whales and dolphins, which rely on sound for communication, navigation, and hunting.

Climate change is also having significant impacts on marine ecosystems, including sea level rise, ocean acidification, and warming waters. These changes can alter marine habitats and food webs and affect the distribution and abundance of marine life.

Overall, the impacts of marine pollution on ocean ecosystems are significant and wide-ranging, and urgent action is needed to reduce pollution and protect these vital ecosystems.

1.2 Combat Strategies on Marine Pollution

Combatting marine pollution requires a multi-faceted approach involving various strategies and actions at different levels – from individual behaviour changes to international policy agreements. Here are some combat strategies on marine pollution.

i. **Regulatory Framework and Policy Making**
   - Strengthen and enforce existing international agreements and conventions like MARPOL (International Convention for the Prevention of Pollution from Ships).

- Develop and implement stricter regulations on waste disposal, sewage discharge, and ballast water management for ships.
- Enforce laws against illegal fishing practices, dumping, and plastic waste disposal.
- Establish marine protected areas and regulate human activities in sensitive marine ecosystems.

ii. Waste Management

- Improve waste management infrastructure, especially in coastal areas, to prevent land-based pollutants from entering the oceans.
- Promote waste reduction, recycling, and responsible waste disposal practices among individuals, communities, and industries.
- Implement extended producer responsibility (EPR) programs to hold manufacturers accountable for their products' end-of-life waste.

iii. Plastic Pollution Mitigation

- Ban or restrict single-use plastics and microplastics in products.
- Promote alternatives to plastic products, such as biodegradable materials.
- Develop efficient waste collection systems to prevent plastic waste from reaching the oceans.

iv. Educational Campaigns

- Raise public awareness about the impacts of marine pollution through educational campaigns, documentaries, and media.
- Educate individuals about proper waste disposal, recycling, and sustainable consumer choices.
- Conduct Ocean Literacy Training Program in collaboration with UN Agencies, International Ocean Institute and other local / regional and international NGOs.

v. Technological Solutions

- Develop and implement innovative technologies for cleaning up marine debris, such as ocean cleanup systems and autonomous drones.

- Use advanced sensors and satellite imagery to monitor pollution sources, hotspots, and movement patterns.

vi. International Collaboration

- Foster collaboration among countries to share best practices, data, and research on marine pollution.
- Facilitate joint efforts to address transboundary pollution and implement coordinated response strategies.

vii. Scientific Research

- Conduct research to better understand the sources, distribution, and impacts of marine pollution.
- Study the effects of pollutants on marine ecosystems and wildlife to inform policy decisions.

viii. Corporate Responsibility

- Encourage industries to adopt sustainable production practices and reduce their pollution footprint.
- Support corporate initiatives for responsible waste management, product design, and supply chain management.

ix. Community Engagement

- Involve local communities in beach cleanups, coastal restoration, and pollution monitoring activities.
- Empower coastal communities to take ownership of their natural resources and engage in sustainable practices.

x. Government Support and Funding

- Allocate funding for research, infrastructure development, and pollution control measures.
- Provide incentives for businesses and individuals to adopt environmentally friendly practices.

Combatting marine pollution requires a collaborative effort involving governments, industries, communities, and individuals. The combination of regulatory measures, technological innovation, education, and collective action can help reduce and eventually eliminate the threat of marine pollution.

1.3 SDG 14 - Current Scenario

SDG-14 aims to protect and ensure the sustainable use of oceans. This includes reducing marine pollution and ocean acidification, end overfishing, combat illegal, unreported and unregulated (IUU) fishing and conserve marine and coastal ecosystems.

Here are some recent updates on the success of SDG 14 targets:

i. **Target 14.1:** By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

ii. **Target 14.2:** By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration: According to the United Nations, only 7.5% of the world's oceans are currently protected in marine protected areas, which falls short of the target of 10% by 2020. However, there has been progress in restoring degraded ecosystems, such as coral reefs and mangroves, which are vital for marine biodiversity.

iii. **Target 14.3:** Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels: The scientific understanding of ocean acidification has increased, and there is growing awareness of its impacts. However, more needs to be done to address this issue, such as reducing carbon emissions and increasing research and monitoring efforts.

iv. **Target 14.4:** By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics: While progress has been made in some regions, global overfishing remains a major concern, with 34.2% of fish stocks being overfished in 2017, according to the Food and Agriculture Organization of the United Nations.

v. **Target 14.5:** By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information: As mentioned earlier, only 7.5% of the world's oceans are currently protected in marine protected areas, which falls short of the target of 10% by 2020.

vi. **Target 14.6:** By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.

The World Trade Organization (WTO) has been negotiating on fisheries subsidies for several years, with the aim of reaching an agreement to prohibit harmful subsidies. In December 2020, the WTO members agreed to a new set of rules that would prohibit subsidies that contribute to overfishing and overcapacity, but with exemptions for certain types of subsidies for developing countries.

vii. **Target 14.7:** By 2030, increase the economic benefits to Small Island Developing States (SIDS) least developed countries from sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

1.4 Additional Targets of SDG 14

14.a: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular Small Island Developing States (SIDS) and least developed countries.

14.b: Provide access for small-scale artisanal fishers to marine resources and markets.

14.c: Ensure the full implementation of international law, as reflected in the United Nations Convention on the Law of the Sea for States parties thereto, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources by their parties.

Below Table shows how the SDG 14 targets can be simply grouped according to the three key themes.

Table 1 - Grouping of SDG 14 targets with three key themes

Marine Pollution	**Ocean and Climate**	**Sustainable use of Marine and Ocean Resources**
14.1	14.2	14.4
	14.3	14.6
	14.5	14.7

Overall, progress towards achieving SDG 14 has been mixed, with some targets being met or exceeded, while others are falling behind. More concerted efforts are needed to address the challenges facing the world's oceans and marine resources, such as overfishing, pollution, and climate change.

1.5 Global Collaborations on SDG 14

Sustainable Development Goal 14 (SDG 14) focuses on conserving and sustainably using the oceans, seas, and marine resources for sustainable development. It aims to address various challenges related to marine ecosystems, overfishing, pollution, and climate change impacts on the oceans. Global collaborations on SDG 14 are essential to achieve its targets and ensure the long-term health and sustainability of our oceans. Here are some examples of global collaborations and initiatives related to SDG 14:

United Nations Convention on the Law of the Sea (UNCLOS): UNCLOS is a global legal framework that establishes the rights and responsibilities of nations regarding the use of the world's oceans and their resources. It provides a basis for international cooperation in managing marine resources and protecting the marine environment.

The Ocean Conference: The United Nations has organized Ocean Conferences to raise awareness and accelerate actions for the implementation of SDG 14. These conferences bring together governments, NGOs, scientists, and other stakeholders to discuss and share best practices for ocean conservation and sustainable use.

World Ocean Day: Celebrated on June 8th each year, World Ocean Day provides an opportunity for people around the world to come together to raise awareness about the importance of the oceans and to promote sustainable practices.

Partnerships and Collaborative Initiatives: Numerous international partnerships and initiatives focus on ocean conservation and sustainable use. These include collaborations between governments, non-governmental organizations, academia, and the private sector. Examples include the Global Partnership for Oceans, the Global Ocean Observing System (GOOS), and the Coral Triangle Initiative.

Marine Protected Areas (MPAs): Countries around the world are establishing marine protected areas to conserve biodiversity and provide a safe haven for marine life. These efforts often involve international collaboration to establish transboundary or interconnected MPAs.

International Research and Monitoring Programs: Scientific research is crucial for understanding the state of the oceans and identifying effective conservation strategies. Initiatives like the Intergovernmental Oceanographic Commission (IOC) of UNESCO support international ocean research and monitoring efforts.

Sustainable Fisheries Management: International organizations such as the Food and Agriculture Organization (FAO) work to promote sustainable fishing practices and support the management of fisheries to prevent overfishing and ensure long-term fish stocks.

Reducing Marine Pollution: Global efforts to reduce marine pollution involve collaboration on waste management, plastic reduction, and other measures to minimize the impact of pollutants on the oceans.

Climate Change Mitigation and Adaptation: Since climate change significantly affects the oceans, global collaborations on climate change mitigation and adaptation strategies play a crucial role in achieving SDG 14.

Capacity Building and Knowledge Sharing: Many initiatives focus on building the capacity of developing countries to manage their marine resources sustainably. Knowledge sharing and technology transfer are essential components of these efforts.

These are just a few examples of the many global collaborations and initiatives aimed at achieving SDG-14. The interconnected nature of ocean health and our own survival requires ongoing cooperation and joint efforts at the international level to ensure the well-being of our oceans and their resources for current and future generations.

1.6 Role of IMO in achieving SDG 14 Targets

The International Maritime Organization (IMO) plays a crucial role in achieving the targets set out in Sustainable Development Goal 14 (SDG 14), which focuses on conserving and sustainably using the oceans, seas, and marine resources for sustainable development. SDG 14 consists of several targets aimed at addressing various aspects of marine sustainability, including marine pollution, overfishing, ocean acidification, and the protection of marine ecosystems. The IMO's role in achieving these targets primarily revolves around its regulatory and coordination functions within the maritime industry. Here's how the IMO contributes to the achievement of SDG 14 targets:

Marine Pollution (Target 14.1): The IMO is responsible for developing and implementing regulations to prevent and reduce marine pollution from ships. It has established various conventions, including the MARPOL Convention, which sets standards for the discharge of pollutants from ships into the oceans. The IMO also addresses the issue of plastic pollution in the oceans and works towards reducing the use of single-use plastics in the maritime sector.

Sustainable Management of Fisheries (Target 14.4): The IMO contributes to the sustainable management of fisheries by developing guidelines and regulations that help prevent illegal, unreported, and unregulated (IUU) fishing activities. These activities contribute to overfishing and threaten marine biodiversity. Through its capacity-building programs and technical assistance, the IMO assists countries in enhancing their ability to combat IUU fishing.

Ocean Acidification (Target 14.3): While the direct role of the IMO in addressing ocean acidification is limited, its efforts to reduce greenhouse gas emissions from ships indirectly contribute to mitigating this phenomenon. The IMO's Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) regulations aim to reduce the carbon footprint of the maritime sector, which can help mitigate the impacts of ocean acidification.

Conservation of Marine and Coastal Ecosystems (Target 14.5): The IMO supports the conservation of marine and coastal ecosystems through measures such as designating Particularly Sensitive Sea Areas (PSSAs) and Special Areas, where additional protective measures are applied to prevent environmental damage from shipping activities.

Support for Developing Countries (Target 14.A): The IMO provides technical assistance and capacity-building support to developing countries to help them effectively implement international regulations related to maritime safety and environmental protection. This support enhances these countries' ability to contribute to SDG 14 targets.

Research and Data Collection (Target 14.7): The IMO facilitates the exchange of information and data related to maritime safety, security, and environmental protection. This information exchange supports evidence-based decision-making and contributes to the understanding of the state of the oceans and marine resources.

Global Partnership for Sustainable Oceans (Target 14.b): The IMO collaborates with other international organizations, governments, and stakeholders to achieve the goals of SDG 14. Through partnerships, joint initiatives, and cooperation, the IMO contributes to the global effort to ensure the sustainability of the oceans.

In summary, the IMO's role in achieving SDG 14 targets involves establishing and implementing regulations, providing technical assistance, promoting cooperation, and facilitating sustainable practices within the maritime industry to ensure the conservation and sustainable use of oceans and marine resources.

1.7 Role of IUCN in Achieving SDG14 Targets

The International Union for Conservation of Nature (IUCN) plays a significant role in achieving the targets set out in Sustainable Development Goal 14 (SDG 14), which focuses on conserving and sustainably using the oceans, seas, and marine resources for sustainable development. The IUCN is a global organization that works on a wide range of conservation issues, including marine and coastal conservation. Here's how the IUCN contributes to the achievement of SDG 14 targets:

Advocacy and Policy Development: The IUCN plays a key role in advocating for strong policies and regulations that promote the conservation and sustainable use of marine ecosystems. It provides scientific expertise and policy recommendations to governments and international bodies, influencing the development of policies related to marine protected areas, fisheries management, and ocean governance.

Marine Protected Areas (MPAs) and Biodiversity Conservation (Targets 14.2 and 14.5): The IUCN works to establish and manage marine protected areas around the world. It provides guidance on MPA design, management, and monitoring, helping countries create effective networks of protected areas that contribute to conserving marine biodiversity and ecosystems.

Sustainable Fisheries Management (Targets 14.4 and 14.6): The IUCN promotes sustainable fisheries management practices by providing scientific assessments, guidelines, and recommendations for responsible fishing. It advocates for the adoption of ecosystem-based fisheries management approaches that take into account the broader marine ecosystem and its health.

Climate Change and Ocean Resilience (Targets 14.3 and 14.7): The IUCN conducts research and assessments on the impacts of climate change on oceans and marine ecosystems. It contributes to the understanding of ocean acidification, sea level rise, and other climate-related challenges. The organization also promotes the conservation and restoration of coastal habitats to enhance the resilience of marine ecosystems to climate change.

Capacity Building and Knowledge Sharing: The IUCN provides training, capacity-building programs, and knowledge sharing to governments, communities, and stakeholders. It helps build the capacity of local communities and institutions to manage marine resources sustainably and implement effective conservation strategies.

Public Awareness and Education: The IUCN raises public awareness about the importance of marine conservation through campaigns, education initiatives, and communication efforts. It helps foster a sense of responsibility and stewardship for the oceans among individuals and communities.

Partnerships and Collaboration (Target 14.B): The IUCN collaborates with governments, non-governmental organizations, academic institutions, and the private sector to promote joint efforts in achieving SDG 14 targets. It works to build partnerships that leverage diverse expertise and resources to address complex marine conservation challenges.

Assessment and Monitoring: The IUCN conducts assessments of marine species, habitats, and ecosystems to provide up-to-date information on their conservation status. These assessments inform decision-making and support the identification of priority areas for conservation.

In summary, the IUCN plays a vital role in achieving SDG 14 targets by advocating for policy change, promoting conservation strategies, providing expertise and guidance, building capacity, raising awareness, and fostering collaboration. Through its multi-faceted approach, the IUCN contributes to the global effort to ensure the sustainability of oceans, seas, and marine resources.

1.8 Role of UNFCCC in Achieving SDG 14 Targets

The United Nations Framework Convention on Climate Change (UNFCCC) plays a significant role in addressing climate change, including its impacts on the oceans, and contributes to the achievement of various Sustainable Development Goals (SDGs), including SDG 14 which focuses on the conservation and sustainable use of oceans, seas, and marine resources. While the primary focus of the UNFCCC is on addressing climate change, its actions have implications for ocean health and marine ecosystems.

Here's how the UNFCCC contributes to the goals of SDG 14:

Climate Change Mitigation (Targets 14.3 and 14.7): The UNFCCC's main objective is to stabilize greenhouse gas concentrations in the atmosphere to prevent dangerous human-induced interference with the climate system. The reduction of greenhouse gas emissions, including carbon dioxide, is essential for minimizing the impacts of climate change on the oceans. This is important for combating ocean acidification and ensuring the overall health and resilience of marine ecosystems.

Global Temperature Goals: The UNFCCC's Paris Agreement aims to limit global warming well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit it to 1.5 degrees Celsius. Achieving these temperature goals is crucial for preventing the most severe impacts of climate change, including sea-level rise and changes in ocean circulation patterns that could affect marine ecosystems and coastal communities.

Adaptation and Resilience (Targets 14.2, 14.5, and 14.A): The UNFCCC recognizes the need for adaptation to the impacts of climate change. Many of these impacts, such as sea-level rise, increased storm intensity, and ocean warming, directly affect coastal and marine ecosystems. Through the Adaptation Committee and various funds established under the Convention, the UNFCCC supports developing countries in building resilience and adapting to these changes.

Financial Support (Targets 14.a and 14.b): The UNFCCC facilitates financial support from developed countries to developing countries to help them address climate change impacts. This includes support for sustainable ocean management and conservation efforts, capacity-building, technology transfer, and addressing the unique challenges faced by Small Island Developing States (SIDS) and Least Developed Countries (LDCs).

Scientific Research and Monitoring: The UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA) regularly reviews and assesses scientific information related to climate change impacts and adaptation. This includes research on the effects of climate change on oceans, marine biodiversity, and ecosystems.

Synergies with Other Conventions (Targets 14.1 and 14.4): The UNFCCC works in coordination with other international agreements and organizations to address cross-cutting issues such as marine pollution and sustainable fisheries management. For example, actions taken under the UNFCCC can have positive effects on reducing pollution from maritime activities.

In summary, while the UNFCCC's primary mandate is to address climate change, its efforts have profound implications for the health and sustainability of oceans and marine ecosystems. By addressing the root causes of climate change and supporting adaptation and resilience measures, the UNFCCC indirectly contributes to the achievement of SDG14 targets and the overall well-being of marine environments.

2. FINDINGS ON THE BIGGER PICTURE OF SDG 14 – NATIONAL IMPLEMENTATION TO GLOBAL MONITORING

"Global Manual on Ocean Statistics" aims to provide guidance on how to bring together traditional monitoring techniques with new technologies and data science in order to better monitoring our oceans in the context of the SDGs. The report focuses on the SDG indicators where UNEP is the custodian and responsible for global monitoring, including SDG 14.1.1(a) on coastal eutrophication; SDG 14.1.1(b) on marine debris, SDG 14.2.1 on marine area management and SDG 14.5.1 on protected areas and conservation.

"The Global Manual on Ocean Statistics" provides guidance for national governments and national institutions to support the country-level implementation of SDG Indicators 14.1.1a, 14.1.1b, 14.2.1 and 14.5.1 in their national waters. Note that there are a number of challenges and limitations facing monitoring in the high seas. Particularly problematic are transboundary marine issues such as ocean acidification or marine plastics. For such issues, the monitoring of national waters, which is the primary focus of the SDG indicators, only shows part of the picture. This manual focuses on national monitoring, but there is a need for additional research and support to measure the areas beyond national jurisdiction for analytical use, including for analysis of the SDGs.

Implementing SDG indicators at Country Level

The "Global Manual on Ocean Statistics" is intended to support countries in their efforts to implement indicators for tracking progress against SDG 14. The country missions to Fiji and Colombia highlighted that countries start off from different contexts, and face different challenges, in implementing the SDG indicators. Some countries, like Colombia, already have centralised data gathering systems and/or national indicators in place that can be built on to implement the SDG indicators. In contrast, Fiji and other Pacific Island nations are only just starting to address the SDG targets and indicators at country level; here, the SDG process is mainly being driven forward at the regional level by the Pacific Regional Seas Programme and other regional institutions. One common challenge that countries in both regions share is limited funds and capacity for monitoring programs.

Coordinated international monitoring of transboundary issues.

As mentioned in the introduction to the "Global Manual on Ocean Statistics", many issues remain to be resolved in order to achieve more complete global monitoring of transboundary marine issues, including in areas beyond national jurisdiction. This will require countries to work together in a coordinated effort using both satellite remote sensing and in situ international surveys, including shared data collection protocols, good data sharing practices, innovative and cost-effective sampling methodologies.

Table 2 - Databases used to assess the achievement of SDG-14

Target	UN Indicator	Databases	Proportion of countries covered
14.2	Proportion of national exclusive economic zones managed using ecosystem-based approaches	- Franzao et al., 2020 - IOC-UNESCO status of Marine Spatial Planning - MSP Global Compendium of MSP initiatives - Barrag´an Mu˜noz (2020) (with all four sources combined) Ocean Health Index (OHI)	81% 100%
14.4	Proportion of fish stocks within biologically sustainable levels	Sea Around Us stock status plots Marine Trophic Index (MTI)	78% 97%
14.5	Coverage of protected areas in relation to marine areas	World Database on Protected Areas Key Biodiversity areas (KBA)	100% 93%
14.6 (This target refers to fisheries subsidies but its indicator refers to IUU fishing).	Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	IUU Fishing Index	100%
14.7 (This target refers to SIDS and least developed countries	Increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism		

(Courtesy: Ocean and Coastal Management 227 (2022) 106273; M. Andriamahefazafy et al.)

The Regional Seas Programs are working towards coherent and coordinated monitoring approaches within, as well as across, regional seas, and could play an important role in facilitating coordinated international monitoring efforts.

Globally applicable methodologies to track global progress.

Finally, the “Global Manual on Ocean Statistics” recognises that the agreed SDG and their indicators only capture part of the associated SDG targets. In the long-term, these limitations will have to be addressed to ensure that SDG 14 is fully met. In the meantime, however, it is important to focus on what can be realistically achieved by all countries, so that data can be meaningfully aggregated to give a global picture of progress towards SDG 14.

The “Global Manual on Ocean Statistics” aims to support this effort by providing step-by-step indicator methodologies that require minimum resources and technical capacity, can be integrated with existing national and regional approaches, and provide the minimum parameters required to monitor progress against SDG Targets 14.1, 14.2 and 14.5.

Assessment of Achievements – Methodology

Currently, various databases of UN agencies can be accessed to have updated information on assessment and achievement levels of SDG 14 targets.

2.1 SDG 14 Reporting Methodologies and Proposed Indicators (Ref: UNEP 2021)

A review of existing indicators and methodologies used by Regional Seas Programs and other key intergovernmental, international or regional bodies shows that marine plastic debris is currently monitored in four areas of the marine environment. The agreed indicator for marine plastic litter under SDG Target 14.1, as proposed by the IAEG-SDGs, is on marine plastic debris (14.1.1b).

Based on the existing internationally agreed Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) guidelines and the existing national data collections, it is recommended that the SDG reporting includes sub-indicators related to beach litter, floating plastic and plastic in the sea column, plastic on the sea floor and additional option indicators. Indicators on micro-litter may also be considered as optional.

The proposed global indicators are based on feasibility and relevance. All indicators described below are consistent with the GESAMP guidelines on monitoring marine plastics which were published in 2019. The GESAMP 2019 (Guidelines for Monitoring and Assessment of Plastic Litter in the Ocean) is an internationally agreed standard which was launched in March 2019.

i. **Reporting Level 1: Proposed global indicators:**

1. Plastic patches greater than 10 meters (for Areas Beyond National Jurisdiction or Total Oceans).
2. Beach litter originating from national land-based sources.

ii. **Reporting Level 2: Proposed national indicators:**

1. Beach litter count per km2 of coastline (surveys and citizen science data).
2. Floating plastic debris density (visual observation, manta trawls).
3. Water column plastic density (demersal trawls).
4. Seafloor litter density (benthic trawls (e.g., fish survey trawls), divers, video/camera tows, submersibles, remotely operated vehicles).

iii. **Reporting Level 3: Supplementary indicators:**

1. These are listed in a separate table for information but are not described in detail in this man.

2.2 Ocean Source of Our Life and Livelihoods – A Sustainable Relationship

The benefits provided by oceans, seas and marine resources are important to all people, the poor, indigenous peoples, and vulnerable groups with a high dependency on natural resources and ecosystem services may have their well-being especially tied to these benefits. The link between oceans, seas and marine resources and human well-being is not one-sided. While an increase in human well-being is frequently generated at the cost of ecosystem integrity, it can also potentially reduce the negative anthropogenic impacts on the marine environment due to a more sustainable use of resources, changes in production and consumption patterns and improved management and control of human activities, for example. In order for this to happen, good governance and an enabling environment are, however, required.

The seas are warmer than at any point in human history and life under water is facing myriad threats, but there are still reasons to hope to maintain sustainable relationship between humans and ocean in order to timely achievement of the Sustainable Development Goals (SDGs) focused on the world's oceans can be met.

Table 3 - Monitoring parameters for marine plastic litter to track progress against SDG Indicator 14.1.1b. (UNEP 2021)

Monitoring Parameters (and methods)	**Level 1**	**Level 2**	**Level 3**
Plastic patches greater than 10 meters*	X		
Beach litter originating from national land-based sources	X	X	
Beach litter (beach surveys)		X	
Floating plastics (visual observation, manta trawls)		X	
Water column plastics (demersal trawls) Seafloor litter (benthic trawls (e.g., fish survey trawls), divers, video/camera tows, submersibles, remotely operated vehicles)		X	
Beach litter microplastics (beach samples)			X
Floating microplastics (manta trawls, e.g., Continuous Plankton Recorder)			X
Water column microplastics (demersal plankton trawls)			X
Seafloor litter microplastics (sediment samples)			X
Plastic ingestion by biota (e.g., birds, turtles, fish)			X
Plastic litter in nests			X
Entanglement (e.g., marine mammals, birds)			X
Plastic pollution potential (based on the use and landfilling of plastics)			X
River litter			X
Other parameters related to plastic consumption and recycling			X
Health indicators (human health and ecosystem health)			X

** This indicator is most useful for areas beyond national jurisdiction or total ocean area, not for national monitoring. These indicators are marked as levels 1, 2 or 3, level 1 being global data or globally modelled, level 2 including national monitoring and level 3 describing supplementary / recommended indicators.*

Reducing pollution from shipping as well as emitting CO2 ships are a major sources of air pollution. From 2020, to comply with the International Convention for the Prevention of Pollution from Ships, ships operating worldwide, have had to use fuels that contain less than 0.5 per cent sulphur. In 2021, the IMO's Marine Environment Protection Committee adopted updated guidelines for exhaust cleaning systems, as well as a resolution urging the voluntary use of cleaner alternative fuels and alternative methods of propulsion for ships operating in or near the Arctic. Another major form of maritime pollution is bunker oil spills. Risks are growing and the need to ensure the availability of adequate compensation deserves renewed attention. While work continues at the IMO on developing a claims manual for the Bunker Oil Pollution Convention, 2001, it will be important to ensure that the manual effectively responds to the needs and concerns of claimants, including in vulnerable developing countries. In November 2021, reacting to the ever-growing crisis of plastic pollution the IMO adopted a strategy on marine plastic litter from ships. And in March 2022, UNEP adopted a resolution for an international legally binding instrument to end plastic pollution.

2.3 SDG 14 – To what degree have we achieved the 2020 targets for our oceans

As a whole, achievement of SDG 14 has been meagre, with no single country having achieved the four targets aimed for by the SDG 14 indicators (Fig - 1 and Fig – 2). Only two countries worldwide (Belgium and Germany) have achieved three of the targets (Table - 3). Less than 30% (45 countries) have achieved at least one of the targets, resulting in the significant finding that more than two thirds of coastal states globally (107 out of the 152) have not achieved a single of the four SDG targets under assessment. (more details on achievement of each country per indicator available on databases referred in UNEP database).

Figure 1 - Global status of achievement across four SDG 14 targets

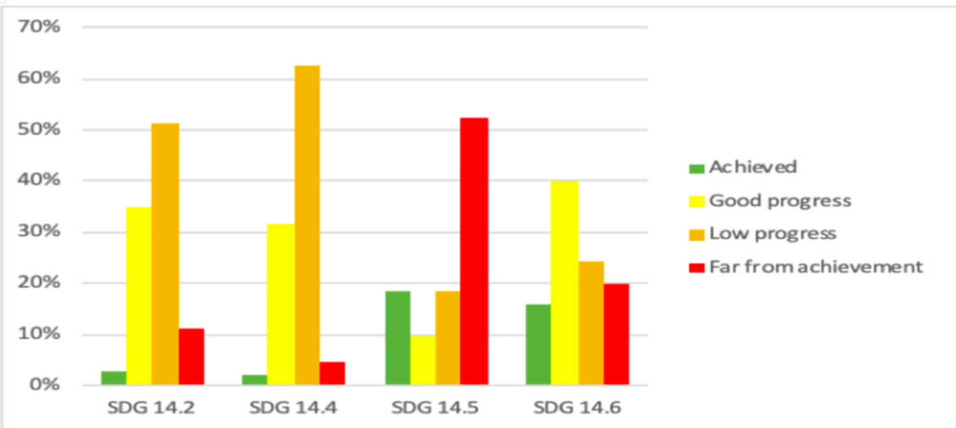
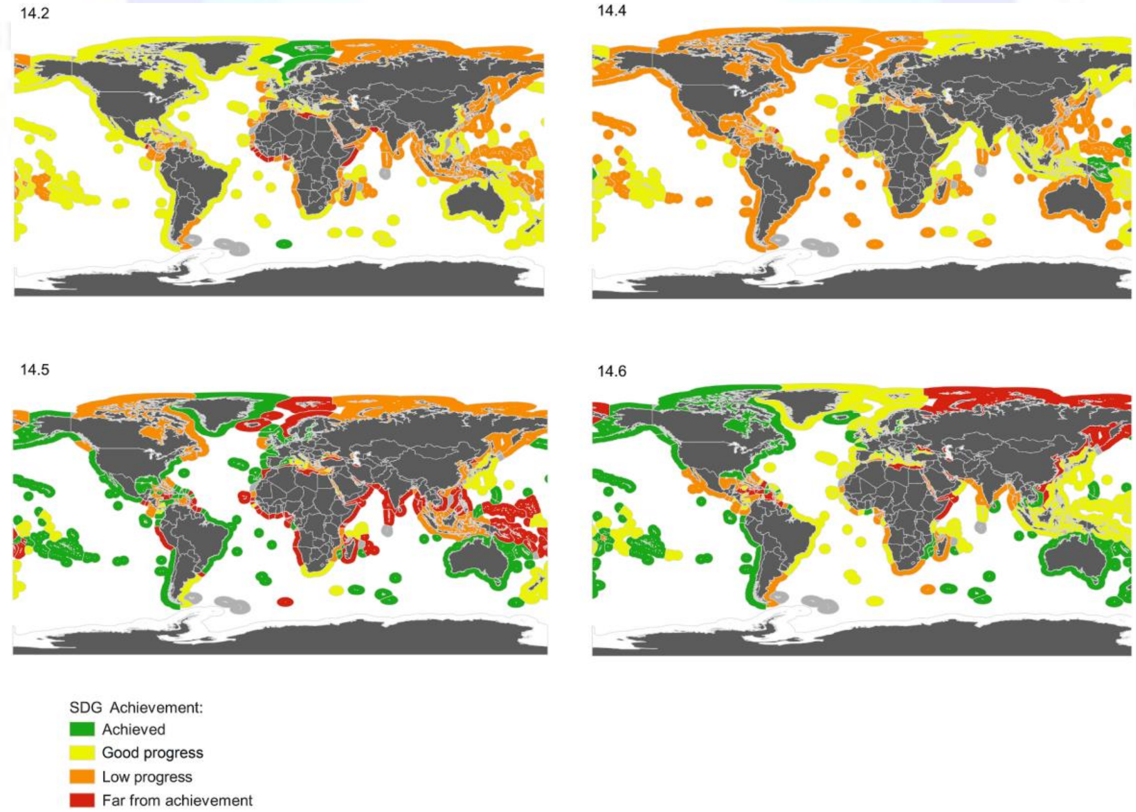


Table 4 - Countries at the highest classification, having made the most progress for one of the 4 targets

Country	**Region**	**SDG 14.2**	**SDG 14.5**	**SDG 14.4**	**SDG 14.6**
Belgium	Europe	✓	✓		✓
Germany	Europe	✓	✓		✓
Ecuador	South America		✓		✓
Estonia	Europe		✓		✓
France	Europe		✓		✓
Netherlands	Europe	✓	✓		
Poland	Europe		✓		✓
Romania	Europe		✓		✓
Sweden	Europe		✓		✓
USA	North America		✓		✓

Source: M. Andriamahefazafy et. Al

Figure 2 - Global maps of achievement of the four SDG 14 targets (14.2, 14.4, 14.5 and 14.6).



Source: M. Andriamahefazafy et. Al

Table 5 - Countries at the highest classification, far from achievement for at least 2 targets.

Country	Region	SDG 14.2	SDG 14.4	SDG 14.5	SDG 14.6
Bahrein	Middle East		x	x	x
Eritrea	Africa	X		x	x
Libya	Africa	X		x	X
Somalia	Africa	X		x	X
Syria	Middle East	X		x	x
Antigua and Barbuda	Caribbean and Central America		x	x	
Brunei Darussalam	Southeast Asia			x	x
Benin	Africa	X		x	
Bosnia and Herzegovina	Europe	X		x	
C^ote d'Ivoire	Africa	X		x	
El Salvador	Caribbean and Central America	X		x	
Georgia	Middle East	X		x	
Guinea	Africa	X		x	
Guyana	South America			x	x
Haiti	Caribbean and Central America				x
Iraq	Middle East	X		x	
Lebanon	Middle East	X		x	
Liberia	Africa	X		x	
Pakistan	Asia	X		x	
Nigeria	Africa	X		x	

Country	Region	SDG 14.2	SDG 14.4	SDG 14.5	SDG 14.6
Sierra Leone	Africa	X		x	
Togo	Africa	X		x	

Source: Ocean and Coastal Management, M. Andriamahefazafy et. al.

2.4 Sustainable Development Goals progress at the midpoint

A reality check of the progress made on the SDGs at the midpoint towards 2030 reveals significant challenges. The latest global-level data and assessments from custodian agencies1 paint a concerning picture of the approximately 140 targets that can be evaluated, half of them show moderate or severe deviations from the desired trajectory. Furthermore, more than 30 per cent of these targets have experienced no progress or, even worse, regression below the 2015 baseline. This assessment underscores the urgent need for intensified efforts to ensure the SDGs stay on course and progress towards a sustainable future for all.

Delays towards SDG 14 targets

Based on the foregoing analysis, it arises that the achievement of the four assessed 2020 targets of SDG 14 has been underwhelming. This result embodies both a reality-check and a wake-up call showing that not enough has been done, and that the global achievement of the 2020 SDG 14 targets is a round and inclusive failure. The lack of achievement was not surprising considering the ambition of the 4 targets and especially that two indicators (14.2 and 14.4) were entirely new compared to the other two (14.5 and 14.6) that were monitored relatively well through other existing targets or indexes.

Protected area coverage alone does not give a full indication of the importance of an area in terms of biodiversity (and derived ecosystem services), for example the diversity of species that have been protected or the number of people who are benefiting from the protected area (Gill et al. 2017). As such, a calculation of the relative coverage, by protected areas, of those marine areas which are of particular importance for biodiversity (and derived ecosystem services) is a useful approach to assess the comprehensiveness and value of an MPA network. Surprise came that SDG 14.5 (MPA coverage) which found many countries still far off from achieving the goal.

Figure 3 - Progress assessment for the 17 Goals based on assessed targets

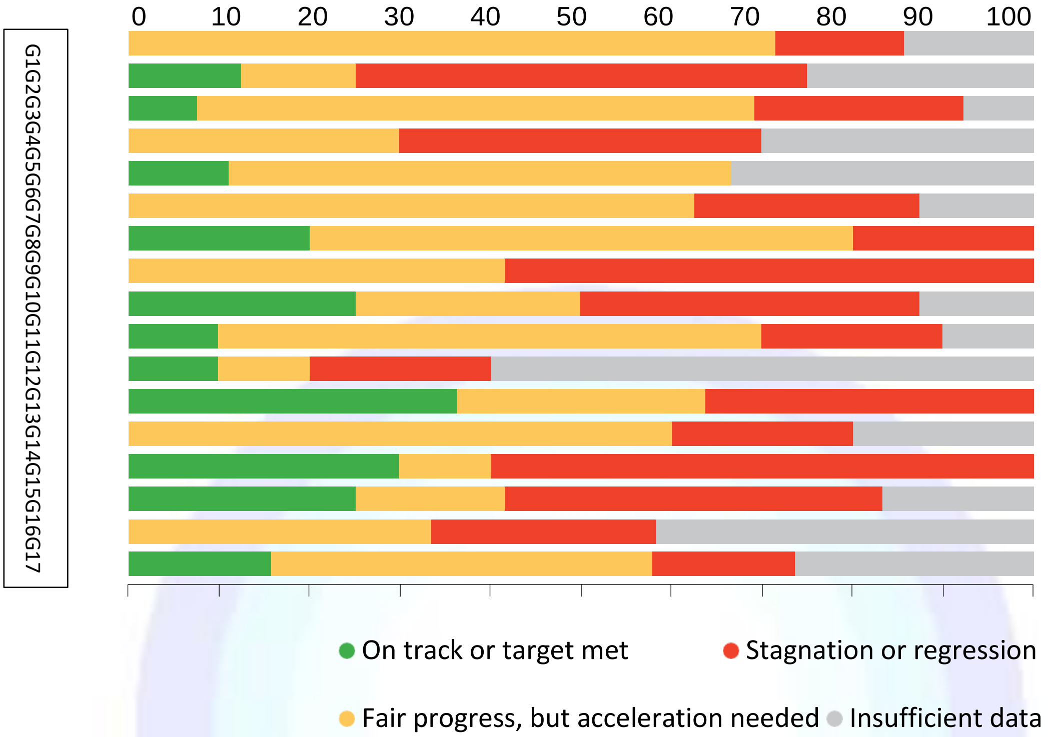
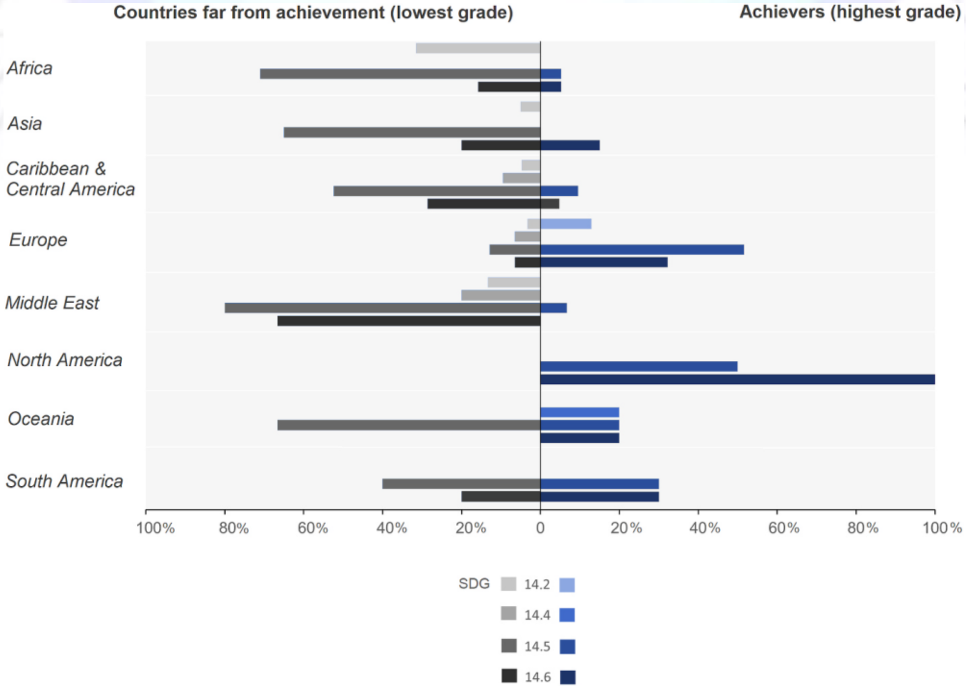


Figure 4 - Percentage (%) of achieving and non-achieving countries in each region by targets



Source: Ocean and Coastal Management, M. Andriamahefazafy et. al.

The goal is not new and builds on the CBD Aichi target 11 set in 2011 which also aimed at achieving 10% of MPA coverage by 2020. Even so, the achievement of SDG 14.5 could also be questioned as achievement can also be linked to the gazetting of large marine areas that harbour few coastal communities (the case of countries like France, the UK or New Zealand gazetting overseas and outermost uninhabited territories) and can greatly increase the global achievement of MPA coverage. These areas currently make up 17.8% of all EEZs, and 7.68% of all marine areas. Furthermore, implementing such a quantitative target is not without controversy. These objectives can distract attention, among other things, from the real “outcomes” expected of these MPAs, for instance, to guarantee general functionality of natural environments (Visconti et al., 2019), while low-income countries lack capacity to create and maintain large offshore MPAs.

SDG 14.6 on combatting IUU fishing is the target that has seen the most progress of the four assessed, more than half of countries having achieved or made good progress. By developing national plans of action to combat IUU fishing, and signing up to response-related instruments, such as the FAO Compliance Agreement or the Agreement on Port State Measures, nations are gradually improving their ability to establish better systems to combat IUU fishing.

2.5 SDG 14 – Consistent Challenges

Oceans, seas and marine resources are increasingly threatened, degraded or destroyed by human activities, reducing their ability to provide crucial ecosystem services. Important classes of threats are, among others, climate change, marine pollution, unsustainable extraction of marine resources and physical alterations and destruction of marine and coastal habitats and landscapes. The deterioration of coastal and marine ecosystems and habitats is negatively affecting human well-being worldwide. Key challenges for achieving sustainable development goal “Life Below Water” are envisioned as stated below:

- War and Instability – Regional / Global Conflicts due to geo-political and geo-economic issues
- Suitability and Availability
- Governmental Issues in specific countries
- Poverty and Unemployment
- The Global Economy

- Population Growth and Demographic Conflicts Created
- Resurfacing of Pandemic Diseases

In the course of the last century, the oceans have been transformed by human activity. Intensive fishing has decimated marine life, stripping the seas of scores of species. Plastic has infiltrated the remotest points on the planet, from the bottom of the Marina Trench to the Siberian Arctic.

In order for oceans, seas and marine resources to successfully contribute to human well-being, ecosystem integrity, with properly functioning biogeochemical and physical processes, is required. This does not require unperturbed systems, but systems that have not suffered serious or irreversible harm. Ecosystem integrity allows for the provision of so-called supporting ecosystem services which, in turn, are the bases of important regulating, provisioning and cultural ecosystem services that are of crucial importance for humans.

Humanity's 200-year habit of pumping carbon dioxide into the atmosphere is raising the temperature of seawater while lowering its PH level causing acidification of it, hence, unleashing a series of potentially catastrophic cascading impacts, from the melting of the polar ice caps and the rise of global sea levels to the collapse of the planet's coral reefs and the acidification of its oceans.

Responding to this environmental crisis, in 2015 the UN devoted one of its 17 Sustainable Development Goals (SDGs) exclusively to the state of the oceans and SDG 14 described as "Life Under Water" establishes a wide-ranging goal to "conserve and sustainably use the world's oceans, seas and marine resources". Breaking down this broad ambition are 10 targets, addressing key threats to ocean ecosystems, such as pollution, overfishing, eutrophication and acidification, while also setting specific goals for extending protected areas and supporting sustainable fisheries in the developing world.

Rising ocean temperatures are causing bleaching events in the world's corals and cause stress leading to the expulsion or reduction of the photo synthetic algae. Since these algae are responsible for producing a significant portion of the coral’s food and contribute to the vibrant colours of the corals, their loss results in a pale or bleached appearance. The reduction in algae compromises the coral’s energy production, making them more susceptible to diseases and other environmental stressors.

2.6 Epilogue

The United Nations has estimated that humankind discharges around 400 million tonnes of pollutants into the sea annually. Evidence of this persistent pollution can now be found in all regions of the world‘s oceans – on remote islands, in the polar regions and in the deepest ocean trenches. Substances that are concentrated in the food chain are especially harmful because these pose a real danger to marine organisms as well as to people. Building the climate resilience of maritime transport systems is therefore a precondition for sustainability.

Climatic factors such as rising water levels, floods, storms, precipitation, extreme weather events, and associated risks such as coastal erosion, inundation, and deterioration of hinterland connections have implications for shipping volumes and costs, cargo loading and capacity, sailing and/or loading schedules, storage, and warehousing.

Here, we foresee the obstructive role that marine pollution plays in, and challenges imposed in achieving all the targets of SDG-14 and likewise the national and international interests that drive the processes of negotiating international agreements, as well as their challenges to date. significance in emerging global initiatives such as the UN Decade of Ocean Science for Sustainable Development (2021–2030).

Human well-being cannot be achieved without the protection and conservation of the Earth’s ecosystem. To maintain the quality of life that the oceans have provided to humankind, while sustaining the integrity of their ecosystems, a change will be required in how humans view, manage and use oceans, seas and marine resources.

Following the principles of multi-stakeholder partnerships for the enhancement of the Global Partnership for Sustainable Development, complementing the multi-stakeholders’ partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries is the utmost desirable scenario in coming days.

While my literature review is consistent and keeping pace with new findings on SDG 14 targets achievements, it needs to remain continuous and updated.

APPENDIX

SDG 14 - Targets

Conserve and Sustainable Exploitation of the Ocean, Seas and Marine Resources for the Sustainable Development

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported, and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported, and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation*

14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.

14.b Provide access for small-scale artisanal fishers to marine resources and markets.

14.c Ensure the full implementation of international law, as reflected in the United Nations Convention on the Law of the Sea for States parties thereto, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources by their parties

14.1.1 (a) - Coastal eutrophication.

14.1.1 (b) - Marine Debris.

14.2.1 - Marine Area Management.

14.5.1 - Protected Areas and conservation.

**Taking into account ongoing World Trade Organization negotiations, the Doha Development Agenda and the Hong Kong ministerial mandate.*

Use of Existing UN Databases Reference

The existing databases referred are based on two criteria. First, they had to provide data that responded closely to the established UN indicator for the 152 coastal states or the majority of them to allow comparison between countries (Table 4). As the list of coastal states differed slightly between databases, the list of 152 coastal states in the IUU Fishing

(http://www.iuufishingindex.net) / (Macfadyen and Hosch, 2021) (used to assess SDG 14.6) was chosen. The list was also fully covered in the World Database on Protected Areas (WDPA) used to assess SDG 14.5. The analysis was closely aligned to what is suggested by various UN manuals on the four SDGs targets. Second, the databases chosen were established for at least three years to ensure that the data was not based on one-off assessments, that it has been used by others since and that it was updated since the adoption of the SDGs in 2015. For SDG 14.5 and 14.6, data until

2020 was available. For SDG 14.2 and 14.4, the two databases of choice held data until 2018. They were complemented by one other database respectively, providing data up to 2020.

ACRONYMS

EBSA	Ecologically or Biologically Significant marine Areas – Convention on Biological Diversity (CBD)
PSSA	Particularly Sensitive Sea Area – IMO
VME	Vulnerable Marine Ecosystem - FAO
WHS	World Heritage Site - UNESCO
Ramsar	Ramsar Sites (Wetlands of International Importance) – Convention on Wetlands of International Importance (Ramsar Convention)
IBA	Important Bird and Biodiversity Areas – Bird Life International
KBA	Key biodiversity Areas – IUCN, Birdlife International, Plant-Life International, Conservation International, Critical Ecosystem Partnership Fund and others (Note: KBA include IBAs and AZE Sites)
Natura 2000	European network of protected sites under the European Habitats and Birds Directives - EU
AZE Sites	Alliance for Zero Extinction Sites - Alliance for Zero Extinction
GESAMP	Guidelines for Monitoring and Assessment of Plastic Litter in the Ocean

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