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Minderoo's Global Fishing Index

Minderoo Foundation

MINDEROO'S GLOBAL FISHING INDEX

Background material

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Purpose

The next ten years mark a critical juncture for reaching the United Nations' Sustainable Development Goals and the future they represent. To successfully navigate this transition, we need a better means of identifying priorities areas for action, tracking country-level progress, and holding decision-makers to account, particularly where performance is poor.

The Global Fishing Index (GFI) addresses these challenges by providing an independent, country-level assessment of fisheries sustainability around the world that can be used as an evidence base to prioritise and inform action to end overfishing and restore fish stocks to sustainable levels.

Specifically, the GFI is a tool for governments, the fishing and seafood industry, investors, and civil society organisations to better understand the scope of progress toward sustainable fisheries, effective governance approaches, and key areas for improvement, so they can advocate for and help create the positive change needed to end overfishing and restore fish stocks to sustainable levels in every country, globally.

Index scope

The GFI combines biology and social science to report on two fundamental and complementary aspects of fisheries sustainability in over 140 maritime countries: (1) the state of their fish stocks and (2) the strength of their fisheries governance systems, in terms of a country's capacity to end overfishing and achieve sustainability goals, within national waters. Together, these components provide a tool that can be used to guide change at a global, regional, and national level.

The GFI's Progress Score reports on national progress toward Sustainable Development Goal 14.4; that of maintaining fish stocks in national waters at or above biologically-sustainable levels. The components of the progress score consider both the state of assessed fish stocks, as well as the availability of data regarding the state of marine fish stocks that occur within their country's waters.

These scores are reported alongside a GFI Governance Rating, which is designed to evaluate a country's capacity for ending overfishing and achieving biologically-sustainable fisheries within national waters. The Governance Rating uses a novel and unique framework to characterise a country's fisheries governance system across six dimensions. Assessment results are used to highlight a country's current strengths, as well as identify critical areas for improvement. Additionally, this framework allows for the comparison of governance characteristics between countries with similar socioeconomic and ecological contexts, providing a means of information sharing and learning across peer groups. This data is supplemented with a series of case studies, sharing innovative approaches to fisheries governance that can be adapted and replicated in new areas to address common challenges.

Together, these two components of the GFI can be used to guide improvement efforts: the sustainability scores provide a global picture of the state of fish stocks, which can be used to identify priority countries

for action at a global and regional scale. At the national level, the governance assessments enable decision-makers to identify and focus resources on addressing the most critical aspects of fisheries governance needed to tackle unsustainable activities.

The GFI is an ongoing study that will be published every two years, allowing us to track and learn from country-level progress toward restoring all fish stocks to biologically-sustainable levels (SDG 14.4). All country-level results, case studies, and methodology will be available for download from the Global Fishing Index website.

Methods: **Scoring progress towards SDG14.4**

The progress component of the Global Fishing Index measures the sustainability of a country's marine fish stocks and is designed to track country-level progress toward restoring or maintaining fish stocks at biologically-sustainable levels (SDG target 14.4).

Our approach

A country's GFI Progress Score reflects the sustainability of its marine capture fisheries resources and is determined based on the state of assessed fish stocks, determined by stock abundance, as well as the state of knowledge of stock health within a country's marine waters.

To assess country-level performance, we compiled relevant, publicly available information for over 1000 fish stocks. Where available, we used official data and stock assessment results to determine stock status (~420 stocks). Additionally, we used established data-limited methods to produce novel estimates of relative abundance for another ~580 stocks. The addition of these new estimates substantially increases the scope and resolution of fisheries data globally and allows for comparison across countries.

A country's stock sustainability is determined based on the proportion of assessed stocks whose abundance is at or above level that can produce maximum sustainable yield (MSY)[a]. This measure is directly relatable to other indicators used by the United Nation's Food and Agriculture Organisation (FAO) and national governments to track fisheries sustainability and progress toward SDG 14.4.

Our Progress Score also incorporates a measure of the state of knowledge of stock health, which is used to qualify stock sustainability based on the level of data availability. Specifically, we estimate the proportion of a country's total marine catch that is harvested from stocks with abundance estimates. We also evaluate the level of knowledge regarding the state of coastal, domestically-managed[b] fisheries, which is used to highlight the importance of these fisheries for local communities and ensure our scores accurately reflect country-level performance.

These components are combined to produce a single Progress Score for each country. These scores represent a country's current level of stock sustainability and the remaining gap in achieving SDG 14.4.

Results will be used to identify bright spots and priority areas for improvement at a global and regional scale, as well as track county-level progress toward restoring fish stocks to biologically sustainable levels, over time.

[a] Maximum sustainable yield is the highest amount of catch (yield) that can be continuously harvested from a stock under constant (and current) environmental conditions, without affecting the long-term productivity of the stock.

[b] i.e. excluding fisheries of highly-migratory stocks of tunas and other pelagic species which are managed and assessed by Regional Fisheries Management Organisations (RFMOs)

Data collection and analysis

The GFI Progress Scores were generated in partnership with the *Sea Around Us* initiative[c], based at the University of British Colombia and the University of Western Australia (www. seaaroundus.org), and Quantitative Aquatics, Ltd.

There are three primary types of data needed to estimate abundance and assess stock health: information on stock life history characteristics, time series of catch and (where available) biomass indices (e.g. catch-per-unit-effort). Data collection was conducted by research staff at the *Sea Around Us* initiative and Quantitative Aquatics, Ltd, and comprised four main activities:

1. Updating the *Sea Around Us'* reconstructed catch database to 2018, to provide time series of catches for each country;
2. Collating published fisheries data, particularly stock assessments and supporting data, as well as available biomass indices (e.g. catch-per-unit-effort) and species life history characteristics;
3. Using the collected data to generate novel estimates of relative stock abundance in data-limited countries, where able based on data availability; and
4. Building a comprehensive database of existing and novel relative abundance estimates and related fisheries information, which can be used to evaluate global and country-level performance.

This comprehensive dataset was used by the Minderoo Sustainable Fisheries research team to calculate a Progress Score for each of the 145 maritime countries in the GFI.

Catch reconstruction process

Global fisheries statistics have been collected by the UN FAO since 1950. While comprehensive in their coverage across member states, the country-level statistics are often incomplete due to variations in fisheries reporting systems and standards between member states. For example, catch data may not be collected or reported for particular fisheries sectors, particularly small-scale fisheries, or may be collected at different levels of detail between countries or sectors within a country.[1] These differences result in gaps across FAO's global catch statistics[2], which may misrepresent global trends and potentially result in incorrect conclusions regarding the state of fisheries globally.

Catch reconstruction redresses many of these issues, producing higher-resolution and complete catch time series that can be used with data-limited approaches to generate estimates of stock abundance.

The *Sea Around Us'* catch reconstruction process is based on the idea that every fishery leaves a 'shadow' — even where catch data are not recorded, fisheries leave a trace on the society in which they are embedded.[2] By considering additional types of information, such as trade records, household seafood consumption rates, national employment data and vessel registries, one can estimate those catches not captured in formal statistics.[3]

The catch reconstruction process involves first collating historical information on *reported* catch, including data reported to the FAO and national catch statistics, then identifying potential *unreported* catch components and using alternative sources of information to estimate their catch values over time — resulting in a complete catch time series dating back to 1950. This information can also be used to improve the resolution of the data, in particular details regarding the catch of individual species or groups of species. Once the *total reconstructed* catch has been estimated, catches are spatially allocated to the ocean area where it was most likely caught, based on the biology and distribution of the species caught, origin of the original catch data, characteristics of the fleet harvesting the catch and known fishing rights and access agreements.[4]

[c] Further information about the work of the *Sea Around Us* initiative can be found on their website, available at www.seaaroundus.org

The result is a time series of spatially-disaggregated estimates of annual catch, allocated to a distinct area of the ocean, and further split by fishing country (flag of vessel harvesting the catch), species, reporting status, and fishing gear. Importantly, these catch time series provide the resolution needed to generate novel estimates of abundance for previously unassessed stocks.

Estimating relative stock abundance

The status of fish stocks is generally determined based on the relationship between stock abundance and life history parameters, including individual growth rates, fish size, age, reproductive rates and natural mortality (collectively referred to as 'productivity'[5]). The availability of these varies substantially across the world's fisheries, with some fisheries subject to intense, long-term monitoring, while others are entirely absent from official records, due to either a lack of data or lack of reporting.

To account for this variation, we considered the availability of data on a country-by-country and stock-by-stock basis. Data collection focused on identifying and collating publicly available fisheries data for each country, including official stock assessment reports, catch and effort data, previous estimates of abundance, stock productivity, and management information, which could be used to estimate relative stock abundance. Priority was given to larger stocks, with the goal of ensuring that as much of a country's total catch was accounted for in abundance estimates.

Where available, abundance estimates from recent[d] official stock assessment results were used directly. Note, official estimates could be derived from classic and data-limited methods. Where recent official estimates were not available, Sea Around Us used available data to generate novel estimates of relative abundance using established data-limited methods, as follows:

Where a complete time series of catch data, productivity metrics, and an index of relative abundance were available, stocks were analysed using the Bayesian Schaefer Model (BSM), a Bayesian implementation of a state-space Schaefer model.[6]

Where a complete time series of catch data, productivity metrics, and information on current stock status (for example, from peer-reviewed literature, older published assessments, length-based estimates of depletion and/or expert knowledge) were available, stocks were analysed using CMSY++, a catch-based Monte Carlo estimation method.[6] Using this tiered approach, Sea Around Us built a global database of relative abundance estimates for over 1000 fish stocks (Table 1).

Table 1. ***Source and/or method used to estimate relative stock abundance***

Source/method	Number of stocks
Published official assessments, including those completed by regional and national fisheries management organisations, academic institutions, or research agencies	424
Bayesian Schaefer Model (BSM)	395
CMSY++ with informed recent abundance priors	186
Total	***1005***

Aggregating stock outcomes to a country-level score

A country's Progress Score reflects the sustainability of its marine capture fisheries resources and is determined based on the state of assessed fish stocks, determined by stock abundance, as well as the state of knowledge of stock health within a country's marine waters.

[d] Assessments were considered recent if based on stock data from 2016 or later.

Assessing stock sustainability

We use abundance-based reference points to determine the sustainability of fish stocks. In line with international conventions[e], a stock whose estimated abundance (based on biomass) is at or above the level that can produce MSY is classified as biologically sustainable. On the other hand, when abundance falls below this level, it is classified as biologically unsustainable.

While we recognise that abundance-based reference points are likely to vary between stocks, based on their biological characteristics, we use the criteria established by the FAO in the *Review of the state of world marine fishery resources* (2011)[5] to determine stock status. These criteria are based on the standard Shaefer model, which assumes MSY occurs at 50 per cent of unfished stock levels. Given the level of variation in stock abundance over time and uncertainties around estimates, current estimates of stock abundance above 40 per cent of unfished levels[a] are classified as biologically sustainable.

Assessing state of knowledge of fisheries resources

To fully understand the state of a country's fish stock status, all fish stocks within a country need to be assessed. However, most countries lack the resources, technical capacity, and/or data required to evaluate the health of all stocks within their waters.[7] Instead, managers often focus on the 'most important' stocks, as determined by levels of catch, economic value, ecological role, and/or social and cultural considerations. These differences in assessment capacity and focus create vastly different levels of understanding regarding the state of marine fish stocks across countries.

To account for these discrepancies and allow for comparison across countries, we incorporate a measure of the state of knowledge of fish stock health into our scoring metric. Specifically, we estimate the proportion of a country's total estimated marine catch[f] that is harvested from assessed stocks.

Additionally, we evaluate the level of knowledge regarding the state of coastal fisheries, as indicated by the presence or absence of domestically-managed stocks in our dataset. This criterion is used to ensure that a country's score reflects their performance is maintaining or restoring stocks within their mandate to a sustainable level. Additionally, it is used to focus attention on the coastal fisheries that contribute to the livelihoods, food, nutrition, and wellbeing of local communities.

Creating the index score

A country's Progress Score is the product of its stock sustainability (proportion of assessed stocks that are sustainable) multiplied by the level of knowledge (proportion of total estimated marine catch represented by assessed stocks), rescaled to provide a score out of 100. A country can therefore improve its Progress Score by monitoring and reporting more of its fisheries and/or by increasing stock sustainability, through improved management.

Where countries do not have any knowledge of their coastal fisheries (indicated by the presence of at least one domestic/shared stock among its assessed stocks), their score is capped at 10 out of 100. The purpose of this is to further encourage these countries to focus attention on improving domestic fisheries data collection and management.

Internal and external review

All novel estimates were reviewed by the Sea Around Us research team to confirm that estimated outputs (for example, catch, relative abundance, fishing mortality) aligned with one another and were logically consistent. Additional logic checks were conducted by the Minderoo Sustainable Fisheries research team upon receipt of the final dataset prior to scoring.

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[e] The United Nations Convention on the Law of the Sea (UNCLOS), the United Nations Fish Stocks Agreement (UNFSA), and the FAO Code of Conduct for Sustainable Fisheries (FAO, 1995) all require maintaining or restoring stocks to levels capable of producing the MSY.

[f] Based on reconstructed catch estimates generated by the Sea Around Us initiative

A private firm is currently in the process of undertaking an independent assessment of the GFI Progress Score analyses. This assessment will endeavour to determine if the analyses processes align to the agreed technical methods and documentation; and, the analyses processes do not alter or manipulate the relevant dataset(s) beyond the stated intent and agreed technical methods.

Future Considerations

A key challenge in assessing the state of fisheries, both globally and at country level, is quantifying the 'unknown unknowns', i.e., how many unassessed stocks exist in a country or region. In this iteration of the Global Fishing Index, we use unassessed catch as a proxy for the knowledge gap that exists in fisheries. While this in part reflects reality 'on the water', it fails to capture how many stocks remain to be monitored and assessed, which is the true measure of the task ahead. Additionally, status was not reported for stocks which have catch data but lack sufficient complementary information to allow their biological status to be reliably estimated with current tools. Future work will focus on developing better estimates of stock richness in each country, and on improving both status estimation models and data sources to allow expanded coverage of the GFI.

Methods: GFI Governance Ratings

In line with SDG 14.4, the Governance component of the Global Fishing Index (GFI) evaluates a country's fisheries governance system against certain criteria recognised to constrain overfishing and effectively regulate harvesting of fish stocks in national waters to achieve biologically sustainable fisheries. As such, our governance framework takes a *coastal state* perspective and is limited to policy and practices that apply or occur within a country's exclusive economic zone (EEZ)[g].

Conceptual Framework

Our framework is based on principle elements of governance that are recognised to be associated with overfishing specifically, rather than a single best-practice system of controls. In line with this scope, in defining our conceptual framework, we asked the following research question: *What aspects of fisheries governance enable or constrain overfishing within a country's national waters?*

The theoretical basis was established from current scientific understanding and further refined and developed in consultation with fisheries experts. Our resulting conceptual framework comprises of a two-level hierarchical structure and evaluates countries across six, interconnected dimensions, comprising of 18 attributes (Figure 1). These dimensions and attributes have been identified as fundamental to effective fisheries governance from current scientific understanding and further refined in consultation with fisheries experts. This framework is accompanied by 76 indicators, which are used to characterise and help evaluate each attribute.

[g] As defined in Part V of the 1982 United Nations Convention for the Law of the Sea (UNCLOS).

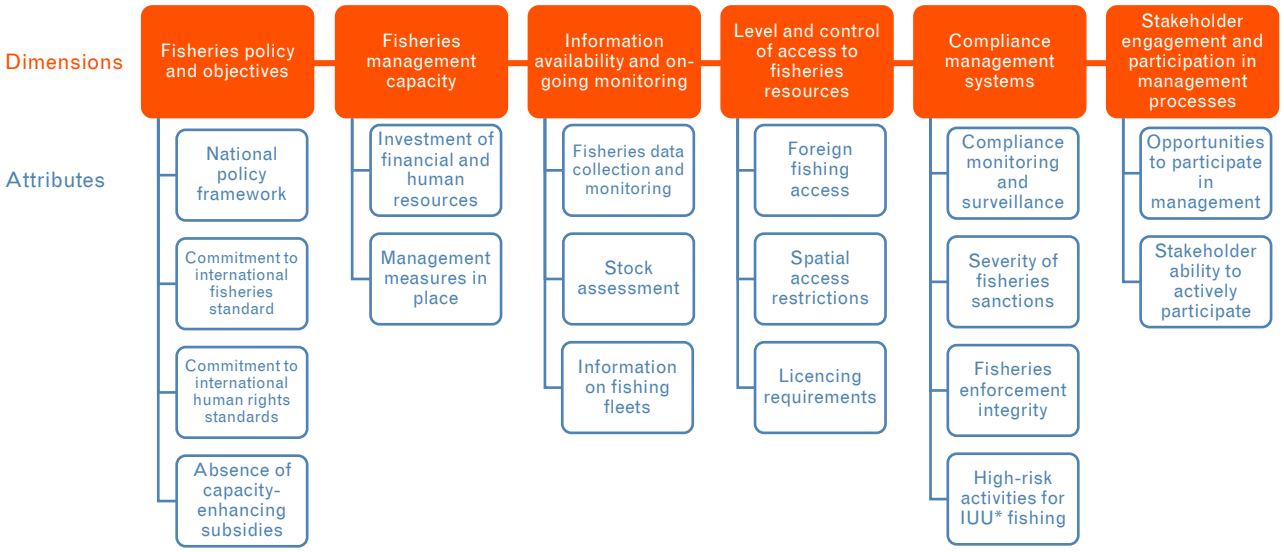

Figure 1. Fisheries governance framework. Our framework uses a hierarchical structure to evaluate countries against 6 interconnected dimensions, comprising 18 attributes.

Dimension Descriptions

Fisheries policy and objectives (Dimension 1) evaluates the policy foundation in place for governing fisheries, as well as stated fisheries goals. This includes the establishment of national fisheries policies and related environmental, economic, and social sustainability objectives, as well as policy alignment with international standards and conventions for fisheries management and the worker rights and safety in the fisheries sector. Finally, this dimension assesses the use of capacity-enhancing subsidies, which have been linked with overcapacity and the overexploitation of fish stocks.

Fisheries management system (Dimension 2) assesses the resources, expertise, and tools available to effectively implement the strategies and objectives outlined in fisheries policy. This includes the presence of adequate financial resources that are successfully translated into technical and human resources, such as the employment of fisheries observers. Countries must also demonstrate the ability to implement effective on-the-ground management measures, with a particular focus on science-based management tools.

Information availability and on-going monitoring (Dimension 3) examines the scope, quality, and resolution of the fisheries information available to inform management and decision-making processes. This includes collecting information about fisheries operations, evaluating the state of fish stocks through formal stock assessments, and understanding the size and structure of the fishing fleets operating inside a country's national waters.

Level and control of access to fisheries resources (Dimension 4) examines the diversity of tools used to monitor and regulate fishing access to their national waters. This includes the use of fishing licenses or permits across all fleet sectors, with a particular focus on controlling and monitoring foreign fishing access. This dimension also considers the use of spatially-based access restrictions, such as closed areas and coastal fishing zones reserved for artisanal fleets.

Compliance management system (Dimension 5) examines the strength and diversity of the tools used to ensure fisheries controls are set, monitored, and enforced adequately. This includes the effectiveness of monitoring and surveillance systems in identifying and deterring high-risk activities for illegal fishing or labour exploitation. This dimension also examines whether fisheries sanctions are sufficient for discouraging individuals or organisations from violating fisheries laws, rules, and regulations. Finally, countries are assessed against the perceived integrity of the fisheries authority and judicial system, to ensure the intent behind their compliance system is not undermined by issues such as bribery or corruption.

Stakeholder engagement and participation in management processes (Dimension 6) assesses the ability of fisheries stakeholders, including fishers and fish processers, governmental and non-governmental organisations, research institutions, and local communities, to actively partake in fisheries governance processes. This includes assessing the opportunities provided to stakeholders to engage in management, for example, through community-based management arrangements, as well as the capacity of stakeholder groups to actively participate in these processes.

Data collection

We used a combination of secondary and primary data to characterise fisheries governance in the 145 maritime countries included in the index. Country-level measures for 27 of the 76 indicators were sourced from secondary data sources, including existing global or regional datasets, and four novel indicators sourced from public vessel tracking data.

Primary data were collected at an indicator level by a multinational team of 44 researchers based in 22 countries and territories using a structured assessment instrument and protocol. The assessment instrument comprised a 77-item structured questionnaire, administered both online and face to face in interviews with experts. Country assessments were informed by either: desk-based research and

interviews with country experts; desk-based research and online-questionnaire responses; or, all three data sources (Figure 2).

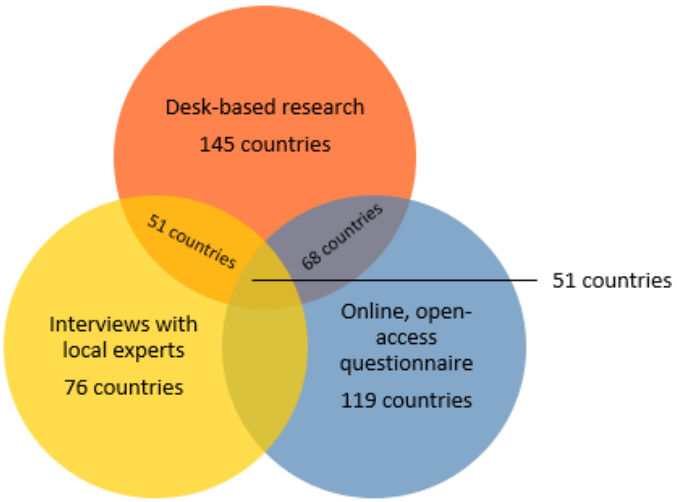

Figure 2. Data triangulation and sources, including sample sizes.

A dedicated country researcher followed the following four-step research protocol for each country's assessment:

1. Review current published literature to identify initial responses, data gaps, and references;
2. Interview local fisheries experts (where applicable) to confirm accuracy of published information, fill data gaps from Step 1, and collect additional relevant information for the assessment;
3. Review and integrate any responses from the online open-access questionnaire; and
4. Complete a final assessment for each country using all available information. Triangulation increases confidence in the final response through confirmation via independent data sources.

This comprehensive dataset was used by the Minderoo Fisheries Governance research team to calculate a Governance Rating for each of the 145 maritime countries in the GFI.

Compilation of Governance Ratings

Scoring

Each indicator was scored on a scale of zero to one (0 – 1), with a higher score attributed to an indicator response identified to be more effective at constraining overfishing in national waters. To ensure all countries could be assessed consistently against the conceptual framework, any missing values were imputed using expert judgement or statistical imputation (specifically, *k-nearest neighbours* imputation). Overall, less than five per cent (5%) of the total dataset was imputed using these methods.

Weighting and Aggregation

We aggregated indicators, attributes, and dimensions into a single composite assessment score for each country and converted results into scores out of 100 for ease of presentation.

A key consideration during the weighting and aggregation process is the level of compensation among the components of a framework. Equal weighting was applied at the indicator and attribute level as we conceptualized that these components should contribute *equally* to attribute and dimension scores, respectively. It is important to note that equal weighting can lead to artificial bias when the number of sub-components (e.g. indicators) within a higher level (e.g. attributes) are not equal, as occurs in our

framework. When aggregating components, an arithmetic mean implies perfect substitutability between components, whereas a geometric mean implies only partial substitutability although cannot be applied when zeros are present.

Consultation with the Expert Advisory Panel suggested that compensability between dimensions, i.e. high performance in one dimension compensating for low performance in another, is not appropriate. We administered an expert elicitation survey using the Analytic Hierarchy Process[8] method to collect empirical evidence on the relative importance of each fisheries governance dimension in influencing overfishing in national waters, and inform the dimension weighting process (Figure 3).

Figure 3. Dimension weights based on expert elicitation as a proportion of 100 per cent. Weights ranged between 14.3 and 22.3 per cent for each of the six dimensions.

The results of the expert elicitation were used in combination with a geometric mean (i.e. weighted geometric mean) to aggregate the six dimensions into a final assessment score for each country. The final weighting and aggregation approach are outlined in Table 2.

Table 2. Application of weighting and aggregation

	Indicators	**Attributes**	**Dimensions**
Weighting	Equal	Equal	Expert derived
Aggregation	Arithmetic	Arithmetic	Geometric

Creating the Governance Ratings

Each country's governance is presented as a categorical rating, which considers a country's overall governance assessment score, as well as performance across each of the six dimensions (Table 3).

Where a specific criterion is not met, countries were capped at the next highest rating. For example, if the minimum standards for B band rating are not met, countries are capped at a CCC rating. Additionally, to reach the highest rating (A), countries must meet the A criteria plus demonstrate four key pillars, representing the use of an integrated and holistic approach for fisheries governance:

1) The implementation of a framework for combatting illegal fishing;
2) A demonstrated commitment to protecting fishers' safety and right to fair work;
3) The removal of harmful capacity-enhancing subsidies; and
4) The promotion of ocean health through protection of key habitats and ecosystems.

Table 3. Ratings criteria and descriptions.

Rating	Assessment score	Dimension score	Key Pillars	Description
A	> 90	Minimum score of 50 across all six dimensions	Country applies all four key pillars	There is an **integrated** and **holistic** approach to fisheries governance that includes a comprehensive system aimed at ensuring fish stocks at maintained at a biologically-sustainable level, alongside strong protection of fishers' rights and safety and the protection of marine ecosystems and biodiversity.
BBB	80 – 90	Minimum score of 30 across all six dimensions	▲	There is a **comprehensive** system of fisheries governance in place recognised to effectively regulate harvesting of fish stocks in national waters, comprising a strong policy foundation oriented towards biological sustainability, the application of strong fisheries management tools, dedicated high-quality information and monitoring programs, a high degree of control of fishing access to national waters, a comprehensive compliance management system, and high levels of stakeholder participation in fisheries governance.
BB	70 – 80			
B	60 – 70			
CCC	50 – 60	None		There is **limited evidence** of a system of fisheries governance recognised to effectively regulate harvesting of fish stocks in national waters. This may be due to a limited or weak application of known means of addressing overfishing, gaps in data availability, and/or use of alternative systems not currently recognised in our framework.
CC	40 – 50			
C	30 – 40			
D	< 30		▼	

Internal and external review

To ensure the Governance methodology was developed in line with best industry standards, we followed the 10-step process outlined in the Organisation for Economic Co-Operation and Development's (OECD) Handbook for Constructing Composite Indicators,[9] from the development of a conceptual framework to the dissemination of results. The Governance methods were reviewed by the Competence Centre on Composite Indicators and Scoreboards (COIN), responsible for publishing the OECD handbook and advancing the field of building composite indicators,[10] in October 2020.

Internal quality checks were conducted on all data to ensure researchers followed a consistent research protocol, no human errors were introduced during analyses, and no mishandling or manipulation of the data occurred.

Ernst & Young has undertaken an independent assessment of the GFI Fisheries Governance analyses, and based on the activities undertaken it has been determined that:

- The analyses processes align to the agreed technical methods and documentation;
- The analyses processes do not alter or manipulate the relevant dataset(s) beyond the stated intent and agreed technical methods; and

- Comments within the scripts reflect the content and methods contained within the scripts.

Future Considerations

The Fisheries Governance framework, as it currently stands, is bias towards a conventional, top-down approach to fisheries management. This means that countries that have effective fisheries governance systems in place that do not meet this traditional approach may not be fully captured or accurately assessed under the current framework. Future iterations of this report will aim to better recognise and assess a diverse range of fisheries governance models, such as community-based or customary management.

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