TECHNICAL REPORT No. 06 – EXISTING CAPACITY, USES AND NEEDS FOR STOCK ASSESSMENT TRAINING AND COURSES IN THE IORA REGION

'TECHNICAL ASSISTANCE TO IORA FOR THE IMPLEMENTATION AND COORDINATION OF IORA ACTION PLAN ON FISHERIES, AQUACULTURE AND MARINE ENVIRONMENT'

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TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ABARES	Australian Bureau of Agricultural Resource Economics and Sciences
APFIC	Asia-Pacific Fishery Commission
BMU	Beach Management Unit (Kenya)
BOBLME	Bay of Bengal Large Marine Ecosystem
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CEFAS	Centre for Environment, Fisheries and Aquaculture Science (UK)
CGFM	Cluster Group on Fisheries Management (IORA)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DTU Aqua	National Institute of Aquatic Resources (Denmark)
EAF	Ecosystem Approach to Fisheries
FAO	Food and Agriculture Organization of the United Nations
FIDEA	Fishing Data East Africa project
FRDC	Fisheries Research and Development Corporation (Australia)
GIS	Geographical Information System
IO	Indian Ocean
IORA	Indian Ocean Rim Association
IOTC	Indian Ocean Tuna Commission
IRD	Institut de recherche pour le développement (France)
IUU	Illegal Unreported and Unregulated fishing
KMFRI	Kenya Marine Fisheries Research Institute
MASMA	Marine and Coastal Science for Management programme
MMRI	Maldives Marine Research Institute
MoU	Memorandum of Understanding
MS	Member States
MSc	Master of Science
MSY	Maximum Sustainable Yield
NARA	National Aquatic Resources Research and Development Agency (Sri Lanka)
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration (USA)
PhD	Doctor of Philosophy
PSA	Productivity, Susceptibility Analysis
RFB	Regional Fisheries Bodies
RFMO	Regional Fisheries Management Organization
SICA	Scale, Intensity and Consequence Analysis
SEAFDEC	South-East Asian Fisheries Development Centre
SWIOFC	South West Indian Ocean Fishery Commission
TAC	Total Allowable Catch
UBC	University of British Columbia (Canada)
WCPFC	Western and Central Pacific Fisheries Commission
WGBE	Working Group on the Blue Economy (IORA)
WIOMSA	Western Indian Ocean Marine Science Association
WWF	World-Wide Fund for Nature
ZMT	Leibniz Centre for Tropical Marine Research (Germany)

1. Summary

Management of fisheries resources requires knowledge of the size of the resources and the extent to which they can sustain exploitation. Stock assessment is the process by which these are quantified and provide the basis of recommendations to fisheries management. For this, capacity in stock assessment is needed. This report, based on questionnaire responses from 12 IORA Member States (MS) provides these existing stock assessment capacities and needs in detail. It also traces how these are communicated to the actors responsible for fisheries management and the extent to which this leads to improvements in fisheries management. The reports finds that the needs for stock assessment capacity are considerable, that stock assessment practitioners are more often better formed through graduate and post graduate courses and subsequent mentoring which can be facilitated between IORA members, themselves. However, there is also a significant need for fisheries managers to be trained through short-term courses in understanding and properly interrogating stock assessment results. The latter is a potential area for IORA to assist its MS in collaboration with FAO, regional fisheries management organisations, regional fisheries bodies, regional fisheries projects or over the medium-term from its own technical assistance and projects.

2. Introduction and methodology

The Indian Ocean Rim Association (IORA) and France through the Agence Française de Développement (French Development Agency) (AFD) signed a Memorandum of Understanding (MoU) on the 9th of March 2020 for "Strengthening the Capacities of IORA in Promoting the Blue Economy and Fisheries Management".

The partnership will support the implementation of the IORA Action Plan (2017-2021) with an allocation of EUR1 million over three years. It will offer expertise, training, networking and material resources to decision makers, officials and experts working to promote regional cooperation in blue economy and fisheries management issues. In addition, the project will strengthen the capacity of the IORA Secretariat.

The overall objective of the technical assistance (TA) is to "support IORA and its Member States in the coordination and implementation of the Action Plan on Blue Economy and Work Plan of IORA CGFM, with a strong focus on fisheries, aquaculture and protection of marine environment."

One of the specific objectives of this project is "to promote sustainable fisheries management". In the context of this objective, the activity 2.1 "Initiate a Capacity Building programme in fish stock assessment" is planned as part of the IORA Action plan.

The methodology adopted within that activity is to produce a compendium of existing institutions in the IORA region that provide stock assessment courses or related facilities largely from available internet and public sources. This was done and provided as Technical Report No 1[1]. Also, to separately seek information from IORA Member States (MS) on their existing capacities and needs for further stock assessment capacity within a concise questionnaire sent to IORA MS focal points through the IORA Secretariat. The purpose was so that their responses could be analysed in relation to available

[1] Fennessy S., and Harris A., 2021. *Compendium of stock assessment training and courses in the IORA region.* IORA/AFD Technical Assistance Project – Technical Report No. 1, 23pp.

national facilities providing the basis for the development of a capacity programme. Such a programme would have to be in collaboration with the regional fisheries organisations and relevant institutions over the longer term (> 3 years).

The questionnaire was developed by the authors. It was sent to the IORA MS in October 2020 through the IORA Secretariat. This report is the analysis of the responses to the questionnaire by IORA MS received up to the closure of the exercise at the end of February 2021.

The present report starts with a background on stock assessments, what they are and their importance to sustainable fisheries management. It follows with the approach used and the information sought in the questionnaire. It then proceeds to provide analysis of the responses provided by the respondents in relation to their existing capacity and needs, including strengths as well as constraints and threats. It continues in analyzing how stock assessment information is communicated and used for fisheries management, examples of recent stock assessments in the responding countries, and indicative first estimates of the numbers of persons requiring training in stock assessment before finishing with some concluding observations and comments.

3. Background

Formal stock assessments are typically a combination of mathematical and statistical models that are used to estimate stock (resource) abundance and to predict the response of the stock to harvesting pressure. Fish (fisheries) stock assessment is required to be undertaken when management agencies or states have to make decisions about suitable levels of allowable harvesting in order to ensure long-term sustainability of resources. Without stock assessment information, there is substantial risk that resources will be over-exploited, resulting in economic losses and/or declines in food availability for humans, as well as wider ecosystem effects driven by declines in species caught by fisheries.

Fisheries typically catch a variety of species, and even for those which have clear targets, species can be numerous. To reduce uncertainty in results and to improve management advice, formal stock assessments require a large amount of data collected over an extended period of time. Such data collection is expensive, sometimes more so than the economic value of the resource, particularly if artisanal/subsistence fishing is involved. With multiple target species and limited budgets, few countries have the ability to formally assess stock status of all their fished resources – even assuming they have the technical numeracy to apply sophisticated models. Sometimes stock status of a species can be inferred from the status of similar resources, or of other representative species in that fishery. These, and other assessment techniques for data-poor fisheries, are improving on an ongoing basis; however, there is still need for some level of numerical skill in order to undertake even these basic assessments.

Having undertaken a stock assessment, the results, implications and levels of risk to the resource and its associated ecology, as well as consequences for local and national socio-economies, and sometimes geopolitical international imperatives, need to be presented to fisheries managers and other decision-makers in a form which is understandable to those unfamiliar with assessment principles and terminology. This interpretation and presentation of stock assessment findings is also a skill which can require training and capacity building in order to be optimal. It is against this background that Member States were approached via a questionnaire, in order to assess existing capacity and needs for these aspects of stock assessment training.

4. Approach

The detailed questionnaire that was sent to all IORA members by the IORA Secretariat is in Appendix 1. The questionnaire sought to have an indication of the number of persons involved in stock assessment nationally, where they were located and the main technical areas of stock assessment being undertaken. It sought to know of specialised stock assessment facilities/services available in the country, the forms of supranational collaboration taking place and the strengths/opportunities that the country had in the domain. The questionnaire followed with what were the existing needs for stock assessment, where these were located, in which technical areas and what were the constraints and weaknesses that existed in stock assessment nationally. In conjunction with a separate report (Fennessy and Harris 2021) that collated the national availability of training courses and advanced studies, the questionnaire sought to find out the types of training courses available as well as those that are considered as required, and examples of some of the countries' notable stock assessment scientists, personalities, or mentors. The questionnaire also sought to obtain an indication of how stock assessment results were communicated and used for fisheries management with a request for some concrete examples of stock assessments undertaken either nationally or with outside assistance and how their results had been used to manage the countries' fisheries. Finally, the questionnaire sought to obtain an indication of the number of persons requiring training other that what was available nationally, the level of that training, and the extent to which it was to be geared towards suitably mathematically orientated candidates actually undertaking stock assessment or towards fisheries managers to improve their interpretation and use of stock assessment results.

Completed results were received from 12 IORA members[2] (55% of the membership). Responses were 99% complete in that all questions were answered bar a couple of typographical omissions. The level of comment and provision of relevant links were variable but of overall good quality providing useful information towards the context of the responses. Responses to stock assessment personalities and mentors were quite mixed and the authors considered inclusion of these names would not add much to this report, and thus have not been included. Also, as the respondents were communicated along IORA's formal lines of communication, they are not included in this report[3].They were generally senior officials from the country that had knowledge of the subject such as Directors or Principal Scientists responsible for stock assessment or the management of fisheries in their countries.

Responsible authorities

Actual stock assessment work was being led in separate agencies or institutes depending on the local or state/province (in the case of federal governments), area and species. In larger countries these included several agencies (e.g. Australia – CSIRO, ABARES, State agencies and Universities) but also these were sometimes coordinated through a central body such as the National Committee for Fish Stock Assessment such as in Indonesia. These agencies are either within or work on behalf of a national ministry responsible for fisheries together with one of more of the following responsibilities: Agriculture, Aquaculture, Marine Affairs, Blue Economy, Marine Resources, Shipping, Aquatic resources, or co-operatives. There were no countries that responded where there was a ministry of

2 Australia, Bangladesh, Indonesia, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Oman, Seychelles, Sri Lanka and Thailand.

3 The IORA Secretariat retains a list of the names, positions and contact details of the respondents to the questionnaire.

fisheries as a single focus ministry though several included fisheries as the lead department of a mixed Ministry, in the case of countries where fisheries were a significant contributor to the country's national economy.

Generally, the lead Ministries were responsible for policy level decisions and international relations whereas the agencies responsible for stock assessment were at an operational level providing advice to fisheries management and to government policy.

5. Number of persons involved in stock assessment nationally.

Respondents provided an indication of the numbers of persons involved in stock assessment nationally within 5 groups: <10 persons; 10-20 persons; 20-50 persons; 50-100 persons; 100-500 persons. Six countries (Madagascar, Maldives, Mauritius, Oman, Seychelles and Sri Lanka) responded that they had less than 10 persons involved nationally. Kenya had 10-20 persons; Bangladesh, Malaysia and Indonesia had 20-50 persons; Thailand 50-100 persons and Australia, 100-500 persons (Figure 1).

Figure 1 : Country responses of the number of persons involved in stock assessment nationally

6. Location and need for stock assessment capacity

Stock assessment capacity existed nationally in fisheries scientists (9 of 12 responses – 75%) within national fishing authorities/agencies (75%) but also within Universities (50%) and as fisheries managers (42%) and researchers (42%). It was recorded also in NGOS/CSOs in one country (Kenya). Countries did not respond as having stock assessment capacity in Colleges, Environmental Authorities, private companies, private consultants and students (Figure 2).

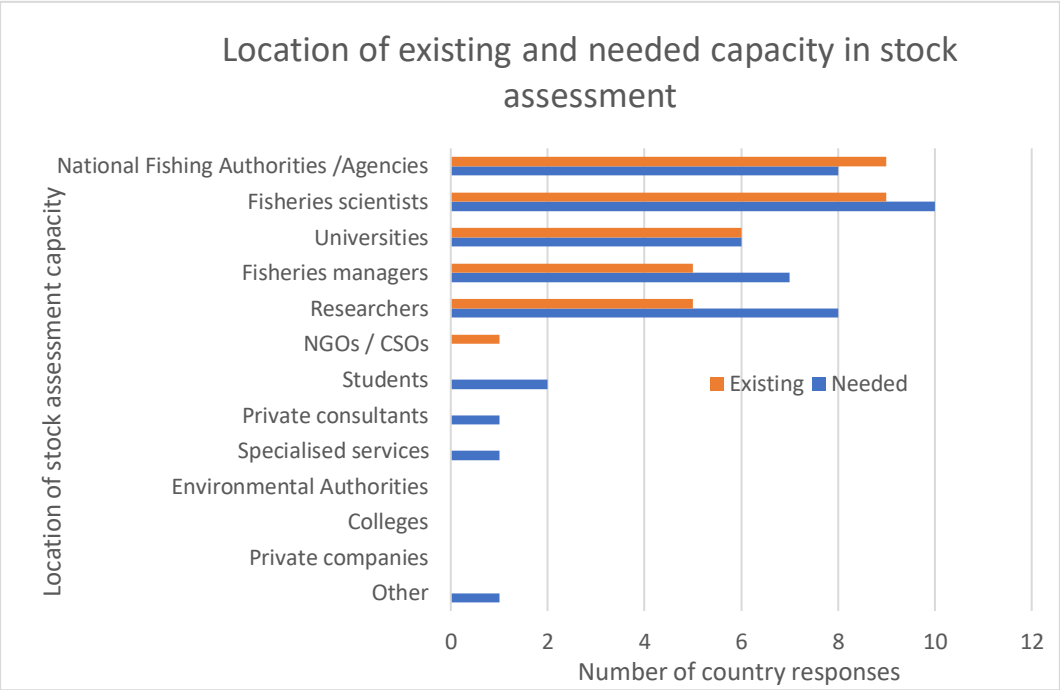

Figure 2: Location of existing and needed capacity in stock assessment

Respondents considered that the need for capacity was for fisheries scientists (10 countries or 83%), National Fishing Authorities/Agencies (66%), fisheries managers (58%), students 16%, private consultants, specialised services and other (each 8%). Other in the responses related to fisheries information systems (Figure 2).

Contrasting the existing against the needed capacity, the responses reflect a need by countries for more stock assessment capacity to be located primarily in fisheries scientists, fisheries managers and fisheries researchers but also in students, private consultants and within fisheries information systems.

7. Existing technical areas and needs

The main technical areas of stock assessment undertaken (Figure 3) were: catch and effort analysis (92%); analysis of catch rates (75%); population dynamics and data-poor methods (66% each). To a lesser extent other technical areas were: acoustic surveys (50%); weight of evidence approaches (25%), SICA/PSA[4] (25%), underwater surveys (17%); tagging (17%); multispecies methods (17%), advanced modelling (17%) and other methods (17%).

Respondents considered that the need in technical areas was for multispecies methods (9 countries, 75%), population dynamics (66%), acoustic surveys (50%), surplus yield analyses and advanced modelling (42% each), catch/effort and analysis of catch rates (33%), SICA/PSA, trawl surveys and tagging (25% each), underwater fish surveys, weight of evidence approaches, and other (16% each), and test fishing (8%). The respondents raised other with respect to Close Kin Mark Recapture and Biological Analysis.

4 Scale, Intensity and consequence analysis / Productivity Susceptibility analysis – see Scandol J., Ives M. and Locket M., 2009. FRDC 2007/16. http://www.fao.org/3/bi382e/bi382e.pdf

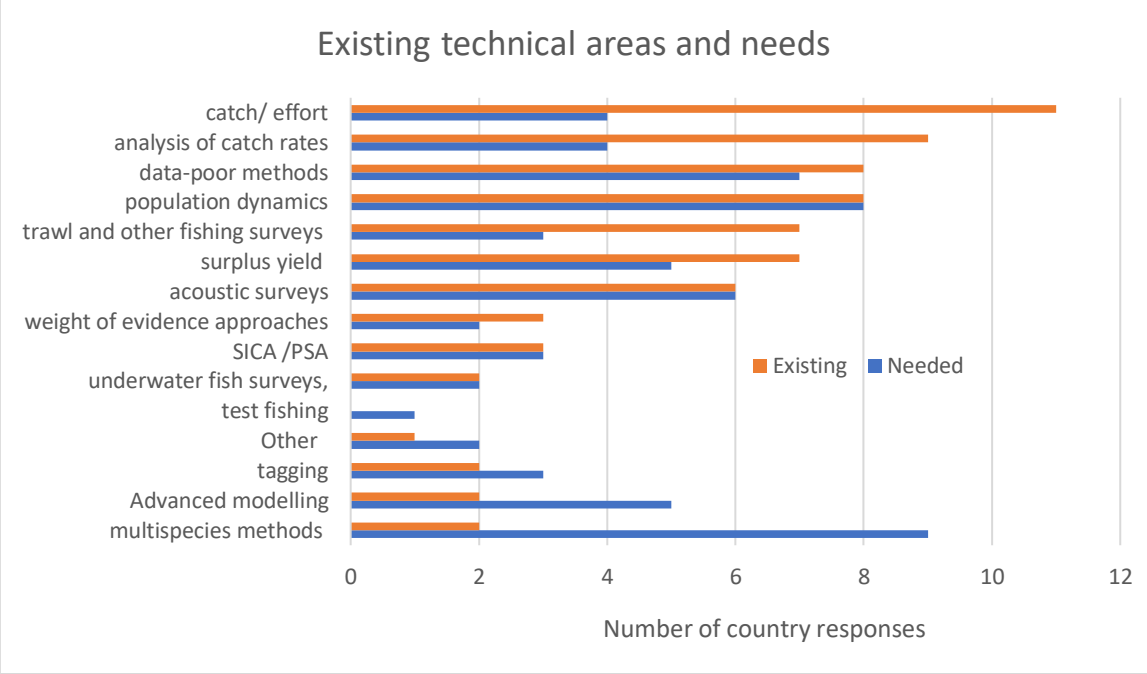

Figure 3 : Existing technical areas and needs

Contrasting the existing against the needed technical areas of expertise, the responses reflect a significant need for multispecies methods and for advanced modelling above what exists. Also, for Close Kin Mark Recapture, tagging and some test fishing. Needs for population dynamics, data-poor methods and acoustic surveys remained high as reflected by 50% or more of the country responses.

Some of the smaller countries remarked that their capacity was at beginner and intermediate level, there was a lack of formal assessments, and that the weight of evidence and data-poor methods were used which sometimes made it difficult to provide sound management advice. Comments also remarked on the importance of stock status advice to the implementation of fisheries management plans.

8. Specialised services in support of stock assessment

Responses from 6 (50%) of the countries noted that they had GIS/Remote sensing as a specialised service in support of the stock assessment institutions (see Figure 4, below). Other available specialised services included fish ageing facilities (42%), genetic stock discrimination (33%), and the capability to provide independent review of stock assessment results (25%). Australia noted that it had another specialised service available as well as those listed. This was Close Kin Mark Recapture facilities, a genetic marking technique developed in recent years and used on a population of Southern Bluefin tuna and of the White Shark on the east coast of Australia/New Zealand. Three countries responded that they had no specialised services available nationally in support of stock assessment.

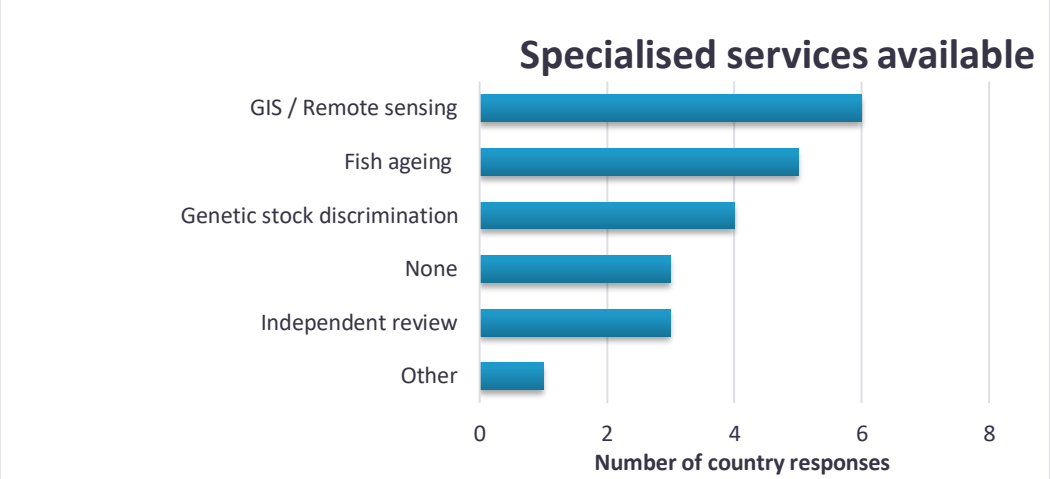

Figure 4 : Specialised stock assessment related services available

9. Strengths in stock assessment.

In assessing their strengths in stock assessment (see Appendix 2), countries mentioned the availability of stock assessment experts in Fisheries Research Centres and Universities, where these existed. At least three countries considered the availability of a national research vessel as a strength. Other countries may also have had research vessels but did not highlight this particularly as a strength. Some countries highlighted their systems for the collection of catch data and drew attention to the long-term data sets that they had available. Others made mention of their analytical laboratories and that they had determined the biological parameters of many of their main target species. One country (Australia) noted that it was relatively rich in stock assessment expertise spanning across technical areas from advanced modelling based on high quality data to weight of evidence and data-poor methods. Still others highlighted their memberships of regional fisheries organisations as one of the factors supporting their strength in fish stock assessment.

10. Supra-national collaboration.

RFMOs/RFBs[5] were the supranational entities that countries were most involved in collaboration in stock assessment (10 countries, 83%, Figure 5). Across the IORA region, IOTC was clearly identified by most of the countries and was the RFMO of most involvement. To the East of the IORA region, CCSBT and WCPFC were mentioned RFMOs, and APFIC, SEAFDEC as the RFBs. To the West, countries had been involved largely with SWIOFC (RFB) and SIOFA (RFMO). Other regional entities and projects mentioned were BOBLME, WIOMSA, MASMA, WWF and FIDEA. FAO was considered as an international collaborator that provided regional training courses in stock assessment. CSIRO (Australia) was usually mentioned with regard to bilateral cooperation in stock assessment. Other particular bilateral agreements such as between Bangladesh and Malaysia were mentioned. Clearly the responses did not cover the broad range of supranational collaboration that takes place. Fennessy and Harris (2021) drew attention to the international contributions from outside of the IORA region from institutions such as CEFAS (UK), UBC (Canada) and NOAA (USA).

5 Regional Fisheries Management Organizations / Regional Fisheries Bodies – RFMOs have mandatory responsibilities for fisheries management (including ability to sanction members) whilst RFBs have purely advisory functions including promotion, collaboration and exchange over various fisheries related areas.

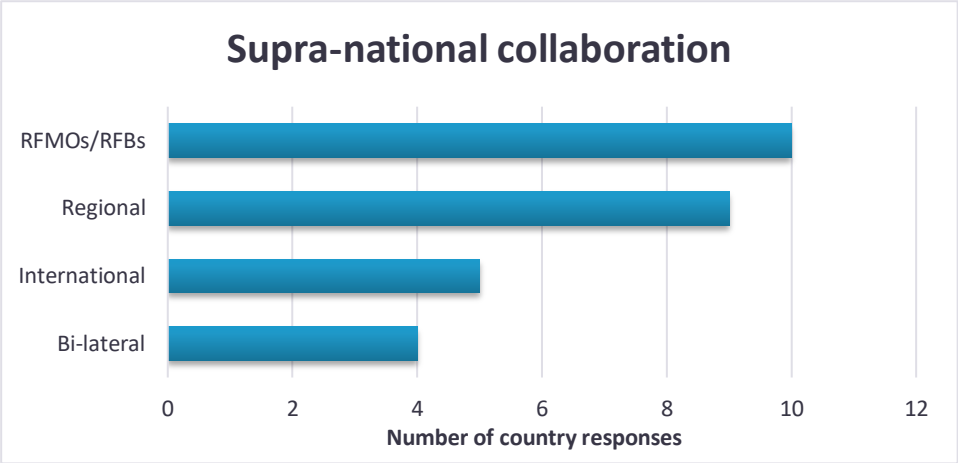

Figure 5 : Supra-national involvement in stock assessment training

11. Availability and needs for training courses.

Eight (66%) responding IORA countries drew attention to the availability of University graduate courses in their countries that provided stock assessment training, and six countries also had post graduate courses (Figure 6). Nevertheless, they still considered that there were continuing major needs for such training. Institutes of technology with stock assessment training was recorded in one country (Bangladesh), and other country (Oman) recorded such training as a need. Diploma level training was recorded in Bangladesh and Indonesia and expressed as a need in four countries (Bangladesh, Indonesia, Malaysia and Maldives).

No countries recorded the availability of short-term (non-diploma) courses but the need for such courses was raised by 50% (6) of the countries (Bangladesh, Madagascar, Maldives, Mauritius, Seychelles and Sri Lanka). Such short-term non-diploma courses are usually those provided by entities such as RFMOs/RFBs, Regional Projects, FAO and occasional courses supported by outside sources of technical expertise such as DTU Aqua, IRD, UBC, and ZMT (Fennessy and Harris 2021). Malaysia noted that apart from any of the training options on the questionnaire, its Department of Fisheries Officers were provided occasional stock assessment training in-house. Four countries noted that they had absolutely no availability for training in stock assessment nationally (Oman, Mauritius, Maldives and Seychelles). Australia, on the other hand, noted that for the purposes of this survey it does not have a need for stock assessment training.

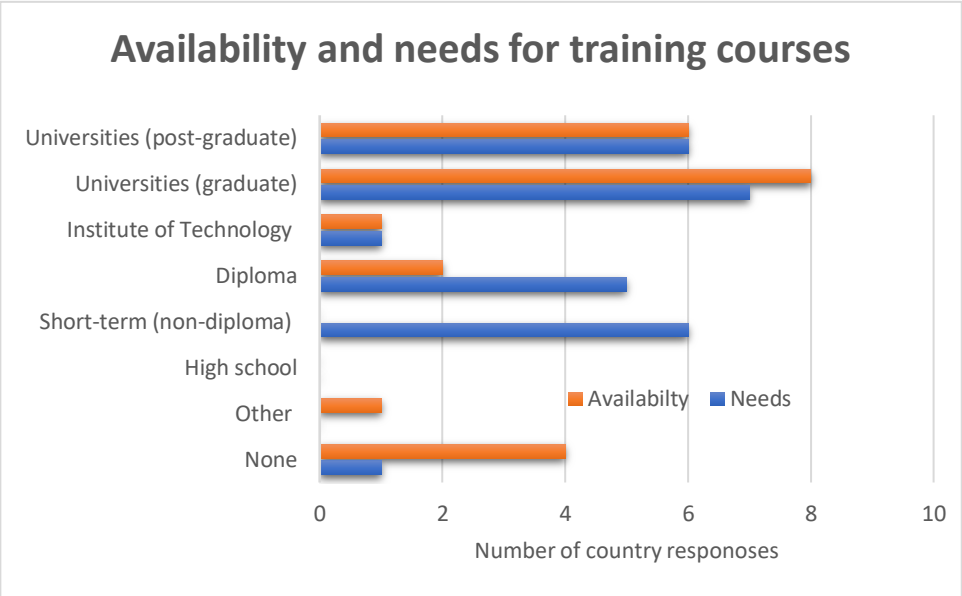

Figure 6 : National availability and needs for training in stock assessment

12. Constraints, threats and technological assistance.

Lack of skilled manpower to conduct stock assessments and limitations on the availability and quality data, often in a context of complex tropical multi-species, multi-gear and multi-fishery situations were recognised most commonly as major constraints by respondents (Appendix 3). Others included inadequate cooperation in relevant agencies and institutions, inadequate funding and logistical support; and absence of a well-equipped research vessel.

Respondents indicated that addressing the skilled manpower needs could be advanced though short-term training and capacity building, undergraduate and post-graduate opportunities (particularly in mathematical or statistical disciplines) not always available in the country. This was particularly recognised in the smaller countries. Short-term overseas training on stock assessment (particularly if outside of IORA) may not be directly applicable to the specific needs of the country. Several countries mentioned that insufficient attention and priority was given to encouraging young students with appropriate aptitudes into the area of stock assessment. This is clearly a long term and continuous process. Even in the responding country with the most capacity, it was recognised that the main threat is to maintain the recruitment of young scientists through universities.

In relation to limitations on the availability and quality of data, responding countries gave examples of how these could be addressed such as through improved national data collection systems, scientific monitoring, beach management units, and logbooks as well as better control of IUU fishing by national authorities and regional fisheries bodies.

The need for technological assistance were reflected by means of addressing the constraints and threats existing in the different responding countries (Appendix 3). Specificities included assistance in: GIS/remote sensing; use of advanced software for storage and analysis; advanced stock assessment modelling; training in R software; data-poor assessment methods; hydro-acoustics; equipment for fish reproductive biology; ageing; web-based spatial data storage and analysis; development of fisheries management plans; equipment for marine surveys, genetic and tagging studies; and deep-sea resource surveys.

13. Communication of stock status and use for management.

The questionnaires also provided an opportunity to obtain indications on how stock assessment results are disseminated, how they are used to manage fisheries resources by the various actors in the process, and to what perceived success, or otherwise.

Stock assessment results are disseminated primarily by national fishery reports, official reports as grey literature, and published peer-reviewed scientific papers in the respondent countries (Figure 7). Verbal communication was scored in 3 countries while publishing in international reports (non-scientific) was the response of one respondent country.

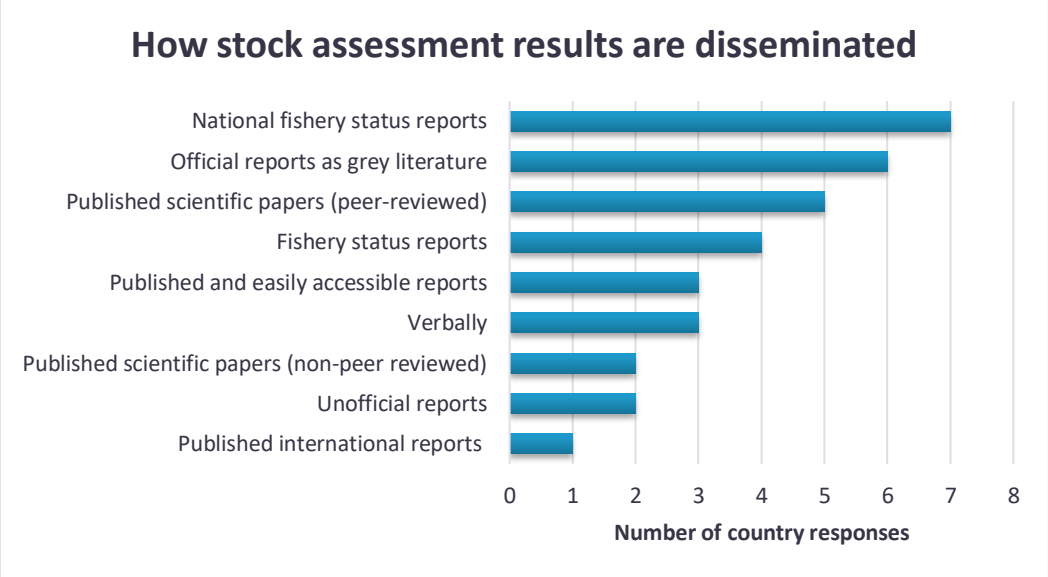

Figure 7 : Dissemination of stock assessment results

Questions 23, 24 and 25 of the questionnaires sought to obtain an indication of the extent that these stock assessment results are communicated well to fishers and other stakeholders, to fisheries managers and to the high-level management and policy process (Permanent/Principal Secretaries; Ministry; Ministers). Elements of good communication of stock assessments were provided as part of an addendum to the questionnaire (see Appendix 1). Using scores of 1 (never) up to 6 (always) respondents scored how well stock assessment results are communicated.

The results shown in Figure 8 below indicate that the results are less well communicated to fishers and stakeholders (average score 3.8) and to high-level management and the policy process (average score 4.5) than to managers (average score 4.9). This was perhaps to be expected given the nature of the stock assessment dissemination results shown in Figure 7. All average results were above 3.5, suggesting that even communication to fishers and stakeholders was considered slightly better than this midpoint score.

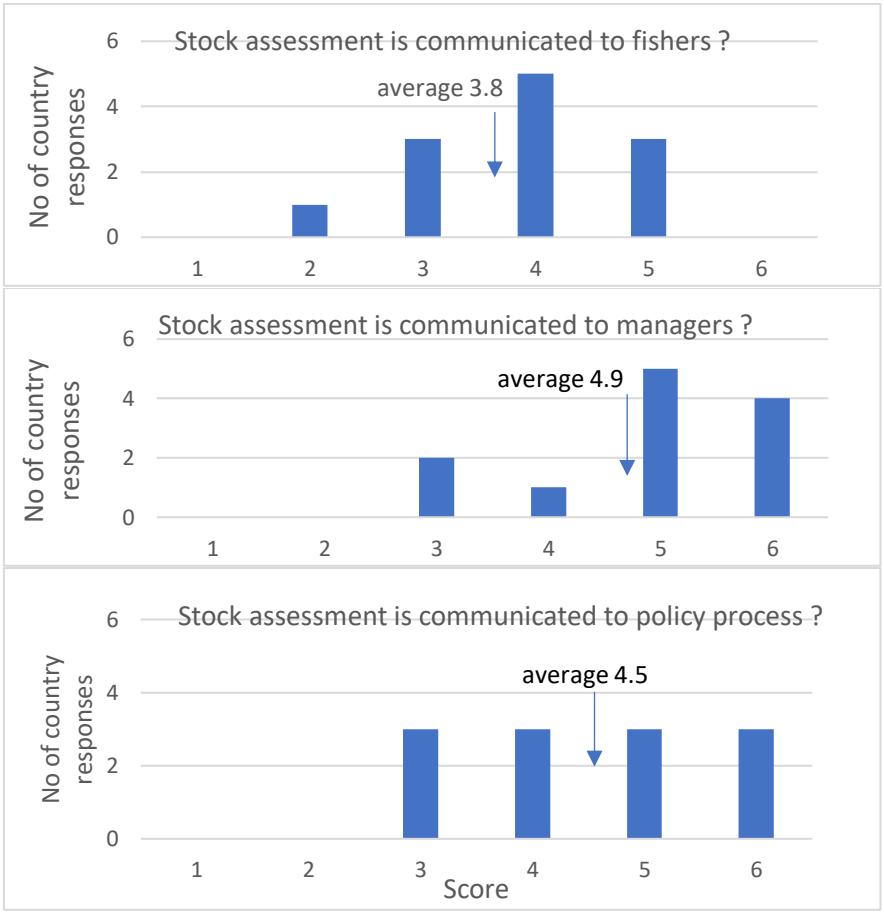

Figure 8 : Communication of assessment results to fishers, fisheries managers and the policy level. Extent of communication score: 1 = never; 6 = always.

National fisheries authorities obtained their stock assessment advice primarily from national universities and from inhouse fisheries scientists (50% of respondents for each of these categories) as shown in Figure 9. National research organisations, as well and regional fisheries management organisations and regional fisheries bodies were important sources of stock assessment advice in over 33% of the respondents. One country (Indonesia) noted that the national fishing authority obtained its advice from a separate National Commission for Stock Assessment. While international and national consultants contributed to the advice, respondents did not score international universities or national companies as having any contribution to this process.

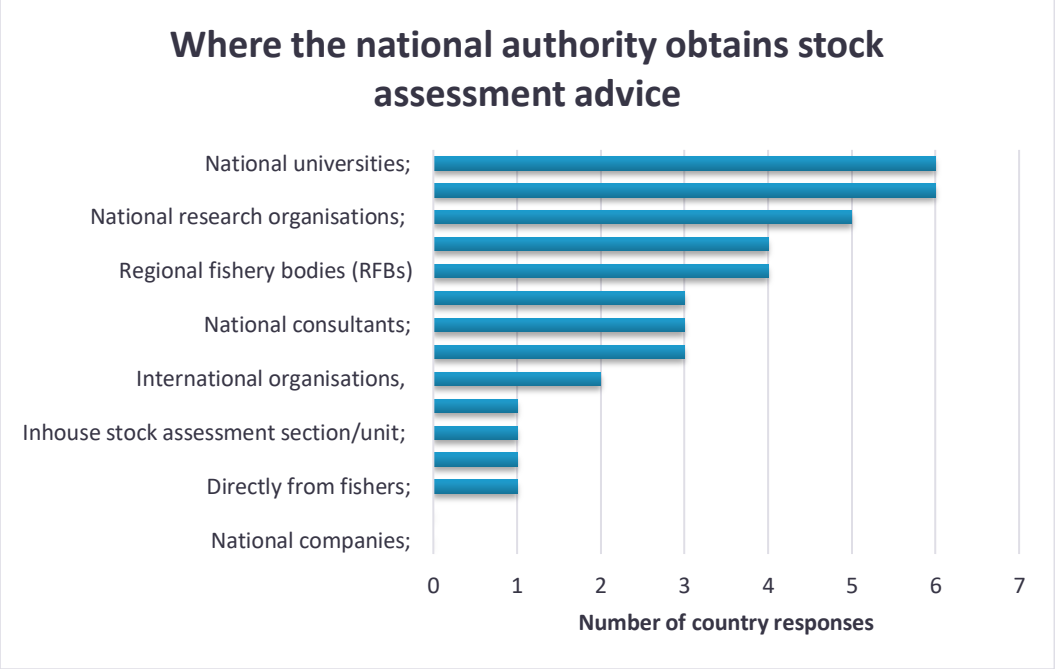

Figure 9 : National fisheries authorities' sources of stock assessment advice

Using scores of 1 (not familiar) up to 6 (uber familiar) respondents scored the familiarity of fisheries managers with the stock assessment process itself at an average of 3.5 with 4 countries scoring 3 and 4 countries scoring 5 (Figure 10). No countries scored 1 or 6. The average score if countries had scored each of the presented scores (randomly) would likewise have been 3.5.

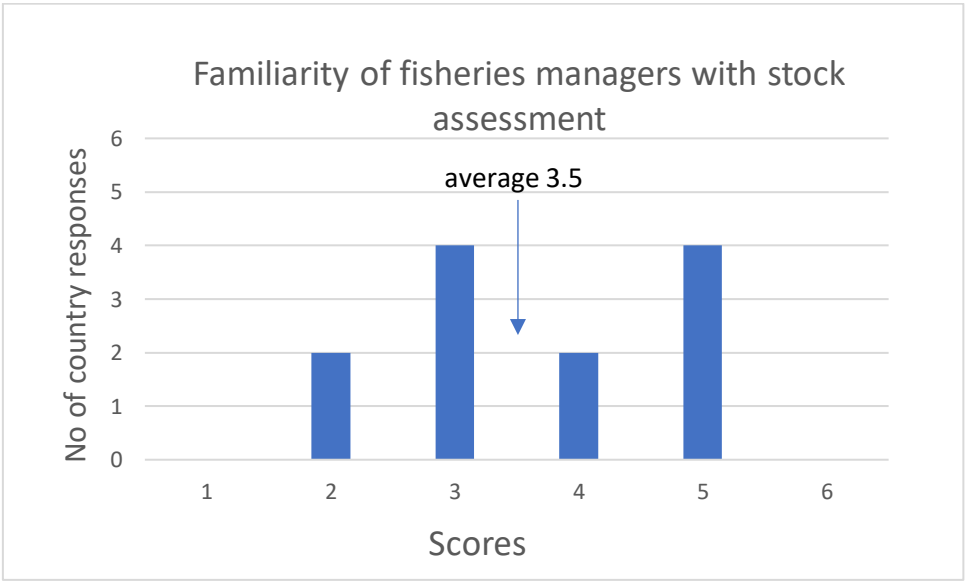

Figure 10 : Familiarity of fisheries managers with stock assessment. Extent of familiarity: 1 = not familiar; 6 = uber familiar.

Managers had primarily become familiar with stock assessments from on the job experience followed, as part of their management studies, from regional and international workshops, and post graduate study and publications (Figure 11). These results are to be expected as managers are not supposed to

be stock assessment experts as that is not their role. Nevertheless, some have PhDs and specialisations as was recorded in 3 of the respondent countries.

Figure 11 : How fisheries managers have become familiar with stock assessment

Stock assessment recommendations get to managers primarily from formal processes of stock assessment such as from regional fisheries bodies, regional fisheries management organisations, and annual reviews of management plans (Figure 12). Still there are fairly high scores of information getting to managers from ad hoc processes (which would include from fishers and word of mouth). The category other was used in some countries to represent information emanating from formal assessments such as from Scientific advisory groups (SAGs) and assessment reports from research agencies. No responding countries claimed that the manager's source of information on stock assessments came from lobby groups, whilst one was sourced to NGOs.

Figure 12 : How stock assessment recommendations get to fisheries managers

All respondents indicated that, invariably managers used stock assessment results primarily to implement management plans (Figure 13). Other main uses were to reduce fishing effort, to revise regulations, to communicate with stakeholders and to set quotas. Under half of the responses were to reduce fishing capacity and to reduce fishing mortality. No other uses of stock assessment were proposed in this question, and no responses indicated that stock assessment results were not used.

Figure 13 : How fisheries managers use stock assessment results

The extent to which stock assessment results and recommendations were used by fisheries managers to manage their fisheries, and separately the extent to which the major fisheries are managed according to stock assessment advice are captured in the following three figures below. Scores were 1 (never) up to 6 (always).

The extent to which management of fisheries in the country was based on stock assessment results and recommendations formed a distribution tailed toward the lower side (Figure 14a) but with some high scores of 5 and including a 6 in one country, with average score of 4.2. How receptive fisheries managers of the national fishing authority were to acting based on stock assessment advice also scored an average of 4.2 (Figure 14b) this time with a somewhat more normal distribution with one country scoring never and two countries scoring always. On the extent that the main/major fisheries of the country were managed according to stock assessment advice (Figure 14c), the average score was 3.7 with a distribution split into exactly into two groups – six countries scored on the lower end again with one scoring never, and six countries scored on the higher end with one scoring always. This result would seem to suggest that other factors apart from the influence of stock assessment and fisheries managers significantly affected the way that fisheries were managed in some countries.

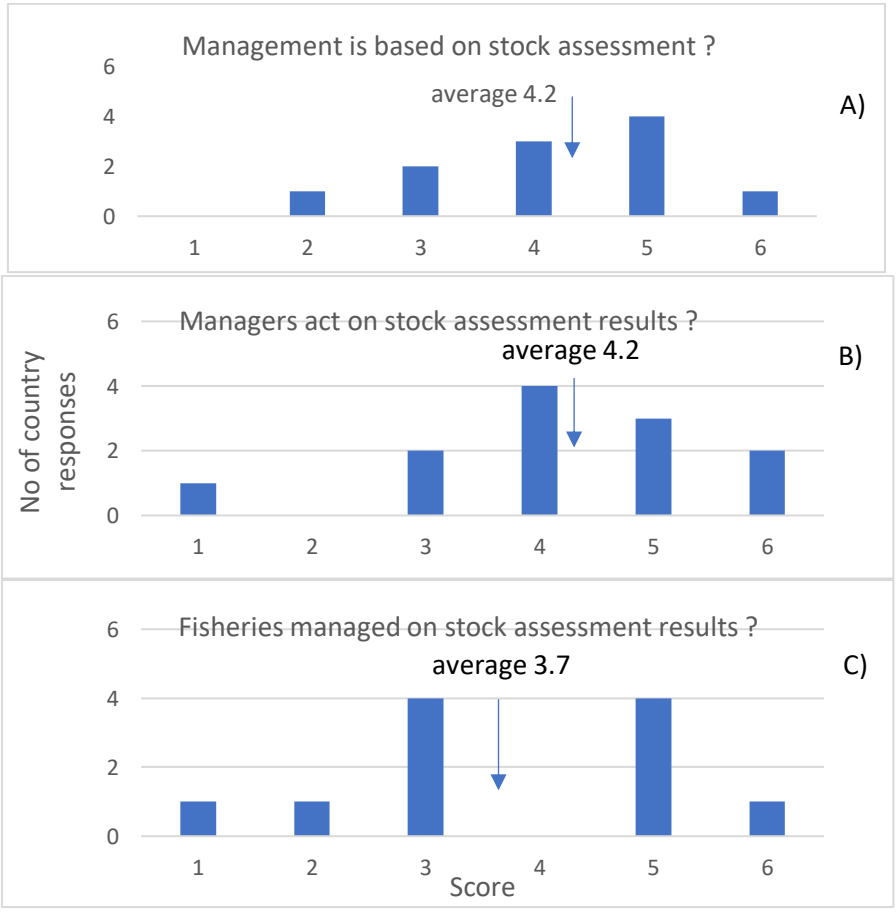

Figure 14 : Extent that the management of fisheries was based on stock assessment results. Extent score: 1 = never; 6 = always.

14. Examples of recent stock assessments per country

Examples of stock assessment results and the management measures taken as provided by respondents are shown in Appendix 4. Stock assessments of the flathead in Australia's Southern Eastern Scalefish and Shark Fishery in 2019 led to quota implementation of a total allowable catch (TAC) of 2468 tonnes. In Bangladesh assessments of marine fisheries in 2019 found that some commercial fish stocks were declining and recommended vessel and fishing effort restrictions/ban which led to restrictions of new industrial fishing vessels entering the fleet. In Indonesia assessments of the Ground fishery led to decrees in 2015 and 2017, restrictions of TACs and a revised fishing permit policy. There appears to have been no enforcement, however. Assessments of the shallow water prawn fishery in Kenya in 2010 showed the need to limit the fishing effort (number of vessels) and supported the development of a management plan with several measures including a closed season and a zone up to 5nm from shore that excluded prawn trawlers. In Madagascar, there is an annual assessment of the shallow-water prawn fishery which determines the start and duration of the closure period which is usually of 3 months duration every year. Malaysia undertook assessments of their demersal, small pelagics, prawns and tuna fisheries between 2014 and 2016 which became the basis for the development of a management plan. Maldives is yet to have a history of assessments of its non-tuna fisheries. Currently management measures (such as minimum sizes) are based on research conducted on an as-needed basis. Recently it has developed a draft management plan for sea-cucumber in which research actions will underpin the plan. Oman undertook assessments in 2018 which recommended that the harvest of immature sized species be reduced, leading to setting of allowable fishing sizes for most commercial targeted species. Seychelles had a sea-cucumber assessment in 2017 that showed evidence of population declines, sometimes significantly. The recommendations led to the introduction of a quota system with TAC capped at 2016 catch levels. Sri Lanka undertook assessment of five of its export-orientated fisheries including sea-cucumber, lobster and shrimp in 2008. The recommendations of the assessment led to size regulations, capacity control and effort control by limiting licences. There appears to have been no enforcement, however. Thailand assessed its demersal fishery in 2020 which resulted in a maximum sustainable yield (MSY) estimate of 790,985 tonnes and a TAC set at 95% of the MSY. Management measures taken included limitation on the fishing day.

Not all countries responded to the request on whether an ecosystem approach to fisheries (EAF) management had been taken. Such an approach may or may not have been undertaken in these cases. Good fisheries management in open democratic countries usually entails ecologically sustainable principles as a normal part of fisheries management, akin to EAF, but it may not be mentioned as EAF specifically. Some may also consider EAF less efficient for particular fisheries. Those that responded positively made mention of using EAF indicators, extensive consultation with all relevant stakeholders, co-management and establishment of appropriate local committees.

The questionnaire also sought to have information on the most recent stock assessment that had been undertaken on the stock/s of a main or major fisheries. It also sought to find if this was undertaken through national capacity or whether it had been provided using non-national expertise. The timeliness and regularity of stock assessments undertaken by a country itself provides a good indication of its capacity in this field. On the other hand, timely and regular assessments made by a country using outside expertise, while possibly a good indication that the country has the information to manage its fisheries based on proper stock assessments, does not indicate that the country has that stock assessment capacity, and perhaps quite the opposite.

Appendix 5 captures the responses provided on the most recent stock assessments of main or major species undertaken nationally or with regional/international expertise. Countries with recent national

assessments, in order of timeliness, were: Australia (all Commonwealth fisheries, 2020); Kenya (longline fisheries, 2020); Oman (demersal, small-pelagic, lobster, sea-cucumber, 2019); Seychelles (key indicator snapper and grouper species, 2019); Thailand (pelagic fish, demersal fish and anchovy, 2019); Indonesia (small and large pelagics, demersal reef, penaeids, 2 crabs, squid, 2017); Malaysia (demersal, small pelagic, prawns and tuna, 2016); Sri Lanka (Blue swimmer crab, 2015); Bangladesh (demersal trawling, 1999).

Countries with stock assessments requiring regional/international expertise were: Maldives (skipjack tuna and groupers, 2020); Bangladesh (shrimp, demersal and pelagic, 2019); Sri Lanka (small pelagic and demersal species, 2018); Seychelles (demersal handline and trap species, 2015); Oman (small pelagic and demersal species, 2008), and; Mauritius (2002).

15. Estimates of the need for training courses in stock assessment.

The two last questions of the questionnaire sought to have a roughly quantitative indication of the needs of the responding country for training courses in stock assessment, that could not be provided within the country itself. This was with a view to identifying the IORA region-wide needs that would be the subject of exchanges of training courses by IORA members, or for the support of RFBs, RFMOs, and regional projects in providing such courses and capacity building. The previous report (Fennessy and Harris 2021) collating training courses in the IORA region provides a good indication of such possible sources of capacity building as well as some suggestions as to how IORA could assist.

To provide some resolution on the level of the courses, they were classed as basic, intermediate, and advanced for courses aimed at students and fisheries scientists with the appropriate analytical, statistical and mathematical grounding to advance their knowledge of stock assessment techniques and modelling. These would be towards supporting and increasing the numbers of would-be practitioners in the field.

Another set of courses at two levels, introductory and advanced, are primarily focussed on fisheries managers, so that they are able to understand the concepts of stock assessment and interrogate stock assessment providers intelligently, critically and purposefully in national and regional (e.g. RFMOs) situations. In both sets, respondents were asked to score their needs for the courses they wished as <5 persons, 5-10 persons, 10-20 person, or >20 persons.

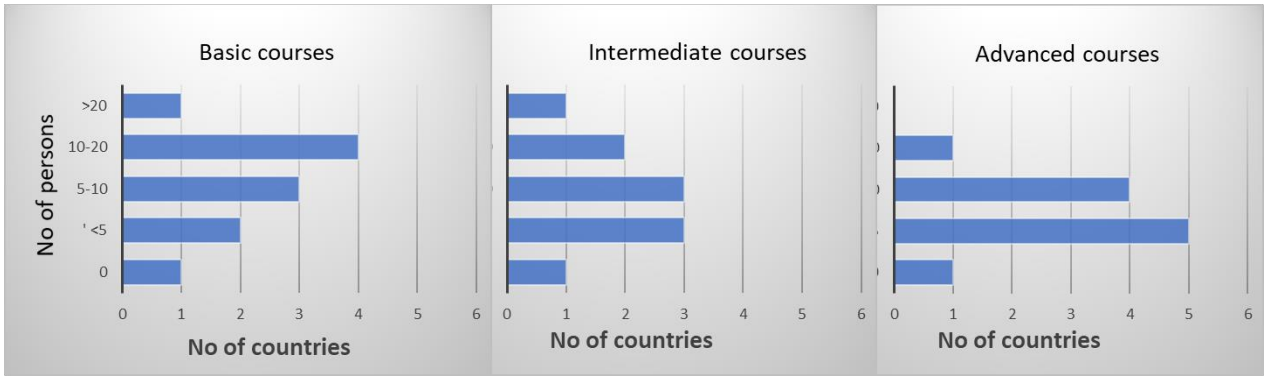

Figure 15 : Need for training courses for stock assessment practitioners

The respondent's results of stock assessment training for practitioners are shown in Figure 15 above. For basic courses the modal point of the response was for 10-20 persons required by 4 countries; for intermediate courses the modal point was for up to 10 persons required by 6 countries, and for

advanced courses the modal point was for less than 5 persons required by 5 countries. Roughly and conservatively estimated, based on these responses, this would amount to 110 persons for basic courses, 85 persons for intermediate courses and 55 persons for advanced courses as the needs of 12 of the now 23 IORA member countries[6].

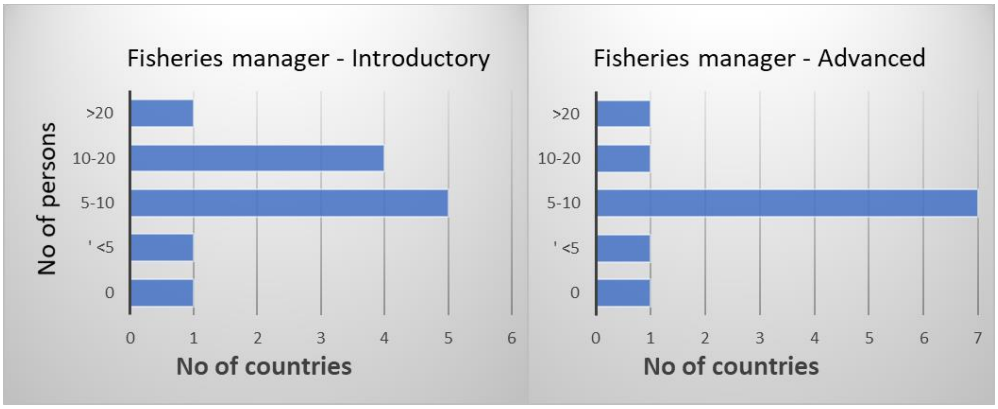

Figure 16 : Need for stock assessment training courses for fisheries managers

The respondent's results of stock assessment training for fisheries managers are shown in Figure 16 above. For introductory courses, the modal point of the response was for 5-10 persons required by 5 countries noting also that 10-20 persons were required by 4 countries, and for advanced courses the modal point was strongly 5-10 persons required by 7 countries. Roughly and conservatively estimated based on these responses, this would amount to 125 persons for introductory courses and 95 persons for advanced courses as the needs of 12 of the 23 IORA member countries.

Across these results, generally the more populous countries such as Bangladesh, Indonesia, Malaysia and Thailand scored higher (greater needs) in the range of 10-20 persons or >20 persons needing courses. One country, Australia, indicated that it had no needs for training of stock assessment practitioners nor for training of fisheries managers in stock assessment, at least for such intended courses. However, it noted that it may have scientists capable of delivering such courses to IORA member countries.

16. Concluding observations and comments

A previous report (Fennessy and Harris 2021) collating the availability of and/or capability to present stock assessment courses in the region found that these were concentrated largely in three countries, South Africa, India and Australia. It recognised the important need for universities to contribute to stock assessment capacity at undergraduate as well as post-graduate level. Also, it reflected on the sometimes-mixed utility of the contribution of short-term training courses to the furtherance of capacity towards more stock assessment practitioners. The report did not have access to the full response of countries to the questionnaire at the time, as the results of only half of the present responding countries were available.

6 France became the 23rd IORA Member State in December 2020 and was not involved in responding to this questionnaire.

Unfortunately, two of the important countries identified in that report (India and South Africa) did not provide any responses to the questionnaire.

Nevertheless, many of the findings of that report are reflected in the present results. Clearly there is a significant expressed need across the region for stock assessment capacity, as initially suggested by the IORA Working Group on the Blue Economy. This need is especially pronounced in the smaller, less populous IORA countries. The nature of the expressed need varied widely, in terms of the various technical areas of stock assessment for which capacity-building was identified, but this report provides some guidance in this regard, relative to the areas in which respondents indicated that they already had some expertise. The importance of universities, not only for their current contributions to stock assessment advice, but also the important role they have as providing the initial environment for identifying numerate individuals and developing capacity, is further emphasised here. Slightly differently though, whilst there may be concerns as to the actual impact of short-term courses, many countries raised that they saw these as an important source of support and capacity building for those professionals in the field that may not be specialists in stock assessment, or to supplement post-graduate university training in this field. Here, it is probably largely related to the area of assisting fisheries managers to properly understand stock assessments and to intelligently interrogate the specialist experts and their reports and recommendations, as was raised in that report. Indeed, this is reflected also in the high scoring of the need for stock assessment courses in the present report.

This report identifies that 12 of the 23 IORA MS indicated that collectively they require training for some 250 persons to be supported in graded training as practitioners of stock assessment, and for some 220 persons who are managers to be provided training to properly interrogate stock assessment specialists, their reports and recommendations. Across the entire IORA region these numbers would likely double.

This report, in conjunction with the previous report (Fennessy and Harris, 2021) provides a fair amount of resolution as to the exact needs of IORA MS for such stock assessment training or training courses, and also the sources of such training and expertise within the IORA MS themselves. With the facilitation and coordination of IORA's CGFM and the WGBE, this information provides a basis for IORA MS to collaborate between themselves to address some of these needs, whether these are for university graduate and post-graduate training or short-term courses. It also provides a basis for the IORA Secretariat to approach FAO, regional fisheries management organisations, regional fisheries bodies or regional fisheries projects in collaborating in the provision of short-term courses particularly for fisheries managers. In addition, it could seek to advance this through its own supporting projects or technical assistance providers though capacity for this is likely to be limited to the medium term following the appropriate consideration of such an option and the availability of projects and funds vis-à-vis other priorities of its Action Plan 2020-2023.

Appendix 1: Questionnaire

TECHNICAL ASSISTANCE TO IORA FOR THE IMPLEMENTATION AND COORDINATION OF IORA ACTION PLAN ON FISHERIES, AQUACULTURE AND MARINE ENVIRONMENT

"Promoting sustainable fisheries management"

Questionnaire on "Existing capacity and needs for stock assessment training in the IORA region" under activity 2.1 "Initiate a Capacity Building programme in fish stock assessment."

Background information

The Indian Ocean Rim Association (IORA) and France through the Agence Française de Développement (French Development Agency) (AFD) signed a Memorandum of Understanding (MoU) on the 9th March 2020 for 'Strengthening the Capacities of IORA in Promoting the Blue Economy and Fisheries Management'.

The partnership will support the implementation of the IORA Action Plan (2017-2021) with an allocation of EUR1 million over three years. It will offer expertise, training, networking and material resources to decision makers, officials and experts working to promote regional cooperation in blue economy and fisheries management issues. In addition, the project will strengthen the capacity of the IORA Secretariat.

The strong focus of the project is therefore on building the capacity of IORA and its member states to achieve the specific objectives listed in the IORA Cluster Group on Fisheries Management (CGFM) Work Plan and the WGBE Action Plan concerning mainly fisheries, aquaculture and protection of the marine environment through the implementation of various activities also listed within the WGBE action plan.

Under the objective of promoting fisheries management, one of the early activities to further

this objective is to "Initiate a capacity building programme in fish stock assessment". Stock assessments provide crucial scientific information to resource managers. They play a key role in the management process by providing the scientific basis for fisheries management, setting annual catch targets and limits to ensure that stocks are not overfished, and overfishing does not occur. Stock assessments are a key component of the stewardship of living marine resources to benefit the IORA countries.

This questionnaire seeks to encourage IORA countries to provide information on their existing capacities and needs for stock assessment training with a view to assisting the IORA Secretariat to facilitate knowledge exchange and collaboration among IORA Member States and with partners. It will form part of an assessment of available facilities to provide the basis for the development of a capacity-building programme facilitated by IORA or in collaboration with regional fisheries organisations and relevant institutions over the longer term (> 3 years).

For an explanation of what is meant by stock, stock assessment, capacity building, communication and the national fishing authority (the target of this questionnaire), a short glossary of key terms is included at the end of the questionnaire.

MEMBER STATE PROFILE

Country:	**Name of respondent :**
Role/position of respondent:	**Phone number:**
E-mail address:	

1. Which is the Ministry/ Department / National Fishing Authority responsible for fisheries management? ……

2. Which Institution/ Agency is responsible for stock assessment? ……

3. What form of cooperation exists between the National Fishing Authority (in Question 1) and the Institution (in Question 2) responsible for stock assessment?

Remarks, links or details: ……
……
……
……

4. Estimate of number of persons involved in stock assessment, nationally:

☐ < 10 pers.
☐ 10 – 20 pers.
☐ 20 – 50 pers.
☐ 50 – 100 pers.
☐ 100 – 500 pers.
☐ > 500 persons.

EXISTING CAPACITY

5. Where does the stock assessment capacity of the country mostly reside?

☐ Students
☐ Researchers;
☐ Fisheries scientists;
☐ Fisheries managers;
☐ Private consultants;
☐ Private companies;
☐ Colleges;
☐ Universities;
☐ National fishing authorities/agencies;
☐ NGOs/CSOs;
☐ Environmental authorities/agencies;
☐ Other ……

Remarks, links or details: ……
……
……
……

6. What main technical areas (methods) of stock assessment are undertaken in the country by the individuals, institutions or organisations ticked above?

☐ Advanced modelling,
☐ surplus yield
☐ multispecies methods,
☐ trawl and other fishing surveys,
☐ acoustic surveys
☐ weight of evidence approaches
☐ SICA/PSA;
☐ population dynamics,
☐ catch/effort,
☐ analysis of catch rates,
☐ tagging,
☐ underwater fish surveys,
☐ data-poor methods
☐ Other ……..

Remarks, links or details: ……
……
……
……

7. What specialised facilities/services specifically supporting stock assessment are available in the country?

☐ Fish ageing
☐ GIS / Remote sensing
☐ Other ……
☐ Genetic stock discrimination
☐ Independent review

Remarks, links or details: ……
……
……
……

8. What supra-national collaboration in stock assessment is the country involved in?

☐ Bi-lateral
☐ RFBs
☐ International
☐ Regional
☐ RFMOs
☐ Other ……

Remarks, links or details: ……
……
……
……

9. What are the strengths and opportunities in stock assessment that the country has?

Remarks, links or details: ……
……
……
……
……

EXISTING NEEDS

10. Where is the greatest need (lack of capacity) for stock assessment capacity in the country (tick a maximum of 4 only)?

☐ Students;
☐ Researchers;
☐ Fisheries scientists;
☐ Fisheries managers;
☐ Private consultants;
☐ Private companies;
☐ Colleges;
☐ Universities;
☐ National fishing authorities/agencies;
☐ NGOs/CSOs;
☐ Environmental authorities/agencies;
☐ Specialised service providers
☐ Other ……

Remarks, links or details: ……
……
……
……

11. What are the technical areas of stock assessment that are most required by the country to meet its fisheries management needs (tick a maximum of 6 only) ?

☐ Advanced modelling,
☐ population dynamics,
☐ surplus yield
☐ catch/effort,
☐ multispecies methods,
☐ analysis of catch rates,
☐ trawl and other fishing surveys,
☐ tagging,
☐ test fishing,
☐ acoustic surveys,
☐ underwater fish surveys,
☐ data poor methods,
☐ Scale Intensity Consequence Analysis (SICA)/Productivity and Susceptibility Analysis (PSA);
☐ weight of evidence approaches.
☐ Other ……

Remarks, links or details: ……
……
……
……

12. What are the constraints, weaknesses and threats to stock assessment that the country has and suggest how these can be addressed.

Remarks, links or details: ……
……
……
……

13. What types of technological assistance does the country require to increase its stock assessment capacity

Remarks, links or details: ……
……
……
……

NATIONAL AVAILABILITY OF TRAINING COURSES, ADVANCED STUDIES, MENTORS

14. Types of training/courses that are available nationally on stock assessment

☐ None
☐ Short-term (non-diploma)
☐ Institute of Technology
☐ Universities (post-graduate)
☐ High school
☐ Diploma
☐ Universities (graduate)
☐ Other ……

Remarks, links or details: ……
……
……
……

15. Types of training /courses that are required nationally on stock assessment.

☐ None
☐ Short-term (non-diploma)
☐ Institute of Technology
☐ Universities (post-graduate)
☐ High school
☐ Diploma
☐ Universities (graduate)
☐ Other ……

Remarks, links or details: ……
……
……
……

16. Names of some of the country's notable stock assessment scientists/personalities/mentors:

Remarks, links or details: ……
……
……
……

COMMUNICATION OF STOCK STATUS AND USE FOR MANAGEMENT

17. How is a major part of stock assessment results communicated in the country

☐ verbally
☐ official reports as grey literature
☐ fishery status reports
☐ published international reports
☐ published scientific papers (peer-reviewed)
☐ unofficial reports
☐ published and easily accessible reports
☐ national fishery status reports
☐ published scientific papers (non-peer reviewed)
☐ Other ……

Remarks, links or details: ……
……
……
……

18. Where does your National Fishing Authority obtain its stock assessment advice?

☐ directly from fishers;
☐ Inhouse *adhoc* (unplanned, informal);

☐ inhouse from individual fisheries officers
☐ Inhouse stock assessment section/unit;
☐ national companies;
☐ national research organisations;
☐ international universities;
☐ regional fishery bodies (RFBs)
☐ inhouse fisheries scientists;
☐ national consultants;
☐ national universities;
☐ international consultants/companies;
☐ international organisations,
☐ regional fisheries management organisations (RFMOs)

19. To what extent are your fisheries managers familiar with stock assessment? (Score between 1 and 6)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

Not familiar **Uber familiar**

19 a. How have your fisheries managers become familiar with stock assessment?

☐ on the job experience,
☐ from regional/international workshops;
☐ graduate stock assessment courses/modules
☐ PhDs and specialisation in stock assessment;
☐ from national training workshops;
☐ part of their fisheries management studies,
☐ post-graduate study and publications;
☐ other sources

Remarks, links or details: ……
……
……
……

20. How does stock status information and recommendations mainly get to your fishery managers?

☐ does not get to managers;
☐ primarily from fishers;
☐ lobby groups;
☐ industry groups;
☐ annual review of management plan;
☐ international fora;
☐ other ……
☐ ad hoc;
☐ word of mouth;
☐ NGOs,
☐ a formal process of stock assessment;
☐ published scientific literature;
☐ RFBs and RFMOs;

Remarks, links or details: ……
……
……
……

21. How are stock assessment results and recommendations used by your fishery managers?

☐ largely not used;
☐ to implement management plans,
☐ to set quotas,
☐ to reduce fishing effort,
☐ other ……
☐ to revise regulations,
☐ to communicate with stakeholders,
☐ to reduce fishing mortality,
☐ to reduce fishing capacity,

21a. Give a concrete example of your response to one of the above.

- Fishery: …… Year: ……
- Stock assessment result/recommendation: ……
- Management measure/s taken: ……
- Is/was the management measure adequately supported by legislation? ☐ Yes ☐ No
- Is/was the management measure adequately supported by enforcement? ☐ Yes ☐ No
- Citation or relevant weblink/website: ……
- How was an Ecosystem Approach to Fisheries (EAF) management taken in this process? ….
  ……
  ……
  ……

22. To what extent is the management of your fisheries based on stock assessment results and recommendations? [Score between 1 and 6)

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐
Never					**Always**

23. To what extent are the results of stock assessments communicated well to fishers and other stakeholders?

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐
Never					**Always**

24. To what extent are the results of stock assessments communicated well to fisheries managers?

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐
Never					**Always**

25. To what extent are the results of stock assessments communicated well to high-level management and policy process (Permanent/Principal Secretary, Ministry, Minister) ?

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐
Never					**Always**

26. For your main or one of your major fisheries:

- Which year was the last time a stock assessment of the main fish stock/s undertaken? ……
- Which fish stock(s) and what stock assessment method/s was/were used? ……
  ……
- Person/s, group, institution or organisation that undertook the assessment? ……
  ……
- Their contact details or link ……

26a. If the above answer referred to an international consultant, international company or regional/international organisation: [otherwise ignore]

- Which year was the last time a stock assessment of the main fish stock/s was undertaken by a national consultant, national company or national fishery authority/organisation …….
- Which fish stock and what stock assessment method/s was/were used: ……
  ……
  Person, group, institution or organisation that undertook the assessment? ……
- Their contact details or link ……

27. How receptive are the fisheries managers of the National Fishing Authority to acting based on stock assessment advice?

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐
Never					**Always**

28. To what extent are the main/major fisheries managed according to the stock assessment advice

1	2	3	4	5	6
☐	☐	☐	☐	☐	☐

Never **Always**

STOCK ASSESSMENT TRAINING

This section seeks to obtain an indication of the needs for stock assessment training and knowledge that cannot be undertaken nationally by this IORA Member State. It seeks to obtain some measure of needs of this IORA Member State that may be met by other IORA Member States or competent relevant regional organisations with the appropriate capacity in stock assessment.

What is the need of stock assessment training courses for fisheries officers / fisheries scientists that already have good mathematical, programming or statistical skills.

Basic: ☐ < 5 pers. ☐ 5 – 10 pers. ☐ 10 – 20 pers. ☐ >20 pers.

Intermediate: ☐ < 5 pers. ☐ 5 – 10 pers. ☐ 10 – 20 pers. ☐ >20 pers.

Advanced: ☐ < 5 pers. ☐ 5 – 10 pers. ☐ 10 – 20 pers. ☐ >20 pers.

Remarks, links or details: ……
……
……
……

What is the need for training courses directed to fisheries managers so as to be confident in the interpretation of the information as conveyed in stock assessment reports, to interrogate/ ask questions about stock assessment results presented, and to further the development of fishery management recommendations

Introductory: ☐ < 5 pers. ☐ 5 – 10 pers. ☐ 10 – 20 pers. ☐ >20 pers.

Advanced: ☐ < 5 pers. ☐ 5 – 10 pers. ☐ 10 – 20 pers. ☐ >20 pers.

Remarks, links or details: ……
……
……
…… **END**

GLOSSARY

Capacity building :

The sum of efforts needed to nurture, enhance and utilize the skills and capabilities of people and institutions at all levels, towards a particular goal, for example participatory management [or here, stock assessment] . (From FAO Term Portal – original source Berkes, F. et al. 2001. Managing Small-Scale Fisheries: Alternative Directions and Methods. International Development Research Centre, Ottawa).

Communication:

Good communication of resource assessments includes elements of :

- Conveying information about the uncertainties associated with the results
- Results are generated and shared in an appropriate and timely fashion
- an awareness of the knowledge, skills and experience of the target audience
- Using information flows and methods of communicating already familiar to stakeholders
- developing trust and building mutual respect
- sometimes including different types of knowledge is challenging but essential.
- Getting target audience engagement and involvement throughout the assessment process, where possible.
- Should seek to overcome issues of culture, translation, levels of education, terminology as well as institutional and personal incentives and attitudes
- helpful if stakeholders collaborate in generating, assessing or evaluating the information so that they understand the results, can see their relevance and are more likely to be committed to the process.
- in resource-poor and educationally limited contexts, emphasis on communication and participation required to overcome unfamiliar approaches and prevent key words, questions and concepts from becoming irrelevant or be misinterpreted.
- People are more likely to accept the results when they know where the information came from and had a hand in producing the answers.

(from: S. Garcia et al. 2008. Towards integrated assessment and advice in small-scale fisheries: Principles and processes. FAO Fisheries Technical Paper 515, Rome).

National Fishing Authority :

The premier government, semi-government, or acknowledged responsible agency for fisheries management in a country. If country is a federation or commonwealth, the central body that is responsible for the management of national fisheries within the federal or commonwealth Ministry responsible for fisheries.

Ecosystem Approach to Fisheries (EAF)

An approach to fisheries management and development that strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human

components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. The purpose of EAF is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems. (from: The Ecosystem Approach to Fisheries, FAO Technical Guidelines for Responsible Fisheries, No. 4 (Suppl. 2), FAO. 2003.)

Stock:

The part of a fish population which is under consideration from the point of view of actual or potential utilization. (Ricker 1975).

Stock assessment:

Stock assessment involves the use of various statistical and mathematical calculations to make quantitative predictions about the reaction of fish populations to alternative management choices (Hilborn and Walters, 1992)

Stock assessment is the process of collecting and analysing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing, and, to the extent possible, to predict future trends of stock abundance. Stock assessments are based on resource surveys [or fishery dependent data]; knowledge of the habitat requirements, life history, and behaviour of the species; the use of environmental indices to determine impacts on stocks; and catch statistics. Stock assessments are used as a basis to assess and specify the present and probable future condition of a fishery (From FAO Term Portal – original source US Department of Commerce 1996).

Stock assessment in relation to RFMOs:

One of the stock assessment objectives is to determine target and limit reference points taking into account biological, and social economic considerations, and measure stock status relative to these reference points so as to determine appropriate management actions. Managers should be confident in the interpretation of the information as conveyed in the stock assessment report and be able to interpret Kobe plots as well as the use of decision tables for ranking possible management options (P. DeBruyn and D. Fu, IOTC, pers. comm.).

Appendix 2: Specialised services available, strengths and opportunities

Country	Specialised Services available	Strengths in stock assessment
Australia	Fish ageing; Genetic stock discrimination; GIS Remote Sensing; Independent review; close kin mark recapture.	Australia is relatively rich in stock assessment technical resources – spanning data poor to data rich techniques and innovative recent methods for example using close kin mark recapture, etc.
Bangladesh	No such specialised facilities are available for the scientists. However, some of the facilities like fish ageing and GIS/ Remote sensing are used by some of the individual researchers personally.	1.Department of Fisheries (DoF) already has Marine Fisheries Survey Management Unit for stock assessment; 2. Marine Fisheries Survey Management Unit has own RV Meen Shandhani for stock assessment; 3. Bangladesh Fisheries Research Institute (BFRI) under Ministry of Fisheries and Livestock; 4. DoF has District and Sub-district office setup all over the country 5. Universities
Indonesia	Fish ageing; GIS remote sensing	Availability of stock assessment experts in Fisheries Research Centre and universities. Availability of research vessel.
Kenya	Fish ageing; Genetic stock discrimination GIS remote sensing;	Kenya has KMFRI whose mandate is to conduct marine and freshwater research; this includes stock assessment of the species. The institute has 16 Fisheries scientists. Kenya has a research vessel (RV Mtafiti) which is used for stock assessment work; there are also ongoing projects such as the World Bank funded KEMFSED project that will contribute towards stock assessments for selected fisheries. Kenya wet-leased a vessel from April - September 2020 to assess the large pelagics in the Kenyan EEZ.
Madagascar	None	Fisheries scientists, catch and effort data
Malaysia	GIS/Remote Sensing; Independent review;	The Department has capacity to conduct data analysis on catch effort and hydro-acoustic scientist. The Department is also in process of procuring a research vessel to conduct periodic stock assessment in order to develop dynamic fisheries management plan. The Department works closely with local universities.
Maldives	None. Human resource capacity, with very few staff familiar with basic working knowledge of GIS/remote sensing capacity exist within the country but have not been utilised yet in fisheries management. This is mainly because of lack of expertise in application of GIS/Remote sensing for fisheries and stock assessments, and lack of access to technical resources (e.g., software, spatial data etc.)	Fisheries researchers at MMRI are slowly being involved in and exposed to stock assessment exercises (primarily through IOTC and SWIOFC and also through the WB funded project), and are gradually adapting to data management and stat/programming used for stock assessments, which is an important strength to build human capacity on. Additionally, the recently adopted fisheries act (2019) requires implementation of management plans for all the fisheries of the country. The management plans that are in the final stages of preparation incorporate measures to strengthen fishery data acquisition and scientific monitoring and reporting of the stocks. Further, the management plans require close monitoring of the stocks and future review will incorporate advice based on stock status.
Mauritius	Independent review	In addition to catch data, the Ministry has a fish biology [lab] for biological analysis, and a new research vessel (Investigator II) has recently been acquired for stock assessment and verifying new

Country	Specialised Services available	Strengths in stock assessment
		fisheries resources in the EEZ
Oman	Fish ageing; Genetic stock discrimination; GIS remote sensing	Regular data collection, established database for commercial fisheries
Seychelles	Fish ageing ; Limited capacity to undertake fish ageing at SFA, equipment is available, however, staff lacks training, as the team is relatively new	Available staff for capacity building. Good potential for data collection. Good relationship with international and regional bodies (FAO, IOTC, IORA, SWIOFC, WIOMSA, SIOFA) to access potential support for capacity building in stock assessment
Sri Lanka	Genetic stock discrimination; GIS remote sensing	Time series data on some fisheries are available, new sampling scheme has recently been introduced for marine fisheries data collection. NARA has own research vessel to carry out resource surveys. Some ongoing work with international stock assessment experts
Thailand	None	Strengths: Time series catch/effort data; Intensive data collection program; Biological parameters available for main species. Opportunities: Legal basis.

Appendix 3: Constraints, threats and need for technological assistance.

Country	Constraints and threats	Need for technological assistance
Australia	The main threat is likely to be maintaining a level of recruitment of younger scientists through universities. But in the context of this survey, there are not any.	Australia does not need additional technological assistance to increase its stock assessment capacity.
Bangladesh	**Constraints:** Lack of cooperation in related agencies and institutions. **Weakness:** Lack of skilled manpower, Lack of quality data, Inadequate Budget in land-based survey, lack of logistics support. **Threats:** Fish landing other than landing centres.	1. GIS, Remote sensing; 2. Acoustics survey ; 3. Data collection, storage and analysis using advanced application/software.
Indonesia	Limited amount of research to maintain coverage adequacy; Incomplete catch reports; Tropical multi fishery and multi gears complexity.	Advanced modelling; multispecies methods; scale intensity consequence analysis (SICA)/productivity and susceptibility analysis (PSA).
Kenya	Constraints/Mitigation: Lack of a fishing research vessel /The Government hired a longline vessel in April - September 2020; Constraints/Mitigation: Low levels of specialization in stock assessment skills/Training workshops regularly on identified skills; Weakness/Mitigation: Consistency in data collection in landing sites / BMUs were required to collect and compile catch data ; Weakness/Mitigation: BMUs inability to identify fish species to scientific names while collecting catch data / KMFRI has been conducting Catch Assessment Surveys periodically to collect scientific data and catch; Threats/Mitigation: Inability to monitor all the fishing activities and fishing data / Strengthen the national regulatory agencies and regional bodies mandated to control fishing.; Threats/Mitigation: Illegal fishing/ Improvement of monitoring and surveillance; Threats/Mitigation: Insecurity in the fishing areas curtailing access to fishing data. If the data is reported, it is not known to which country the data is originated / A matter of military collaborations and treaties across nations.	Training in modern stock assessment tools; Hydro acoustics technology; Fish aging technology and equipment
Madagascar	Lack of capacity to conduct stock assessment process	Related to data collecting and data processing
Malaysia	Development of fisheries management plan base of fisheries stock assessment has yet to be completed. The Department does not have successors with sufficient expertise on fisheries stock assessment. Fisheries stock assessment requires substantial amount of funding which is not allocated regularly. Therefore, the Department is only able to conduct the assessment after a 17-year gap.	The Department would like to build capacity in the field of : expertise in developing and maintaining web based spatial database on fisheries stock and population size which could be used for decision making; expertise in GIS; modelling and hydroacoustic analysis for non-destructive stock assessment method; and expertise in data analysis and developing fisheries management plans.
Maldives	The key constraint is the absence of technical persons with the capacity to conduct stock assessments. This stems from the lack of fisheries science and similar education (related to stock assessments) locally and also due to lack of students enrolling in related fields, for further education (undergraduate and above) in overseas universities. The second most important is the severe limitation and absence of data to be used. Fisheries data collection, despite dating back to 1959, was solely centred around tuna fisheries due to the traditional prominence of the fishery in terms of foreign exchange, employment, livelihood and volume. Commercial, non-tuna fisheries are relatively recent compared to the centuries old tuna fishery (for example, grouper and sea cucumber fisheries beginning in the 80's).	Instruments related to fish ageing and study of the reproductive biology, technological infrastructure and training in use of GIS/remote sensing for fishery and stock assessment could be of importance and be shared with the National University and other parties.

Country	Constraints and threats	Need for technological assistance
	However, the national fishery data collection has been slow to incorporate catch, catch and effort data collection in a manner that could be useful for resource assessments. Logbooks were introduced for the tuna, grouper and reef fish fisheries, however, these have not been effectively implemented except for the tuna fisheries. The scientific data collection from non-tuna fisheries at MMRI (former Marine Research Centre) has been ad-hoc, until as recent as 2018, and lacked a continuous, representative set of data that could be useful in stock assessments. Since 2018, MMRI has been implementing a biological and fishery data collection program through a World Bank funded project, which will end in 2023. The intention is to continue the program, at a scale depending on availability of funds available from the national budget. Addressing the constraints and weaknesses Absence of technical capacity needs to be addressed through short-term, training and capacity building for working professionals and undergraduate education opportunities for potential fishery scientists and managers. Further, post-graduate opportunities in overseas universities for independent individuals and staff within the Fisheries Ministry and the Maldives Marine Research Institute is critically needed. Training and education opportunities should prioritise existing staff of the Ministry and MMRI in order to retain the capacity of the institutions to implement stock assessments. Strengthening of statistical and mathematical capacity within the institution would also be useful. Further, networking and relationships with experts is required for mentorship, guidance and advice for technical persons within the Ministry and MMRI. Absence of basic fishery data and information (total catch, catch and effort and fleet) needs to be addressed through improvement in the national fishery data collection system and scientific monitoring of the fisheries. It should be noted that several works are under way in this regard including formulation and implementation of management plans for all fisheries, which requires introduction of logbooks for catch and effort data among other things. Further, MMRI with assistance from the World Bank is implementing a national fishery monitoring and sampling program to contribute towards stock assessments. However, the Project ends in 2023 and continued support (ideally through the annual budget) is essential to maintain the continuity of fishery monitoring post project.	
Mauritius	Inadequate fisheries scientists/Human Research. Technical/Scientific/Capability. Well-equipped research vessel	Software for fisheries data compilation and analysis
Oman	Lack of fisheries scientists working in this area, few surveys conducted in the last decades	Provide expertise to analyse such data, provide advanced training for specialists, provide template/protocol for stock assessment analysis

Country	Constraints and threats	Need for technological assistance
Seychelles	There is a lack of specialised local experts in stock assessment, short courses on stock assessments overseas (e.g., ICES) are not tailored for the specific needs of the country (i.e., based on what data is available to determine the appropriate assessment method to use). Courses are only available overseas which often limits the number of participants that can take part due to cost constraints. Not much is being done to highlight the need for local stock assessments experts, therefore, students are not oriented towards this field of study when they are choosing a course to undertake at undergraduate level. An applied, hands on approach would be ideal for people already in employment.	We need students/staff that are specialised in stock assessments. Trainings in R or specialised stock assessment software. Capacity to extend research into tagging, and genetic analysis for stock discrimination is required.
Sri Lanka	Lack of trained stock assessment experts, lack of attention in the university curriculum on stock assessment, lack of reliable data on certain fisheries, brain drain. Provide more training opportunities, capacity building of relevant scientists who are engaged in stock assessment. Add relevant courses to university curriculum	Provide technological equipment to conduct marine surveys / genetic studies / tagging studies etc.
Thailand	Complexity of multispecies fisheries; lack of stock assessment experts	Fish ageing, acoustic survey, deep-sea resources survey

Appendix 4: Examples of stock assessment results, recommendations and management measures taken

Country	Fishery	Year	Stock assessment result/ recommendations	Management measure/s taken	Legislation	Enforcement	Citation or link	EAF approach
Australia	Flathead (Southern Eastern Scalefish and Shark Fishery)	2019	TAC = 2468t	Quota implementation	Yes	Yes	https://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status/trawl-scalefish-hook-sectors#91-description-of-the-fishery	No response
Bangladesh	Marine Fisheries	2019	Some commercial fish stocks are declining/Restrict fishing vessel and fishing effort by imposing fishing ban.	Restricting new industrial fishing vessel to existing fishing fleet	Yes	Yes	http://mfsmu.fisheries.gov.bd/	No response
Indonesia	Ground Fishery	2015		Ground Fishery in Indonesia FMA 718 based on MMAF Decree no. 54/2015 on the Fisheries Management Plan of Indonesia FMA 718; MMAF Decree no. 50/2017 on the Estimation of Fish stock Potential, Total Allowable Catch and Rate of Utilization on Indonesia Fisheries Management Area (FMA); Fishing permit policy to commensurate level of utilization with the level of the stock	Yes	No		EAFM indicators are applied to support management of fisheries.
Kenya	Shallow water prawn	2010	Limitation on effort in terms of the number of vessels	A closed season as effected, a fishing zone was demarcated where trawlers could fish beyond 5 nm from shore	yes	yes	https://www.kmfri.co.ke/images/pdf/Prawn_Management_Plan.pdf	Stakeholder engagement; socio-economic surveys of artisanal fishers sharing the resource with semi-

Country	Fishery	Year	Stock assessment result/ recommendations	Management measure/s taken	Legislation	Enforcement	Citation or link	EAF approach
								industrial prawn trawlers; habitat surveys to understand the association with the species in the fishery
Madagascar	Shrimp	Annually	Closure period	3-month closure period annually	yes	yes		Not really
Malaysia	Demersal, small pelagic, prawns and tuna	2014-2016	Not clear	Develop fisheries management plan	Yes	Yes		Yes
Maldives	Non-tuna fisheries			Maldives is new to stock assessments for fisheries management in relation to non-tuna species and MMRI has in the past not provided a stock assessment and its results / recommendations for management. Adhoc advice is provided (such as minimum size recommendation), based on research conducted on an as needed basis. This response needs to be considered also in the context of the response provided in the question on constraints, weaknesses and how these can be addressed. [Recently it has been developing a sea-cucumber management plan (August 2020) within which research actions will support the plan – authors comments]			https://www.gov.mv/dv/files/draft-sea-cucumber-management-plan.pdf--1	

Country	Fishery	Year	Stock assessment result/ recommendations	Management measure/s taken	Legislation	Enforcement	Citation or link	EAF approach
Mauritius	No example provided		Non provided					
Oman		2018	Reduce harvest for immature sized species	Set allowable fishing size for most commercial targeted species.	yes	yes		Less efficient
Seychelles	Sea-cucumber	2017	Reference cases assessed showed evidence of population declines. In some cases, population reduced significantly compared to pre exploited state. Recommended capping of catches to 2016 catch levels	Introduced a quota system by capping catch at 2016 levels	Yes	Yes	https://mrag.co.uk/experience/sea-cucumber-assessment-seychelles http://www.sfa.sc/index.php/fisheries/sea-cucumber/sea-cucumber-management-measures	Extensive consultation process involving all relevant stakeholders
Sri Lanka	Five export orientated fisheries including sea-cucumber, lobster and shrimp	2008	Results and recommendations of underwater visual surveys were provided to Dept of Fisheries	Size regulations, capacity control and effort control by limiting licences.	Yes	No	Nearshore Fisheries Status Atlas North West South and East Coast Aquarium Fish Chank Lobster Shrimp and Sea Cucumber Fisheries of Sri-Lanka. National Aquatic Resources Research and Development Agency 2010	Co-management Committees were formed with respect to different fisheries and areas
Thailand	Demersal fishery	2020	MSY 790,985 MT, TAC set at 95% MSY	limitation of fishing day	Yes	Yes		Partial EAFM included in this process

Appendix 5: Most recent stock assessments of main or major species undertaken nationally or with regional/international expertise.

	Stock assessments of main fisheries (Non-National)				Stock assessments of main fisheries (National)			
Country	**Year**	**Fish stocks assessed and methods used**	**Persons/ Institution**	**Contact or link**	**Year**	**Fish stocks assessed and methods used**	**Persons/ Institution**	**Contact or link**
Australia	Assessments are all nationally executed				2020	Australia assesses the stocks of all its Commonwealth Fisheries (28) at least once every two years. Each State, with jurisdiction up to 12nm from the coast, also assesses its stocks annually, or less often depending upon their commercial importance.	Australian Bureau of Agricultural Resource Economics &Sciences (ABARES)	https://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status
Bangladesh	2019	Shrimp, demersal and pelagic fishes. Biomass dynamics model	Paul Fanning, Dr Paul Madely, FAO http://www.fao.org/3/ca8782en/CA8782EN.pdf		1999	Swept area method	Wahidunnabi Chowhury	
Indonesia					2017	[*Unclear obtained separately*] 11 Management areas by 9 groups of species: small, big pelagics, demersal, reef, penaeid, lobster, blue swimmer crab, 3-spot crab, squid . New methodology based on an acoustic method.	Fisheries Research Centre and National Commission of Stock Assessment	Indonesia has 11 Fisheries Management Areas. Nearly half of the fish stocks are overfished. https://theaseanpost.com/article/indonesias-fisheries-not-managed-efficiently ; https://www.packard.org/wp-content/uploads/2018/08/Indonesia-Marine-Full-Report-08.07.2018.pdf ;
Kenya					2020	Longline fisheries stock assessment - pelagic fishery short term survey	KMFRI	The Director - KMFRI
Madagascar	Never				Never			
Malaysia					2014-16	demersal, small pelagic, prawns and tuna	Fisheries Research Institute	
Maldives	2020	Skipjack tuna and groupers	Skipjack tuna (IOTC) - SS3; Groupers (Dr Paul Medley) - length converted catch curve and spawner potential ratio	www.iotc.org paulahmedley@gmail.com				

	Stock assessments of main fisheries (Non-National)				Stock assessments of main fisheries (National)			
Country	**Year**	**Fish stocks assessed and methods used**	**Persons/ Institution**	**Contact or link**	**Year**	**Fish stocks assessed and methods used**	**Persons/ Institution**	**Contact or link**
Mauritius	2002							
Oman	2008	NIWA. Small pelagic and demersal species - swept area method and acoustic survey	NIWA..co.nz https://niwa.co.nz/environmental-information/research-projects/fish-resources-assessment-survey-of-the-arabian-sea-coast-of-oman	NIWA	2019	Demersal, small pelagic, large pelagic, lobster, sea-cucumber. Method using annual catch rate	Marine Science and Fisheries Centre	www.maf.gov.om ; alnahdi@gmail.com
Seychelles	2015	Demersal trap and handline – Mahé Plateau, Surplus production models, Catch only method, standardised CPUE, PSA&SICA	Dr. Nico Gutierrez (International consultant)	nico.gutierrezo@gmail.com	2019	Annual assessments are undertaken locally for key indicator species - Lutjanus sebae, Aprion virescens, Epinephelus chlorostigma. Length based catch curves to estimate total mortality and derive fishing mortality and exploitation rates. Yield per recruit analyses	SFA Research Section	rgovinden@sfa.sc
Sri Lanka	2018	Small pelagic and demersal fish stocks - midwater, bottom trawling and accoustic methods	Dr Fidtjof Nansen survey (IMR Norway, NARA and FAO	http://www.nara.ac.lk/wp-content/uploads/2019/08/DFN-a.pdf	2015	Blue swimmer crab using spawning potential ratio (SPR)	NARA : sisirahaputhantri@yahoo.com	http://www.nara.ac.lk/wp-content/uploads/2019/08/DFN-a.pdf
Thailand					2019	3 stocks: pelagic fish, demersal fish and anchovy. Assessed with production model.	Department of Fisheries	