FEED THE FUTURE GHANA FISHERIES RECOVERY ACTIVITY (GFRA)

Collaborative Adaptive Fisheries Management Framework

November 25, 2024

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COVER PHOTO: Group of participants in the Collaborative Adaptive Management Workshop Series poses outside our hotel/ conference center in Cape Coast, Ghana. June 2023.

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LIST OF ACRONYMS

CARE	Comprehensive Assessment of Risk to Ecosystems
CSO	Civil Society Organization
E	Fishing Effort
EAFM	Ecosystem Approach to Fisheries Management
EDF	Environmental Defense Fund
EMSY	Effort at Maximum Sustainable Yield
FC	Fisheries Commission
F	Fishing rate
FMOC	Fisheries Management Operational Committee
GIFA	Ghana Inshore Fisher's Association
GITA	Ghana Industrial Trawlers Association
GFRA	Ghana Fisheries Recovery Activity
GNCFC	Ghana National Canoe Fishermen's Ass
HCM	Harvest Control Measure
HCR	Harvest Control Rule
IEZ	Inshore Exclusive Zone
IUU	Illegal Unregulated and Unreported
MCS	Monitoring, Control, and Surveillance
MFMP	Marine Fisheries Management Plan
MOF	Ministry of Fisheries
MOFAD	Ministry of Fisheries and Aquaculture Development
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
NAFAG	National Fisheries Association of Ghana
NAFPTA	National Fish Processors and Traders Association
OMP	Operational Management Plan
PI	Performance Indicator
NGO	Non-Governmental Organization
RP	Reference Point
SFCS	Safe Fish Certification Scheme
SFMP	Sustainable Fisheries Management Plan
SPCC	Small Pelagic Co-management Committee
STC	Scientific and Technical Committee
USAID	United States Agency for International Development

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EXECUTIVE SUMMARY

The United States Agency for International Development (USAID) awarded the Feed the Future Ghana Fisheries Recovery Activity (GFRA) with the goal of mitigating the near collapse of Ghana's small pelagic fisheries sector and establishing a durable basis for its ecological recovery. Foundational to this goal is a clear fisheries management plan that uses the best available scientific information to develop management measures that will support the recovery of the small pelagic fisheries. In 2022, Ghana adopted the Marine Fisheries Management Plan (MFMP) which serves this function by presenting a series of goals, objectives and specific management measures to support improvement in the country's most important fish stocks, including small pelagic fisheries – anchovies, sardinella and mackerels - through 2026.

The MFMP explicitly calls for an annual Operational Plan (OP), "developed from the Management Plan's priorities, that will transparently designate the actions to be taken in every calendar year." The MFMP also calls for the establishment of a Fisheries Management Operational Committee (FMOC) that will evaluate and assess the annual Operational Plans. Furthermore, the MFMP notes that the lack of annual Operational Plans under the 2015 – 2019 Fisheries Management Plan resulted in a key gap, as the Fisheries Commission was unable to prepare annual reports on the performance of fisheries resources against all performance indicator in accordance with the implementation time frame specified in the Management Plan.

To address this challenge, GFRA partnered with Environmental Defense Fund (EDF) to support the newly inaugurated FMOC to undertake a multistage process to develop the first Operational Plan, designed to be a collaborative adaptive fisheries management framework based on the principles of the ecosystem-based approach to fisheries management. To achieve this goal, EDF led a series of three workshops with members of the FMOC, as well as their counterparts on the Scientific and Technical Committee (STC), between December 2022 and June 2023 in various locations along Ghana's central coast. This iterative approach was designed to build the scientific and management capacity of the FMOC and STC members and to support them in developing a set of science-based performance indicators, reference points, harvest control rules, and management measures to be included in the first annual Operational Plan. These technical measures will support the sustainable exploitation of four key small pelagic stocks and build the resilience of the fisheries and fishing communities who target them, in accordance with the priorities outlined in the 2022-2026 MFMP.

This report presents the result of this iterative set of workshops, capturing goals for management of small pelagic fisheries and fishing communities and detailing a set of collaboratively developed, science-based fishery management decisions and measures that can support the recovery of these four stocks over time. This collaborative adaptive management framework is intended to underpin all annual operational plans, which will ensure progress is being made towards stakeholder and MFMP goals and allow for adjustment as necessary. The collaborative adaptive management framework, along with recommendations for the first annual operational plan, is summarized below.

Management Goals and Objectives

Goal and Objectives from Marine Fisheries Management Plan (2022-2016):

- Goal: Establish and Enhance Sustainable Fisheries Management and Utilization of the Fishery Resources for Improved Livelihoods.
- Specific Objectives:
  - to align fishing effort with estimated annual sustainable levels.
  - to improve data collection and enhance knowledge of the biology.
  - to enforce fisheries legislation more adequately.
  - to enhance knowledge on fishing gear and develop gear regulations.
  - to protect marine habitat, biodiversity and mitigate impacts on climate variability and change.
  - to improve the socio-economic well-being of fishers within the fisheries value chain.

Co-Developed Goals for 2023 Annual Operational Plan:

- Biological:
  - Improve data collection and enhance knowledge on the biology of fish species.
  - Align fishing *effort* with estimated annual sustainable levels.
  - Bring fish *harvests* in line with maximum sustainable yield.
  - Prevent catch of juvenile fish.
- Economic: Improve socio-economic well-being of fishers throughout the value chain.
- Governance: Improve enforcement and prosecution of regulations.
- Food security: Establish levels of fish stocks necessary to support local food security.

Data, Performance Indicators, and Reference Points to Assess Progress Toward Goals

In order to assess how close the fishery is to these collaboratively developed goals, the following Performance Indicators (PIs) and corresponding Reference Points (RPs) can be measured and assessed to track progress.

Goal	Data Stream	How Can We Assess?	Performance Indicator	Reference Points
Align fishing *effort* with estimated annual sustainable levels	Vessel Registry System; Inspection reports; Logbooks	Look at ***trends*** in data over time	# Vessel's fishing (Fishing effort (E))	E_{MSY} = • 10,000 canoes • 239 Inshore boats • 88 trawlers
Bring fishery *harvests* in line with maximum sustainable yield	Landings data	Calculate from landings data	Yield (mts)	MSY = • Canoe = 330,824 mt • Inshore = 9,132 mt • Trawlers = 22,823 mt SPECIES SPECIFIC MSY = • Round Sard = 84,200 mt • Flat Sard = 18,200 mt
	Length frequency data (scientific sample of landings)	Estimate based on sizes of fish in the catch	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to F rate at MSY)

Prevent catch of juvenile fish	Length frequency data (scientific sample of landings)	Assess % of juveniles in the catch against thresholds	Length Frequencies in Catch	Target: >/= 85% mature individuals (<15% juveniles)

Stock Assessment Results

Yield by sector and fishing rate (F) for round and flat sardinella were assessed through application of the surplus production model (Schaefer), while the length-based assessments (Catch Curve, LBAR, and Froese) generated estimates for the fishing rate (F) for all 4 target species as well as an assessment of the percentage of the catch made up of juvenile individuals.

Goal	Data Stream	Performance Indicator	Reference Points	RESULTS
Align fishing *effort* with estimated annual sustainable levels	Vessel Registry System; Inspection reports; Logbooks	# Vessels fishing (Fishing effort (E))	E_{MSY} = • 10,000 Canoes • 239 Inshore boats • 88 trawlers	E_{CURR} = • 14,275 Canoes • 224 Inshore boats • 76 Trawlers
Bring fishery *harvests* in line with maximum sustainable yield	Landings data	Yield (mts)	MSY = • Canoe = 330,824 mt • Inshore = 9,132 mt • Trawlers = 22,823 mt SPECIES SPECIFIC MSY = • Round Sard = 84,200 mt • Flat Sard = 18,200 mt	Current Yield = • Canoe = 170,149 mt • Inshore = 11,353mt • Trawlers = 37,507 mt SPECIES SPECIFIC YIELD: • Round sard = 49,818 mt • Flat sard = 10,196 mt
	Landings and Effort Data	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to F rate at MSY)	F_{CURR} : F_{MSY} = • Round sard = 1.74 • Flat sard = 3.34
	Length frequency data (scientific sample of canoe landings)	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to Natural Mortality)	F_{CURR} : F_{MSY} = Round sard > 2 Flat sard = 1.07 Anchovy > 2 Mackerel > 2
Prevent catch of juvenile fish	Length frequency data (scientific sample of canoe landings)	Length Frequencies in Catch	Target: >/= 85% mature individuals (<15% juveniles)	Current % Juveniles = • Round sard = 45% • Flat sard = 31% • Anchovy = 100% • Mackerel = 83%

Harvest Control Rules

Harvest Control Rules (HCRs) guide management based on relationships of chosen PIs to their associated RPs.

- **Canoe sector:** In order to meet the biological goals for the Canoe sector, the following objectives must be achieved:
  - The number of fish coming out of the water, and the fishing rate (F) need to be reduced (targets are MSY and F_{MSY}).
  - The number of vessels fishing needs to be reduced (target is E_{MSY}).
  - The number of juvenile fish coming out of the water needs to be reduced (target <15% of catch should be juveniles).
  - Illegal fishing (which may be skewing yield estimates) must be prevented.
- **Inshore and Trawl sectors:** In order to meet the biological goals for these sectors, , the following objectives must be achieved:
  - The number of fish coming out of the water needs to be reduced (target is MSY).

- The fishing rate (F), or "pressure," *per vessel* needs to be reduced (target is F_{MSY}).
- The number of juvenile fish coming out of the water needs to be reduced (target <15% of catch should be juveniles).

Management Measures

Participants in this workshop series developed and prioritized a set of fishery management measures for the 2023-2024 OP that will accomplish their shared objectives to move the fishery toward shared goals:

Canoe sector

To reduce the number of fish coming out of the water, and the overall fishing rate (F):

- Evaluate the July closed season – determine if it is the right *length* and *time of year*
- Implement the moratorium on new entrants for three years

To reduce the number of vessels fishing:

- Reclassify vessels currently operating in the canoe sector by size and capacity

To reduce the number of juvenile fish coming out of the water:

- Identify at least 2 areas to be classified as MPAs designed to protect spawning/nursery areas
- Carry out gear audit and implement recommendations to protect juveniles (and also reduce the total number of fish caught)

Inshore sector

To reduce the number of fish coming out of the water:

- Develop and implement a fisher education program, targeting >50% of the fishers, to increase compliance with regulations
- Implement the moratorium on new entrants for three years

To reduce the number of juvenile fish coming out of the water:

- Conduct a gear audit in order to prescribe gear restrictions on mesh size/ monofilament nets
- Implement the 2-month closed season (targeting juvenile and spawning periods)
- Implement the MPAs designed to protect spawning/nursery areas

Trawl sector

To reduce the number of fish coming out of the water:

- Enforce the existing IEZ border; discuss extending the border
- Develop and implement a fisher education program with certification that can be prerequisite for licensing
- Implement the moratorium on new entrants for three years

To reduce the fishing rate (F), or "pressure," per vessel:

- Implement effort limits (limits on number of vessels) based on assessment of economic value

To reduce the number of juvenile fish coming out of the water:

- Enforce Ministerial gear restrictions, especially net size restriction of > 60 mm
- Implement the MPAs designed to protect spawning/nursery areas

SECTION 1: INTRODUCTION

1.1. Background and Objective

The Feed the Future Ghana Fisheries Recovery Activity (GFRA) is a United States Agency for International Development (USAID) funded initiative with the goal of mitigating the near collapse of Ghana's small pelagic fisheries sector and establishing a durable basis for its ecological recovery while enhancing the socio-economic well-being and local resilience of artisanal fisherfolk and their communities. The activity is building on the successes of the USAID Sustainable Fisheries Management Project (SFMP). GFRA activities are being implemented under an overarching framework using an ecosystem approach to fisheries management (EAFM) inclusive of relevant strategic interventions to collectively achieve GFRA's five interdependent strategic approaches:

1. Strategic Approach 1: Align fisheries capacity with ecological carrying capacity of the small pelagic fisheries while enhancing the socio-economic well-being and resilience of artisanal fisherfolk.
2. Strategic Approach 2: Increase the quality and value of artisanal fish products to maintain household income and enhance availability of nutritious foods for local and regional markets.
3. Strategic Approach 3: Strengthen transparency, accountability, and co-management in governance practices for fisheries policymaking, regulation, and enforcement.
4. Strategic Approach 4: Strengthen constituencies to promote and implement sustainable fisheries management.
5. Strategic Approach 5: Improve use of science and research for policy and management decisions.

1.2. Workshop Series Overview and Objectives

Environmental Defense Fund (EDF) was brought in by the GFRA team to support the FMOC in developing technical measures for Ghana's small pelagic fisheries that can be included in their annual Operational Plan to help ensure progress is made toward the goals and objectives of the 2022-2026 MFMP. To achieve this goal, EDF led a series of three workshops with members of the FMOC, as well as their counterparts on the STC, between December 2022 and June 2023 in various locations along Ghana's central coast.

This workshop series was designed to build the scientific and management capacity of the FMOC and STC members, and to support them in developing a set of science-based performance indicators, reference points, harvest control rules, and management measures to be included in the first annual Operational Plan. These technical measures will support the sustainable exploitation of four small pelagic fishery stocks and build the resilience of the fisheries and fishing communities who target them, in accordance with the priorities outlined in the 2022-2026 MFMP. The decision-support tool used throughout this series of workshops is the Framework for Integrated Stock and Habitat Evaluation (FISHE). To best align with the local context and needs, the process focused on FISHE Steps 1-3, and 7-11.

I. **Workshop 1 Objectives Achieved:**
   a. Lay groundwork and build relationships for an inclusive collaborative adaptive management process.
   b. Create set of shared, holistic goals for fishery and community future.

c. Examine participant roles in moving system towards shared goals, as mandated by Marine Fishery Management Plan 2022-2026.
d. Build capacity for developing and implementing science-based fishery management using Performance Indicators, Reference Points, and Harvest Control Rules, to support development of 2023 Operational Plan.
e. Build understanding of challenges, including Illegal, Unreported, and Unregulated (IUU), fishing, data limitations, and climate change impacts.
f. Encourage critical examination of existing management plan and process in relation to shared goals and system challenges.

II. Workshop 2 Objectives Achieved:

a. Broaden the management lens to include ecosystem health and habitat/ biodiversity restoration.
b. Deepen understanding of the impacts of climate change on these four small-pelagic stocks and on the ecosystem.
c. Revisit goals, PIs, RPs, and HCRs developed in Workshop 1 and expand/ add to them based on the above, as well as on updated assessment results.
d. Address key topics of interest elevated by participants at Workshop 1, including: data quality, collection, and use of fishery independent data; common pitfalls in fisheries management such as growth and Recruitment overfishing, effort creep, and multispecies management; and the challenges posed by climate change.

III. Workshop 3 Objectives Achieved:

a. Review results of scientific stock assessments (conducted concurrently to this workshop series) and deepen FMOC and STC member understanding of what these results say about the current status of these stocks.
b. Revisit goals, PIs, RPs, HCRs, and HCMs developed by participants at previous two workshops and identify which "scenario" aligns most closely with the results of the stock assessments.
c. Discuss Harvest Control Measure (HCM) options that align with this scenario and co-develop management and implementation strategies for realistic and effective progress toward goals.
d. Develop long-term plan for adaptive decision-making to allow for iterative progress toward holistic set of goals.

This report details the outcome of this series of workshops, capturing the participants' goals for their fisheries and communities and detailing a set of collaboratively developed, science-based fishery management decisions and measures that can support the recovery of these four stocks over time. This report also lays out a clear plan for adaptive iteration on these management decisions based on additional data and information, which will ensure progress is being made towards stakeholder and MFMP goals and allow for adjustment as necessary.

SECTION II: MANAGEMENT CONTEXT AND STRUCTURE

2.1. History of Management Efforts

Ghana's small pelagic fisheries are extremely important, both as sources of employment and livelihoods for the over 140,000 artisanal and semi-industrial fishers who target them, and as sources of food and nutrition security for Ghana's entire population, both in coastal and inland communities. Unfortunately, a combination of long-term overfishing, negative impacts on habitats and ecosystems, and the impacts of climate change have driven the four primary species – round sardinella (*Sardinella aurita*), Madeiran sardinella (*S. maderensis*), European anchovy (*Engraulis encrasicolus*), and Atlantic chub mackerel (*Scomber colias*) – targeted by these fishers to near collapse.

The Ministry of Fisheries and Aquaculture Development (MoFAD) and its Fisheries Commission (FC) have been trying to rebuild these four stocks by developing and implementing management measures aimed at reducing fishing effort and capacity, building management and enforcement capacity, protecting habitats and biodiversity, and reducing post-harvest losses. As part of this effort, the Marine Fisheries Management Plan (MFMP) (2022 – 2026) recommended the formation and establishment of a Fisheries Management Operational Committee (FMOC), as an advisory body to the FC. The FMOC is expected to facilitate the development of annual "Operational Plans" which would "transparently designate the actions to be taken in every calendar year to ensure achievement of the MFMP (2022-2026) priorities.

Based on the lessons learned and challenges from the implementation of the 2015-2019 MFMP, the Commission identified the creation and implementation of a comprehensive Operational Plan is a key strategy, to ensure effective stakeholder participation and timely implementation of actions in the MFMP (2022-2026). The MFMP (2022-2026) also seeks to employ a precautionary, science-based, ecosystem approach to manage the country's fisheries, and to meaningfully effect a transparent, participatory co-management system. Whereas the FC remains the main implementing body of the Operational Plan, the newly formed FMOC will promote active stakeholder partnership with the Commission for timely and effective implementation of the new MFMP (2022-2026).

2.1.1. Co-Management Structure

According to Section 42 (3) Fisheries Act 2002 (Act 625), "The Commission shall be responsible, in collaboration with such state agencies as the Commission considers appropriate, for the implementation of each fishery plan". Section 9 also grants that "The Commission may appoint committees it considers necessary for the implementation of its functions". On this basis, the FMOC was formally established on March 17, 2023, comprising MoFAD, FC, Development Partners, GMA, GITA, GIFA, GNCFC, NAFPTA, EPA, NAFAG, Academia and CSO/NGOs.

The national co-management policy for the fisheries sector establishes the framework for forming large-scale co-management committees, outlining criteria to support the Fisheries Commission (FC) in managing Ghana's fisheries. The Fisheries Management Operational Committee (FMOC) fully meets these criteria. Drawing on scientific input and advice from the Science and Technical Committee (STC), the FMOC will offer recommendations to the Executive Director of the Fisheries Commission to ensure the effective implementation and development of current and future Fisheries Management Plans.

2.2. Management Goals and Objectives

2.2.1. Goal and Objectives from Marine Fisheries Management Plan (2022-2016):

During the first workshop, in December 2022, participants reviewed the stated goals and objectives in the 2022-2026 MFMP. These are:

- Goal: Establish and Enhance Sustainable Fisheries Management and Utilization of the Fishery Resources for Improved Livelihoods.
- Specific Objectives:
  - to align fishing effort with estimated annual sustainable levels.
  - to improve data collection and enhance knowledge of the biology.
  - to enforce fisheries legislation more adequately.
  - to enhance knowledge on fishing gear and develop gear regulations.
  - to protect marine habitat, biodiversity and mitigate impacts on climate variability and change.
  - to improve the socio-economic well-being of fishers within the fisheries value chain.

2.2.2. Co-Developed Goals for 2023 Annual Operational Plan:

Participants then developed clear, measurable short-term (one year) goals that will feed directly into the medium-term goals articulated in the MFMP, as well as the longer-term goals they share for this fishery. These are:

- **Biological:**
  - Improve data collection and enhance knowledge on the biology of fish species.
  - Align fishing *effort* with estimated annual sustainable levels.
  - Bring fish *harvests* in line with maximum sustainable yield.
  - Prevent catch of juvenile fish.
- **Economic:** Improve socio-economic well-being of fishers throughout the value chain.
- **Governance:** Improve enforcement and prosecution of regulations.
- **Food security:** Establish levels of fish stocks necessary to support local food security.

For a complete set of holistic system goals developed at Adaptive Management Workshop 1, see ***Annex II****.*

SECTION III: DATA COLLECTION AND USE

Through multiple interactive sessions and discussions over the course of the three workshops, participants addressed a series of key questions designed to explore current data collection protocols and to illuminate any gaps in their current system of data collection and use. They then sought to identify and develop effective steps that they can take to address these gaps.

3.1. Data currently being used for stock assessments:

- **Effort Data:**

- Number of vessels (all sectors), number of days at sea (industrial), hours spent fishing (industrial)
- Fishing position of industrial vessels

- **Catch Data:**

- Data on landings for artisanal fishery:
  - Spatial component – 52 sample sites along the coast
  - Temporal component – sampled throughout season, two weeks per gear
- Data on landings from all landing sites for semi-industrial fishery
- Data on landings from industrial fishery, self-reported by every fisher

- **Biological Data:**

- At port inspections of industrial fishing activities (sample of 40 vessels) that include samples of length/ weight and sex.

3.2. Additional Assessments that may be added in future years to reduce uncertainty

- Sensitivity analyses on the assessment models being used to determine what their robustness (*already happening but can be improved)*
- Multiple assessment models using multiple data streams to cross check results
- Use models meant specifically for tropical small-pelagic fisheries

3.3. Additional data collection plans to reduce risk

- Use more data **streams**: Utilize the length/weight data already being collected and expand these collections
- Utilize fishery independent data in additional assessments
- Collect **better** data:
  - Refresh the training for enumerators and observers (*already happening, but can be improved)*
  - Train fishers to collect data
- Better communication between fishers and managers to improve buy-in for data reporting
  - Collect **more** data: Fishery Independent surveys of biomass regularly

SECTION IV: PERFORMANCE INDICATORS, REFERENCE POINTS AND HARVEST CONTROL RULES

Workshop participants collaboratively developed appropriate Performance Indicators (PIs) and corresponding Reference Points (RPs) that are being, or that can be, measured and assessed in order to determine how close the fishery is to the OP goals that participants articulated, as well as those already identified in the MFMP. Available data streams were also discussed – both those that are already in use (e.g., total landings) and those that could be added to the management regime relatively easily (e.g., length-frequencies of each species from the catch) – to improve the understanding of the state of the fishery and stocks, and to reduce uncertainty.

4.1. Selected Performance Indicators (PIs) with corresponding Reference Points (RPs) to track progress toward biological fishery goals

The first two rows of **Table 1** show the existing PIs, RPs, and data streams articulated in the 2022-2026 MFMP for the objective "Align fishing effort with estimated annual sustainable levels." Upon discussion of these existing PIs and RPs in relation to the goals and available data in this fishery, participants in this workshop series chose to add two additional PIs, with corresponding RPs to the set of indicators that they will track this year. Rows 3 and 4 of **Table 1** (text in blue) show these two additional PIs with draft RPs and necessary data streams. This decision to add these two additional PIs supports a precautionary and robust adaptive management system and indicates a clear commitment to applying the best available science in this data limited system.

Table 1: Selected PIs, RPs, and Corresponding Data Streams for Ghana Small Pelagic Stocks[1]

Goal	Data Stream	How Can We Assess?	Performance Indicator	Reference Points
Align fishing *effort* with estimated annual sustainable levels	Vessel Registry System; Inspection reports; Logbooks	Look at ***trends*** in data over time	# Vessels fishing (Fishing effort (E))	E_{MSY} = • 10,000 canoes • 239 Inshore boats • 88 trawlers
Bring fishery *harvests* in line with maximum sustainable yield	Landings data	Calculate from landings data	Yield (mts)	MSY = • Canoe = 330,824 mt • Inshore = 9,132 mt • Trawlers = 22,823 mt SPECIES SPECIFIC MSY = • Round Sard = 84,200 mt • Flat Sard = 18,200 mt
	Length frequency data (scientific sample of landings)	Estimate based on sizes of fish in the catch	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to F rate at MSY)

[1] PIs and corresponding RPs in blue text were added during Workshop 1. RP values in purple text were added based on updated stock assessments conducted in 2023.

Prevent catch of juvenile fish	Length frequency data (scientific sample of landings)	Assess % of juveniles in the catch against thresholds	Length Frequencies in Catch	Target: >/= 85% mature individuals (<15% juveniles)

4.2. Harvest Control Rules (HCRs) determined to align with each PI-RP scenario.

Participants also co-developed a comprehensive set of HCRs that will guide management based on relationships of chosen PIs to their associated RPs. This process involves exploring every possible combination of PIs and RPs, and it requires deep knowledge of the fishery and system, as well as a clear grasp of the process of connecting scientific assessments to management decisions.

Table 2: Harvest Control Rules co-developed at Workshop 1[2]

Scenario	Indicators & Reference Points				**Interpretation / Possible Causes**	**Harvest Control Rule**
	***PI:* Number of Vessels** ***RP:* Target # vessels (varies by sector)**	***PI:* F** ***RP:* F_{MSY}**	***PI:* Yield (mt)** ***RP:* MSY**	***PI:* Length Frequencies in the catch** ***RP:* 85% mature**		
1	✓	✓	✓	✓	Stocks healthy and fishing pressure (effort, catch and size of fish caught) at good level.	Continue to monitor reference point (RP) trends; Make no change if RP trends are stable or just above limits.
2	**X**	✓	✓	✓	Effort is too high (too many vessels), but overfishing is not occurring, and stocks not yet overfished. Perhaps individual vessels are catching less than expected. OR Estimate of EMSY is incorrect.	Continue to monitor, reduce number of vessels if other PIs trends worsen. AND Reevaluate EMSY with additional assessments/ models to confirm.
3	✓	**X**	✓	✓	Overfishing is occurring (fishing rate too high) despite levels of effort deemed appropriate, but number of fish coming out of the water is still ok and fishers are not	Continue to monitor and stay on course if F trends improve. Assess stock and ecosystem health and identify other stressors that can be reduced. If F remains above FMSY or other trends worsen, adjust

[2] Note: A "✓ "indicates that the performance indicator is in good standing with relation to its reference point - I.e., meeting its target or not passing its limit. "X" indicate that the performance indicator is not in good standing with relation to its reference point - I.e., not meeting the target or passing the limit.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	PI: ***Number of Vessels*** **RP:** ***Target # vessels (varies by sector)***	**PI:** ***F*** **RP:** ***F_{MSY}***	**PI:** ***Yield (mt)*** **RP:** ***MSY***	**PI:** ***Length Frequencies in the catch*** **RP:** ***85% mature***		
					catching too many juveniles. Fishing rate could be newly increasing, with effects not yet impacting stock health. OR Estimate of FMSY could be incorrect.	limits (effort and/or yield/ size) to allow recovery. AND Reevaluate FMSY with additional assessments/ models to confirm.
4	✓	✓	**x**	✓	Fishers have started to catch too much, but stocks not overfished yet. Fishers not catching juveniles, but each vessel is catching more fish than expected. OR Estimates of MSY or E-MSY are incorrect.	Re-assess yield to confirm trend. AND Continue to monitor other PIs. If MSY / EMSY stays the same on review, and/or if Yield continues to increase, limit/ reduce yield per boat, consider gear restrictions
5	✓	✓	✓	**x**	Fishers not catching too many fish but catching them too young ("recruitment overfishing"). Perhaps fishing on a nursery area. Stocks in water not yet overfished, but this is unlikely to last for long.	Implement a gear restriction and/or seasonal or area closure to prevent catching juvenile fish. Continue to monitor all PIs
6	**x**	**x**	✓	✓	Too many fishers/ vessels and fishing pressure is too high. Yield is not high because there aren't enough fish left to be caught.	Reduce number of vessels (provide alternative livelihoods) and/or number of fish being caught. Consider a temporary fishery closure to allow stock recovery.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	PI: ***Number of Vessels*** **RP:** ***Target # vessels (varies by sector)***	**PI:** ***F*** **RP:** F_{MSY}	**PI:** ***Yield (mt)*** **RP:** ***MSY***	**PI:** ***Length Frequencies in the catch*** **RP:** ***85% mature***		
					Fishers not catching juveniles.	
7	✗	✓	✗	✓	Too many fishers/ vessels and too many fish coming out of the water but fishing rate appears to be sustainable. Fishers not catching juveniles, which may be helping maintain biomass. OR Estimate of FMSY could be incorrect	Reduce number of vessels (provide alternative livelihoods) and number of fish coming out of the water. Maintain gear restrictions or area/seasonal closures that are protecting juveniles. AND Reevaluate FMSY with additional assessments/ models to confirm
8	✓	✗	✗	✓	Fishing pressure and yield are too high – overfishing is occurring Effort creep – Each vessel is catching more than expected so that too many fish are coming out of the water despite effort limits.	Reduce/ limit catch OR Reduce number of days at sea and apply gear restrictions and/or seasonal/area closures AND MAYBE Limit catch per vessel (e.g., quotas)
9	✓	✓	✗	✗	Number of vessels not over target, fishing rate not too high, but too many fish are coming out of the water and too many of them are juveniles (“recruitment overfishing”). Effort creep – Each vessel is catching more	Reduce/ limit catch – maybe with individual vessel catch limits. AND Implement gear restrictions and/or seasonal/area closures to reduce the number of juveniles being caught.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	PI: *Number of Vessels* **RP:** *Target # vessels (varies by sector)*	**PI:** *F* **RP:** F_{MSY}	**PI:** *Yield (mt)* **RP:** *MSY*	**PI:** *Length Frequencies in the catch* **RP:** *85% mature*		
					than expected, and too many juveniles.	
10	✓	✗	✓	✗	Number of vessels not over target and yield not over MSY, but fishing rate is too high, and too many juveniles being caught ("recruitment overfishing"). This means good yields are made of mostly juveniles, which will lead to stock declines.	Gear restrictions and/or seasonal/ areas closures to reduce number of juveniles caught. Consider temporary yield reductions (stricter limits) or precautionary fishery closure to allow stocks to recover.
11	✗	✗	✗	✓	Too many vessels catching too many fish has led to unhealthy stocks. I.e., overfishing is occurring, and stocks are already overfished. Fishers not catching juveniles.	Consider a temporary fishery closure to allow stocks to recover. Reduce the catch – overall or individual limits. OR Reduce number of vessels (provide alternative livelihoods) Maintain gear restrictions or area/seasonal closures that are protecting juveniles.
12	✓	✗	✗	✗	Likely that both growth and recruitment overfishing are occurring. Data defects? (number of vessels being underestimated OR level of effort could be set too high based on wrong data)	Reassess all PIs with additional assessments and additional data (from different data streams) if possible. Consider a temporary fishery closure to allow stocks to recover. OR Reduce the catch – overall or individual limits.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	***PI:** Number of Vessels* ***RP:** Target # vessels (varies by sector)*	***PI:** F* ***RP:** F_{MSY}*	***PI:** Yield (mt)* ***RP:** MSY*	***PI:** Length Frequencies in the catch* ***RP:** 85% mature*		
					OR Fishery (biomass) was already collapsed when effort limit was set (i.e., effort limit not yet having effect, or not sufficient). AND/OR Effort creep – each vessel catching more fish than expected, and also catching juveniles ("recruitment overfishing"). AND/OR High IUU fishing – if illegal catch is captured in Yield estimates, but not in Effort numbers.	AND/OR Gear restrictions and/or seasonal and/or areas closures to reduce catch, and especially to protect juveniles. Determine if there's a critical habitat that could be protected.
13	✗	✓	✗	✗	Too many vessels, too many fish coming out of the water (overfishing is occurring) and too many of them are juveniles ("recruitment overfishing"). Likely that estimates of F are incorrect.	Reassess F with additional assessments/ alternate models to confirm. Reduce number of vessels (provide alternative livelihoods); Reduce the catch – overall or individual vessel limits. AND/OR Gear restrictions and/or seasonal and/or areas closures to reduce catch, and especially to protect juveniles. Determine if there's a critical habitat that could be protected.
14	✗	✗	✓	✗	Too many vessels catching too many juveniles has led to	Reassess yield with additional assessments/ alternative data streams if possible.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	PI: *Number of Vessels* ***RP:*** *Target # vessels (varies by sector)*	***PI:*** *F* ***RP:*** F_{MSY}	***PI:*** *Yield (mt)* ***RP:*** *MSY*	***PI:*** *Length Frequencies in the catch* ***RP:*** *85% mature*		
					unhealthy stocks (stocks are overfished). Likely that both growth and recruitment overfishing are occurring. Possible that yield estimates are incorrect (i.e., missing data, IUU fishing not captured), or that stock sizes are already so low that it is no longer possible to catch MSY.	Consider a temporary fishery closure to allow stocks to recover. Reduce number of vessels (provide alternative livelihoods); Enforce and prosecute IUU fishing AND Gear restrictions and/or seasonal and/or areas closures to protect juveniles. Determine if there's a critical habitat that could be protected.
15	X	✓	✓	X	Too many vessels catching too many juveniles ("recruitment overfishing"). Could be use of illegal gears, or fishing on nursery grounds. Could be a market demand for juvenile fish. Fishing rate and yield are not too high, indicating that each vessel is catching less than expected. Possible that fishing rate and/or yield estimates are incorrect. High IUU fishing that's not captured in landings data?	Reassess yield and fishing rate with additional assessments and alternative data streams if possible. Reduce number of vessels (provide alternative livelihoods); Enforce and prosecute IUU fishing. AND Gear restrictions and/or seasonal and/or areas closures to protect juveniles. Determine if there's a critical habitat that could be protected.

Scenario	Indicators & Reference Points				Interpretation / Possible Causes	Harvest Control Rule
	PI: ***Number of Vessels*** **RP:** ***Target # vessels (varies by sector)***	**PI:** ***F*** **RP:** F_{MSY}	**PI:** ***Yield (mt)*** **RP:** ***MSY***	**PI:** ***Length Frequencies in the catch*** **RP:** ***85% mature***		
16	**X**	**X**	**X**	**X**	Overfishing is occurring and stocks are already overfished. Likely that both growth and recruitment overfishing are occurring. Too many vessels catching too many fish, and especially too many juveniles, has led to unhealthy stocks. Fishery collapse is likely.	Drastic action needed to reduce number of fish coming out of the water, and especially number of juveniles. Consider a temporary fishery closure to allow stocks to recover. Reduce number of vessels (provide alternative livelihoods) and/or implement catch limits (total or individual). AND Gear restrictions and/or seasonal and/or areas closures to protect juveniles. Identify and protect critical habitat.

SECTION V: ASSESSMENTS AND RESULTS

Scientific assessment is one of the keys to sustainable fisheries management. Multiple methods can be helpful in estimating the status of fisheries — many of these methods can use either fishery independent or dependent data streams. Assessment should be connected to the fishery management goals, in order to monitor the performance of the fishery over time.

Yield by sector and fishing rate (F) for round and flat Sardinella were assessed through application of the surplus production model (Schaefer), while the length-based assessments (Catch Curve, LBAR, and Froese) generated estimates for the fishing rate (F) for all 4 target species as well as an assessment of the percentage of the catch made up of juvenile individuals. See **Annex IV** for more details on these stock assessments. Results for both sets of stock assessments are presented in Table 3.

4.1. Stock Assessment Results

Table 3: Results of two sets of assessments using 2021 and 2022 data to examine the performance of Ghana's small pelagic fisheries.[3]

Goal	Data Stream	Performance Indicator	Reference Points	RESULTS
Align fishing *effort* with estimated annual sustainable levels	Vessel Registry System; Inspection reports; Logbooks	# Vessels fishing (Fishing effort (E))	E_{MSY} = • 10,000 Canoes • 239 Inshore boats • 88 trawlers	E_{CURR} = • 14,275 Canoes • 224 Inshore boats • 76 Trawlers
Bring fishery *harvests* in line with maximum sustainable yield	Landings data	Yield (mts)	MSY = • Canoe = 330,824 mt • Inshore = 9,132 mt • Trawlers = 22,823 mt SPECIES SPECIFIC MSY = • Round Sard = 84,200 mt • Flat Sard = 18,200 mt	Current Yield = • Canoe = 170,149 mt • Inshore = 11,353mt • Trawlers = 37,507 mt SPECIES SPECIFIC YIELD: • Round sard = 49,818 mt • Flat sard = 10,196 mt
	Landings and Effort Data	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to F rate at MSY)	F_{CURR} : F_{MSY} = • Round sard = 1.74 • Flat sard = 3.34
	Length frequency data (scientific sample of canoe landings)	Current Fishing Rate compared with Fishing Rate at MSY	F_{CURR}: F_{MSY} = 1 (Current F rate is equal to Natural Mortality)	F_{CURR} : F_{MSY} = Round sard > 2 Flat sard = 1.07 Anchovy > 2 Mackerel > 2
Prevent catch of juvenile fish	Length frequency data (scientific sample of canoe landings)	Length Frequencies in Catch	Target: >/= 85% mature individuals (<15% juveniles)	Current % Juveniles = • Round sard = 45% • Flat sard = 31% • Anchovy = 100% • Mackerel = 83%

Assessments revealed that effort is currently too high in the Canoe sector (14,275 vessels in comparison with the limit RP of 10,000), but that the Inshore and Trawl sectors are within their limits for number of vessels on the water. Current yield in the Canoe sector appears to be well-below the limit RP (which is an estimate of MSY), while yield in both the Inshore and Trawl sectors is higher than these limits. This seeming conflict between assessments of effort and assessments of yield underscore the shortcomings of using a simple vessel count as a proxy for fishing effort – as there is no guarantee that each vessel is catching the same as the others, nor that the average catch per vessel is consistent over time, it is

[3] Results are presented in relation to their pre-agreed Goals and Reference Points, and with information on data streams that were used.

possible for a certain number of vessels that might seem sustainable to be catching far more than would be expected, potentially pushing the stocks past their ability to replenish their numbers each year. Participants also speculated that the very low catch in the Canoe sector is an indication that these small pelagic stocks are already heavily overfished, such that there simply is not sufficient biomass in the water to allow for a catch at the level indicated as MSY. This supposition is supported by the low yield values for each of the round and flat Sardinella when assessed separately.

Both the surplus production and the length-based models used to assess the current fishing rate (F) indicate that this rate is far too high for all assessed species – fishers are catching significantly more than they would be if they were fishing at a rate aligned with MSY. This indicates that not only are the stocks currently overfished, but overfishing is still occurring. It's worth noting that the length-based assessments used an F value roughly equivalent to each species' natural mortality rate as a proxy for F-MSY, while the NORAD-supported assessments instead reverse-calculated an F rate from their calculations of MSY, thus resulting in essentially 2 different values for the same RP. In other words, the current fishing rates were compared to two different estimates of sustainability, and in both cases the current rates are well above those target values.

Finally, the length-based assessments were used to generate estimates of the percentage of the catch that is made up of juvenile individuals (assumed to be too young to have reproduced). Once again, these assessments indicate that all four species are exceeding their limit RP of 15% of the catch or less being juveniles. In the case of Anchovy, these assessments suggest that fully 100% of the catch were below the size of maturity. It was speculated that perhaps the data for this assessment was collected only during the part of the season when Anchovy are still young. However, as all the other assessments conducted (including those using a different and independent data stream) agree that these stocks are overfished and that overfishing is occurring we can feel confident in concluding that too many juveniles are being caught, further jeopardizing the continued existence of this fishery.

4.2. Identification of HCR Scenario indicated by assessment results

Assessment results indicate current standing of each of the Performance Indicators in relation to its corresponding Reference Point. Examination of the HCR Table (Table 2 above) then allows for identification of the HCR "Scenario" that the fishery is currently experiencing, and the pre-determined interpretations and HCRs (objectives) that stakeholders have developed for that scenario.

Because the Canoe sector assessment results differed from the Inshore and Trawl sector results with respect to the number of vessels (too high and below limits, respectively) and yield (well below limit and exceeding limit, respectively), it was determined that the Canoe sector is in a different scenario than the Inshore and Trawl sectors, which share a scenario:

- **Canoe sector:** falls under *HCR Scenario #14* (or possibly #16 if yield data is inaccurate).
    - Thus, in order to meet the biological goals for the Canoe sector, the following objectives must be achieved:
        - The number of fish coming out of the water, and the fishing rate (F) need to be reduced (targets are MSY and F_{MSY}).
        - The number of vessels fishing needs to be reduced (target is E_{MSY}).
        - The number of juvenile fish coming out of the water needs to be reduced (target <15% of catch should be juveniles).

    - Illegal fishing (which may be skewing yield estimates) must be prevented.

- **Inshore and Trawl sectors:** both fall under *HCR Scenario #12*.
    - Thus, in order to meet the biological goals for these sectors, , the following objectives must be achieved:
        - The number of fish coming out of the water needs to be reduced (target is MSY).
        - The fishing rate (F), or "pressure," *per vessel* needs to be reduced (target is F_{MSY}).
        - The number of juvenile fish coming out of the water needs to be reduced (target <15% of catch should be juveniles).

4.3. Ecosystem Assessments:

Results of Comprehensive Assessment of Risk to Ecosystems (CARE)

The Comprehensive Assessment of Risk to Ecosystems (CARE) model provides a rapid yet comprehensive ecosystem risk assessment tool, including an explicit climate vulnerability assessment component. The CARE tool facilitates the comprehensive, participatory evaluation of every threat facing any type of system or species, both now and in a climate-impacted future time period.

*See **Annex V** for description of assessment method, process of application and full results.*

4.3.1. Climate Impacts:

Overall, climate change is expected to have a **major impact** on the Ghanaian coastal ecosystem and the small pelagic fisheries over the coming 50 years.

The most significant climate change impacts expected for the marine ecosystems in this region include:

- **Temperature increasing** – both the air and the sea surface temperatures are projected to increase significantly in Ghana.
- **Precipitation changes** - rainfall will generally **increase** and may also become more **erratic**.
- **Sea level rise** in Ghana may be well above global average.
- An increase in **wave action and coastal erosion** will continue.
- The **frequency** and **intensity** of major storms may also increase.
- **Ocean acidification** – local data is limited; but available evidence and local knowledge suggest that acidity will increase significantly.
- **Upwelling patterns** and **intensity** will be impacted, but direction of impact is unclear.
- Major area **currents are** showing signs of **slowing**.
- **Harmful algal blooms** are already increasing.

4.3.2. Climate vulnerability:

Vulnerability to climate change is calculated as the expected impact of the climate-driven changes multiplied by the system's or species' ability to respond to (i.e., resist and/or recover from) impact.

The nearshore mangrove ecosystem off the coast of Ghana is predicted to have **moderate vulnerability** to the impacts of climate change over the coming 50 years, with the system's high biological productivity, high species richness, and complex, diverse community structure contributing to its ability to respond to impacts, while its current unhealthy system status and highly modified food web and community structure are driving the system's resilience down.

This can be seen as a positive result, as the features reducing system resilience are within the control of stakeholders (rather than being intrinsic system characteristics). **In other words, if system and species community health can be restored (e.g., reduction of pollution, restoration of mangroves, ending overfishing) the overall resilience of the system will be increased, and thus the severity of the impacts of climate change can be reduced.**

Of the four small pelagic species, three are also scored as having **moderate vulnerability** to climate change (with round sardinella having the highest vulnerability), and one – the anchovy – scored as having **low vulnerability**. These scores are largely driven by these species' intrinsic life history and physiological characteristics, e.g., growth/ mortality rates, reproduction rates, and abilities to tolerate increased temperatures and acidification. However, the current health and status of these four stocks also drive their ability to resist and recover from negative impacts – the round sardinella and the mackerel were both scored as having low current health/ abundance, while the flat sardinella was scored with moderate current health/abundance, and the anchovy was scored as having high abundance/ health.

Also of note is the differential sensitivity of these four species to changes in water temperature and pH (acidity). The round sardinella scored very high sensitivity to these changes, the mackerel scored high, and the flat sardinella and anchovy both scored low. These features indicate whether or not the given species is likely to move out of the area to track its preferred temperature ranges, or whether acidification will reduce its productivity.

4.3.3. Impact of Current Threats on the Ecosystem and Species

The CARE tool also allows users to generate relative "risk" scores for any *current* system threats that they would like to assess. Stakeholders selected the following options: - (1) legal artisanal fishing (2) illegal artisanal fishing and (3) pollution - as the threats to assess with CARE, although they voiced a desire to also examine coastal development.

Risk from each threat is calculated as the current Exposure[4] to impact from the threat multiplied by the system's or species' ability to respond to impact. The same Response scores are used for this component of CARE as were used for the climate vulnerability analysis.

As discussed above, the nearshore mangrove ecosystem has a **moderate** ability to Respond to impact, as does the round sardinella, while the flat sardinella, anchovy and mackerel all have **high/ strong** abilities to Respond (higher numbers are always worse in the CARE analysis). This means that these latter three species have greater intrinsic resilience than do the round sardinella or the ecosystem as a whole.

When comparing the 3 threats examined in this analysis, pollution and illegal artisanal fishing activity have the **highest possible** Exposure scores across all 4 species. Pollution also has this **extreme** Exposure score with respect to the ecosystem, while illegal artisanal fishing activity is scored just slightly

[4] Note that Risk is different from Vulnerability because the *current Exposure* (i.e., what is actually happening to the system or species) is used as the measure of effect, rather than the *expected Impact*, which includes an evaluation of the *likelihood* that a certain change will actually take place.

lower, but still **very high** for the ecosystem. Legal artisanal fishing was given a **moderate** Exposure score across all 5 analyses. Together, these Response and Exposure scores generate the suite of relative risk scores shown below. In general, **illegal artisanal fishing and pollution come out as the most critical risks to both the ecosystem and the four small pelagic species** – these threats require immediate action to reduce and remediate their impacts. The legal artisanal fishery is presenting a medium level of risk to the ecosystem and the round sardinella, and low risk to the other three species.

These results indicate that **if all illegal fishing activity could be removed, and the pollution problems addressed, the legal fishing activity should be relatively sustainable for this system and these species. On the other hand, if not addressed, these two threats could significantly damage both the ecosystem and these target species, potentially undermining any efforts to implement sustainable fisheries management, and to preserve the livelihoods and food provisioning provided by these important fisheries.**

SECTION VI: MANAGEMENT MEASURES FOR THE DURATION OF THE PLAN

The next phase of the collaborative adaptive management process is to develop fishery management *measures* that align with the HCR scenario the fishery is currently in, and that will accomplish the corresponding objectives to move the fishery toward shared goals. Prioritized lists of management measures (including both measures already present in the MFMP, and new measures developed to fill gaps), organized by sector and by biological goal, are presented here. These measures were selected for 1) their potential to move the fishery toward shared biological goals, and 2) their feasibility for implementation within the next year.

A comprehensive list of potential management measures developed by stakeholders during Workshop 3 can be found in ***Annex VI****.*

6.1. Canoe sector

To reduce the number of fish coming out of the water, and the overall fishing rate (F):

- Evaluate the July closed season – determine if it is the right *length* and *time of year*
- Implement the moratorium on new entrants for three years

To reduce the number of vessels fishing:

- Reclassify vessels currently operating in the canoe sector by size and capacity

To reduce the number of juvenile fish coming out of the water:

- Identify at least 2 areas to be classified as MPAs designed to protect spawning/nursery areas
- Carry out gear audit and implement recommendations to protect juveniles (and also reduce the total number of fish caught)

6.2. Inshore sector

To reduce the number of fish coming out of the water:

- Develop and implement a fisher education program, targeting >50% of the fishers, to increase compliance with regulations
- Implement the moratorium on new entrants for three years

To reduce the number of juvenile fish coming out of the water:

- Conduct a gear audit in order to prescribe gear restrictions on mesh size/ monofilament nets
- Implement the 2-month closed season (targeting juvenile and spawning periods)
- Implement the MPAs designed to protect spawning/nursery areas

6.3. Trawl sector

To reduce the number of fish coming out of the water:

- Enforce the existing IEZ border; discuss extending the border
- Develop and implement a fisher education program with certification that can be prerequisite for licensing
- Implement the moratorium on new entrants for three years

To reduce the fishing rate (F), or "pressure," per vessel:

- Implement effort limits (limits on number of vessels) based on assessment of economic value

To reduce the number of juvenile fish coming out of the water:

- Enforce Ministerial gear restrictions, especially net size restriction of > 60 mm
- Implement the MPAs designed to protect spawning/nursery areas

SECTION VII: IMPLEMENTATION PLANS FOR EACH PRIORITY MANAGEMENT MEASURE

Once priority management measures for each sector were articulated, participants worked to develop effective and feasible plans for implementing these measures. These plans are presented here, organized by sector.

7.1. Canoe Sector Implementation Plan

Measure: Conduct gear audit and implement recommendations to protect juveniles

- *Schedule:*
  - Take stock of existing gears (October 2023)
  - Engage stakeholders to validate the audit report (Jan 2024)
  - Provide directive by the Ministry on the recommendations of the audit report (May 2024)
- *Communication Plan*
  - Develop illustrated manuals on gears that are allowed and prohibited
  - Direct stakeholder engagement
  - Posters, TV, & radio
  - Community information centers
- *Monitoring/ Enforcement*
  - Chief fisherman
  - MOFAD & FC
- *Administration*
  - GFRA, MOFAD, FC
- *Challenges*
  - Push back (acceptance of the directive)
  - Political interferences

Measure: Reclassification of Canoes by Size and Capacity

- *Schedule*
  - Develop a concept paper on the reclassification of canoes (Sept 2023)
  - conduct stakeholder engagement (by end of Oct 2023)
  - Develop guidelines for implementation
  - Implement classification
- *Communication Plan*
  - Stakeholder engagement, posters, radio, and tv
  - Community information center
- *Monitoring/ Assessment/Enforcement*
  - Associations

- Chief fisherman
- District assembly & municipal assembly
- MOFAD & FC

- *Challenges*
  - Push back (acceptance)
  - Political interference

- *Administration/Financing*
  - Donor partners (GFRA)
  - MOFAD and FC

Additional Canoe sector management measures co-developed by stakeholders during workshops

Details to be included in finalized OMP.

- **Evaluate length and time of year of closed season**

7.2. Inshore Sector Implementation Plans

Measure: Develop and implement a fishers education program

- *How*
  - Embark on community specific engagements (seven landings sites)
  - Leaders of association
  - Regional FC members

- *Schedule*
  - 3rd quarter – development of materials
  - 4th quarter – engagement and training

- *Communication Plan*
  - Community centers
  - Local radio
  - Community can/information centers
  - Posters, jingles
  - The chief fisherman
  - F2F- fisher to fisher

- *Monitoring/Assessment – target over 50% of fishers*
  - Attendance list for each engagement
  - Use FCs monitoring program
  - Small survey to assess the level of understanding on existing laws/regulations

- *Enforcement*
  - Every two years, education on key fishery laws/regulations
  - Program developed, and implemented
  - Sanction to be enforced

- *Administration*

  - FC lead
  - GIFA – developed materials, jointly

- *Financing*
  - FC, developing agencies
  - Refunded annually

<u>Measure: Conduct Gear Audit to prescribe gear restrictions</u>

- *Schedule*
  - Survey existing gears by October 2023 (completed for trawl vessels, but not canoes)
  - Engage stakeholders to validate the audit report in January 2024
  - Provide directive by the Ministry on the recommendations of the audit report by May 2024

- *Communication Plan*
  - Develop illustrations manuals on gear
  - Stakeholders engagement
  - Use posters, TV, and radio are forms of relaying information
  - Community information center

- *Monitoring/ Enforcement*
  - Chief fisherman
  - MOFAD & FC

- *Administration*
  - GFRA, MOFAD, FC

- *Challenges*
  - Push back (acceptance of the directive)
  - Political interferences

Additional Inshore sector management measures co-developed by stakeholders during workshops

Details to be included in finalized OMP.

- **Implement two-month closed season**

7.3. Trawl Sector Implementation Plans

<u>Measure: Implementation of Ministerial Gear Directive</u>

- *Schedule*
  - Ministerial directive has five components:
    - 60mm mesh size minimum,
    - Net opening diameter minimum,
    - 10-meter net opening elevation from sea floor minimum,
    - Etc.
  - Operational since 1 Sept, 2022

  - Need to official report of implementation since 1 Sept 2022 to present

- *Communication Plan*
  - Issue quarterly reports
  - Conduct quarterly stakeholder engagements

- *Monitoring/ Assessment*
  - Pre-departure inspection
  - At-sea inspections (not reliable, rely on observers reports)
  - Inspection at arrival/landings/nets/gears monitoring catch compositions
  - High incidence of juveniles (how will this inform the directive?)
  - Changing reporting format -- change to for species specific

- *Enforcement*
  - Inspectors to check fish
  - Pre-departure activity - gear
  - Port side monitoring of gear
  - On board observers (need more training! For quality information)
  - Implement Electronic Monitoring System

- *Administration*

- *Financing*
  - IGF, Industry partners

- *Challenges*
  - Allegations of discarding
  - Observers unable to report what is discarded - need requirements on what to report, and training on species identification methods
  - Variability in binning of size classes across the vessels

Measure: Develop and Implement Fishers Education Program, with Certification as Prerequisite for License

- *Schedule*
  - Before, during and after the closed season

- *Communication Plan*
  - Identification of stakeholders, regulators (FC, GMA, EPA, GHAPOHA), vessel operators, crew members, crew management, the various fisheries associations, unions, observers, academics, recruitment companies, NGOs

- *Monitoring/ Enforcement*
  - Inspection (of their certification) pre-departure, at-sea inspections, and inspection on arrival
  - Companies ought to ensure that crew members are complying, recruitment companies to ensure that crew members are certified/ qualified

- Administration

    - FC in collaboration with other institutions such as GMA, associations, unions, and CSOs, and in consultation with the Industry

- Challenges
- Financing
    - FC

Additional Trawl sector management measures co-developed by stakeholders during workshops

Details to be included in finalized OMP.

- **Enforce the existing IEZ border; discuss extending**
- **Implement effort limits (limits on number of vessels) based on assessment of economic value of the fishery**

7.4. Implementation Plans for Measures That Affect ALL SECTORS

Measure: Implement Three-Year Moratorium on New Entrants

- *How:*
    - Stakeholders are sensitized,
    - Enforcement is ongoing,
    - Validation of the canoe survey,
    - Validation of all the engagement done so far
- *Schedule/ Timing:*
    - Close of canoes registration by July 1, no new entrants after. FC takes stock of canoes.
    - July-mid, formalized end to new constructions,
    - 1st Aug, formal announcement.
- *Communication Plan:*
    - Posters, tv, radio
- *Monitoring/ Assessment:*
    - Chief fisher, landing beach enforcement, zonal officers to be doing the M/E.
- *Enforcement:*
    - Zonal officers, FC lead identifying/implementation infractions
- *Administration:*
    - Interagency form FC to relevance on the management measure
- *Challenges:*
    - Industry attitude to ban
- *Financing:*
    - FC/development funds, Annual funding – from FC/ development budgets

<u>Measure: Implement MPAs to protect spawners and juveniles</u>

- *How*
    - Identification of the area/ legal review
    - Start to engage with stakeholders on MPA information and knowledge
    - Conduct bioecological studies to identify nursery/spawning areas
    - Define the area to be designated with stakeholders
    - Designate the MPA
    - Implementation of the MPAs same across all three sectors
    - Stakeholder engagement and education – via SPCCs – national, regional, community
- *Schedule/ Timing*
    - Process; from 2022-2024 with yearly activities
    - Ongoing activities – already hired consultant for legal review
- *Communication Plan*
    - Awareness created across all levels – national regional, a community
    - National- validation of the MPA, results on the studies
    - Use information centers
    - Media, jingles/songs, print and electronic media
    - Validation of MPA
- *Monitoring/ Assessment*
    - M&E of FC ensures availability of inputs
    - Report of activities
- *Enforcement*
    - FC ensures management plan is developed, gazette, and being implemented
    - Reward co-management by SPCC
- *Administration*
    - FC leading with other agencies (EPA, LUSPA< CSIC, GFRA)
- *Financing*
    - FC, developing partnerships
    - CSO, continuous financing

SECTION VIII: ADAPTIVE MANAGEMENT SCHEDULES

The final component of the workshop process is the development of adaptive management schedules, which dictate which aspects of the management implementation plans should be revisited iteratively, and on what timeline this should happen. Adaptive management schedules ensure that all stakeholders are aligned and prepared for their roles and responsibilities over time, and that management decisions can be revised in response to new data in a timely way, without administrative delays.

8.1. Canoe Sector

- *Schedule for revisiting decisions*
    - Annual review of efficacy of measures: based on updated stock assessments
        - Ban on new entrants should still be in place.
    - 6-month review of implementation: look at the challenges of the implementation, assess how it is going and determine ways to improve efficacy.
- *What types of* ongoing *decisions, if any, will need to happen throughout the Operational Plan?*
    - What happens to canoes that are almost complete?
    - Review criteria for implementation.
- *What procedures ensure that managers can respond to common challenges?*
    - Develop replacement for FC.
    - FC, FMOC, SPCC – produce resources that guide collective decision making.
    - STC and FMOC will make recommendations for the consideration of the decision makers.
- *How will managers be able to adapt to issues with:*
    - Changes in fishermen's behavior/patterns
    - Changes in stock status
    - Climate change-driven changes in stock availability
    - Innovations and scientific improvements
    - Outdated regulations

8.2. Inshore Sector

- *Schedule for revisiting decisions*
    - Review – once a year, using monitoring and assessment to guide more frequent (emergency) situations à practicing adaptive management.
- *What types of ongoing decisions, if any, will need to happen throughout the Operational Plan?*
    - Quarterly review to check on the status of the compliance and enforcement.
- *What procedures ensure that managers can respond to common challenges?*
    - FC and IT technical divisions and units respond to specific issues, for example the need for MCS to respond quickly to an issue.
- *How will managers be able to adapt to issues with:*

- Changes in fishermen's behavior/patterns
  - Stakeholder engagements, work with stakeholders
- Changes in stock status/ Outdated regulations
  - Continuous monitoring, review reference points – annually
  - Alternative livelihoods, diversify options for the community
- Climate change-driven changes in stock availability
- Innovations and scientific improvements

8.3. Trawler Sector

- *Schedule for revisiting decisions*
  - Quarterly reports on efficacy – Ministry directive
  - Quarterly review on the state of the implementation
- *What types of ongoing decisions, if any, will need to happen throughout the Operational Plan?*
  - What was the need for the directive, did it work? Will be a need to deploy monitoring and enforcement.
  - If it did change, monitor to assess what is influencing the change.
- *What procedures ensure that managers can respond to common challenges?*
  - Feedback from the industry
  - Inspection report
  - FC acts on MCS report
  - Develop a standing committee between FC and the industry to address challenges
- *How will managers be able to adapt to issues with:*
  - Changes in fishermen's behavior/patterns
    - Continue engagements, increase fisher awareness.
  - Changes in stock status
    - Continuous assessments to know the status of the fishery.
  - Climate change
    - Reduced fishery pressure if climate change is having an impact.
  - Innovations and scientific improvements
    - Implement new technology.
  - Outdated regulations
    - Respond to the issue, immediately.

ANNEXES

ANNEX I: FISHERY CHARACTERISTICS

Biological Overview of Stocks

- **Round sardinella** (*Sardinella aurita*)
  - Range: Atlantic Ocean: West African coast from Gibraltar southward to Saldanha Bay in South Africa, especially in the three West African upwelling areas, from Mauritania to Guinea, from Côte d'Ivoire to Ghana and from Gabon to Angola. Also, in Mediterranean Sea and Black Sea. In western Atlantic Ocean from Cape Cod in USA to Argentina, including Bahamas, Antilles, Gulf of Mexico and the Caribbean coast.
  - Biology: A coastal, pelagic, species preferring clear saline waters, usually with maximum temperatures below 24°C. Found inshore and near surface to edge of shelf and down to 350m, or perhaps even deeper; schooling and strongly migratory, often rising to surface at night and dispersing. It is a cold-water species, temperatures between 18-25°C, approaching the coast and shoaling near the surface in the period of upwelling, but retreating below the thermocline in the hot season, down to depths of 200 to 300m. It feeds mainly on zooplankton, especially copepods and larvae of mysids, but also some phytoplankton, especially by juveniles. It breeds perhaps at all times of the year, but with distinct peaks; the breeding pattern is extremely complex, with two principal spawning periods in some areas. There is no spawning in Black Sea. The juveniles tend to stay in nursery areas, but on maturity rejoin adult stocks in the colder offshore waters.
  - Length, size, age, weight: Lm 18.8, range 13 - 25 cm. Max length: 41.0 cm TL male/unsexed; common length: 25.0 cm SL male/unsexed; max. published weight: 420.00 g; max. reported age: 7 years.

- **Flat sardinella** *(S. maderensis)*
  - Range: Atlantic Ocean: southern and eastern parts of Mediterranean Sea, also penetrating the Suez Canal, and eastern Atlantic Ocean, from Gibraltar southward to Angola and a single recorded specimen from Walvis Bay in Namibia.
  - Biology: A coastal, pelagic species, but tolerant of low salinities; sometimes in estuaries and lagoons. It forms schools, preferring waters of 24°C, at surface or at bottom down to 50m, strongly migratory. It feeds on a variety of small planktonic invertebrates, also fish larvae and phytoplankton. It breeds only once in the year, during the warm season between July and September, in coastal waters; juveniles and adults show clear north-south migrations in the Gabon-Congo-Angola sector and the Sierra Leone-Mauritania sector of the Atlantic Ocean, each area having nurseries; these movements are correlated with the seasonal upwelling. It is of considerable importance off West African coasts, but combined with *Sardinella aurita* in most statistics, partly because both species are often caught together.
  - Length, size, age, weight: Maturity: Lm 13.4, range 11 - 19.5 cm. Max length : 30.0 cm SL male/unsexed; common length: 25.0 cm SL male/unsexed; max. published weight: 927.00 g.

- **European anchovy** *(Engraulis encrasicolus)*
  - Range: Eastern Atlantic: Bergen, Norway to East London, South Africa (perhaps reaching Durban). Also, all of Mediterranean, Black and Azov seas, with stray individuals in Suez Canal and Gulf of Suez; also recorded from St. Helena. Reported from Estonia.
  - Biology: Mainly oceanic, marine species, forming large schools. Tolerates salinities of 5-41 ppt and in some areas, enters lagoons, estuaries and lakes, especially during spawning. Tends to move further north and into surface waters in summer, retreating and descending in winter. Feeds on planktonic organisms. Spawns from April to November with peaks usually in the warmest months. Eggs are ellipsoidal to oval, floating in the upper 50 m and hatching in 24-65 hours. Marketed fresh, dried, smoked, canned and frozen; made into fish meal.
  - Length, size, age, weight: Maturity: Lm 10.1, range 9 - 14 cm
  - Max length : 20.0 cm SL male/unsexed; common length : 13.5 cm SL male/unsexed; max. published weight: 0.00 g; max. reported age: 5 years.

- **Atlantic chub mackerel** *(Scomber colias)*
  - Range: Atlantic Ocean. Warm water; eastern and western coasts, including the Mediterranean and southern Black Sea. Replaced by *Scomber japonicus* in the Indo-Pacific.
  - Biology: Adults and juveniles feed mainly on zooplankton, with relative importance of larger organisms such as cephalopods, crustaceans and small pelagic fish increases with the size of individuals. Caught mostly in purse seine and pelagic trawl fisheries which target sardine and/or anchovy. Usually a by-catch but when availability of target species is low, this species provided an alternative income .
  - Length, size, age, weight: Maturity: Lm 21.3cm range ? - ? Cm. Max length: 55.0 cm TL male/unsexed;

Fishery Overview:

Table A 1.1: Fishery Participants:

Artisanal Fleet (FC, 2020)	Number of vessels: • Motorized – 12,848 • Non-motorized – 1,427 • Total – 14,275 The size of the canoes ranges from 3 meters to almost 20 meters Length Over All (LOA) and are made from "wawa" wood (*Triplochiton* spp.) (Dovlo et., al 2016).
Semi-industrial (Inshore) Fleet (FC, 2020)	Number of vessels: 224 The semi-industrial vessels are made of wooden hulls with inboard engines operate within the Inshore Exclusive Zone (IEZ) and beyond. They are of two types: (a) larger ones with LOA between 20 and 30 meters using primarily bottom trawls and (b) smaller vessels with LOA between 8 to 10 meters using small purse seines.
Industrial Trawl Fleet (FC, 2020)	Number of vessels: 76 This category of fleet are steel boats of up to 30m LOA.

Source: MFMP, 2021.

Table A 1.2: Fishery Characteristics:

Artisanal Fleet (FC, 2020)	Fishing gear: beach seines, encircling nets, hook and lines, drift gill nets etc. Target species: sardinellas anchovy and mackerels Annual catch: 170,149 mt
Semi-industrial (Inshore) Fleet (FC, 2020)	Fishing gears: Purse seine and trawl Target species: sardinellas and mackerels Annual catch: 11,353mt
Industrial Trawl Fleet (FC, 2020)	Fishing gears: bottom trawl Target species: sparids, grouper, cassava croackers, grunts, cuttlefish and snappers Annual catch: 37,507mt

Source: MFMP, 2021.

Current Management Challenges:

Table A 1.3: Key Issues Related to the Fishery (MFMP, 2021)

Key Issues	Description of problem
Excessive fishing effort exerted in all fisheries	Excessive fishing capacity - too many vessels exploiting the current exerted in all fisheries resources, especially in the trawl sector - requires effort reduction to more sustainable levels. The exact extent of overcapacity translates into levels of fishing effort above MSY level of effort representing both economic and biological overfishing. Urgent reduction of fishing effort by management action is required.
Inadequate information on biology of the stocks and current biomass levels	Inadequate scientific information on the biology and current biomass on biology of the stocks and current biomass levels of the main commercial species making it difficult to align stocks with current effort. Available information suggests both the small pelagic and demersal fish stocks are overexploited and require rebuilding strategies.
Weak enforcement of fisheries Laws and regulations	There is weak enforcement of the fisheries laws and regulations due to inadequate resources (both human and financial) and inadequate conflict resolution mechanisms. More strategic use of existing resources in support of new conservation actions since 2013 are being applied.
Inadequate information and regulations on gears	In the past decades, there has not been a consistent inventory of fishing gears in the marine sector leading to infiltration and evolution of destructive fishing gears. Additionally, gear regulations have been on mesh sizes without cognizant to other gear characteristics such as size, construction materials, head rope, wings, panels, hanging ratio etc. In this regard there is a need for an inventory of the gears within the sector and a subsequent development of the gear regulations.
Low levels of Protection of Marine Habitat, Biodiversity and Mitigation of Climate Change	There is inadequate protection of specific marine ecosystems impacting adversely on recruitment patterns of most fish species. Better protection of sensitive ecosystems is required to ensure replenishment of biomass, particularly of coastal areas which are known nursery grounds of various commercial species. Closure of known spawning and nursery areas is required.
Weak socio-economic wellbeing of actors within the	Over exploitation and decline in fish stocks and landings as well as post-harvest losses have contributed to decrease in revenue, income, and nutrition, thereby

fisheries value chain	impacting negatively on the livelihoods of actors within fisheries value chain.

Source: MFMP, 2021.

- **Fisheries Challenges from Lazar et al. 2020:**
  "Landings being taken by trawlers via illegal fishing and transshipment (called "saiko") of catch consists of a high proportion of juveniles (EJF and Hen Mpoano, 2019) (Lazar et al., 2020).

Use of scientific information to inform decision making:

The updated 2022-2026 MFMP represents a significant leap forward in terms of commitment to using science to inform management decision-making. The document lays out a framework for using science-based performance indicators and reference points and relies on regularly collected data from both Ghanaian and international research teams.

The primary source of scientific data used to conduct stock assessments are the Fridtjof Nansen Pelagic Surveys:

Table A 1.4: Results of Fridtjof Nansen Pelagic Survey for 2016, 2017 and 2019

Year	*PEL 1(mt) Anchovy*	*PEL 1(mt) Sardinellas*	*PEL 2 (mt) carangids, scombrids, barracudas & hairtail*	*Total (mt)*
2016	25,000	500	107,000	132,500
2017	56,990	4,000	28,000	88,990
2019	18,372	7,398	41,783	67,553
Total	100,362	11,898	176,783	

(MFMP, 2021)

Stakeholder consultation: Mechanisms in place for consultation with stakeholders

Stakeholder consultation and engagement is another key goal of the 2022-2026 MFMP. To this end, the FMOC was established comprising MoFAD, FC Board, FC, MOF, FEU, Development Partners, GMA, EPA, NAFAG, Academia and CSO/NGOs.

ANNEX II: HOLISTIC MANAGEMENT GOALS, COLLABORATIVELY DEVELOPED AT WORKSHOP 1

Table A 2.1: Collaboratively Developed Management Goals[5]

Timeline	Biological/ Ecological Goals	Economic Goals	Social/ Cultural Goals	Food Security Goals	Governance Goals
Short-Term Goals (Within 1st year of Operational Plan)	Improve data collection and enhance knowledge of the biology. (22)	Improve socio-economic wellbeing of fishers within the value chain. (9)	Improved *prosecution* of fisheries infractions. (9)	Establish levels of fish stocks necessary to support local food security. (6)	Implement the moratorium on new entrants. (11)
	Reliable database established. (4)				Enforce fisheries legislation more adequately. (9)
	Reduce effort. (4)				
	Prevent catch of juvenile fish. (8)				
Medium-Term Goals (By 2026)	Align fishing effort with estimated annual sustainable levels. (22)	Improve socio-economic wellbeing of fishers within the value chain. (9)	Enforce fisheries legislation more adequately *(to reduce IUU fishing*). (29)		Enforce fisheries legislation more adequately *(to reduce IUU fishing*). (29)
	Enhance knowledge on fishing gear and develop gear regulations. (4)				
	Create awareness of need to protect marine habitat, biodiversity and mitigate impacts of				

[5] Numbers in brackets represent the number of participant votes allocated to that goal, such that higher numbers indicate higher priorities)

	climate variability and change. (0)				
	Bring fishery harvests in line with maximum sustainable yield to support sustainable biomass in the water. (12)				
Long-Term Goals (By 2050)	Protect marine habitat, biodiversity and mitigate impacts of climate variability and change	Improved revenue from fish/ fisheries.	Compliance with sustainability regulations.	People eating more fish to reduce their carbon footprint.	Effective MPA network(s).
	Sustainable levels of biomass in the water to support fishery and ecosystem functioning, climate resilience and food security.				Effective spatial planning for beaches and marine areas to preserve local/ fishery access.

ANNEX III: AVAILABLE DATA

- R/V Fridtjof Nansen pelagic surveys, conducted a series of acoustic surveys in Ghana's EEZ and provided relative estimates of biomass of small pelagics in 1990, 1999, 2000, 2002, 2004, 2005, 2006, 2007 and 2016. (Lazar et al., 2020).
- "Biological studies for small pelagic was carried out before and after the May-June 2019 closed season with the conclusion that the May 15 to June 15, 2019 timing for the closed season did not coincide with the peak spawning season" (MFMP, 2021.)
- "The data for landings (1990-2019) by species and fishing sector (artisanal, semi-industrial and industrial) were provided by FC/FSSD." (Lazar et al., 2020).
- "Fishing effort in number of purse seine canoes (1990-2019) targeting small pelagics were provided by the Marine Fisheries Resources Division of the Fisheries Commission." (Lazar et al., 2020).

<u>Research Surveys</u>
In 2016, 2017, and 2019, a survey of marine fisheries resources of Ghana was conducted by R/V Fridtjof Nansen to estimate the total biomass (see table below).

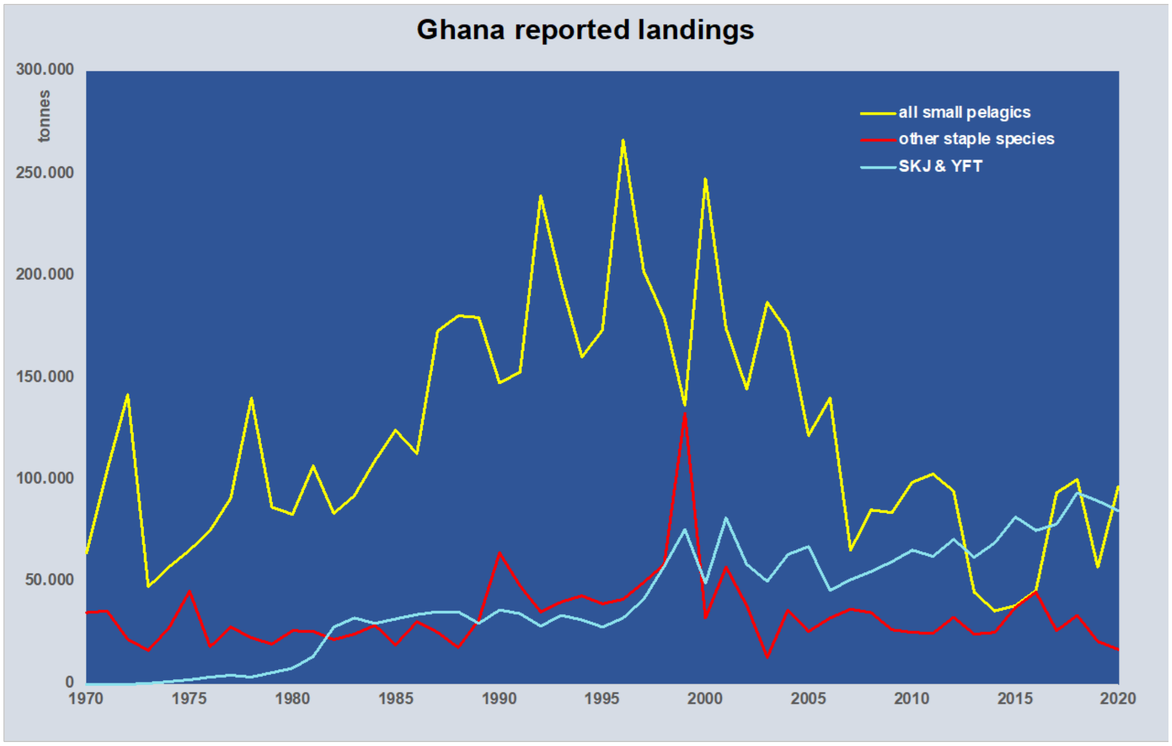
Table A3.1: Results of Fridtjof Nansen Pelagic Survey for 2016, 2017 and 2019

Year	*PEL 1(mt) Anchovy*	*PEL 1(mt) Sardinellas*	*PEL 2 (mt) carangids, scombrids, barracudas & hairtail*	*Total (mt)*
2016	25,000	500	107,000	132,500
2017	56,990	4,000	28,000	88,990
2019	18,372	7,398	41,783	67,553
Total	100,362	11,898	176,783	

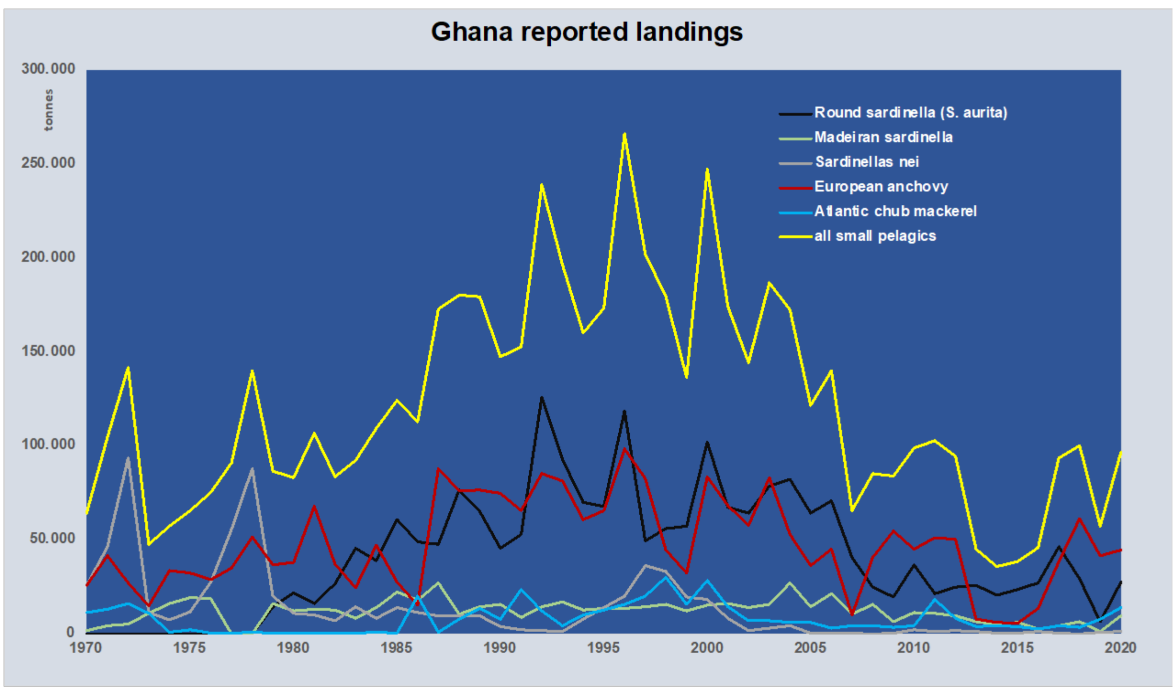
Source: MFMP, 2021.

The MFMP (2021) notes that "From the table above the total biomass of anchovy for the three surveys far exceeded that of the sardinellas. The biomass of the anchovy constituted about half that of the carangids, scombrids, barracudas and hairtail (PEL 2). The total biomass of PEL 1 and PEL 2 however remained stable over the four-year period. The results of these analyses however should be interpreted with caution as the 2016 survey was conducted in a thermocline season whilst the 2017 and 2019 were conducted during the major upwelling season."

Landings:



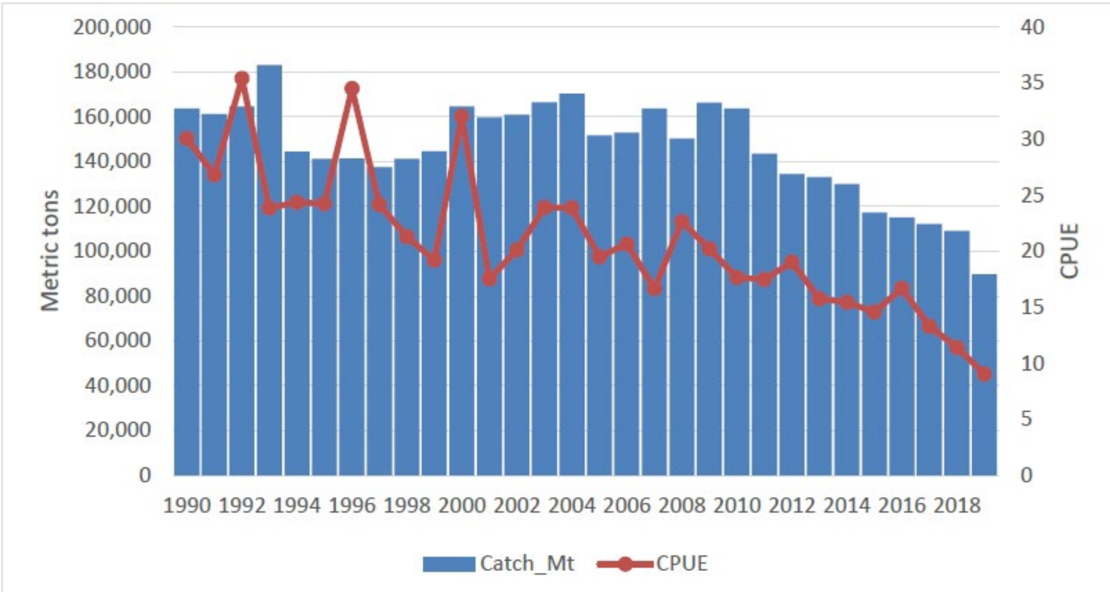
Data: FAO, ITC, 2022



Data: FAO, ITC, 2022

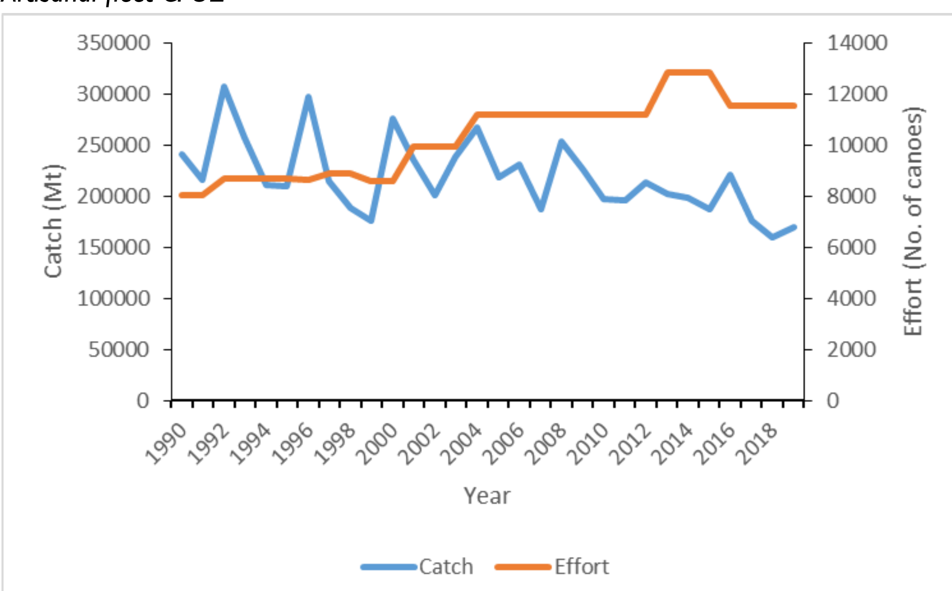
CPUE:

Landings and CPUE of Small Pelagic in Ghana from 1990-2019



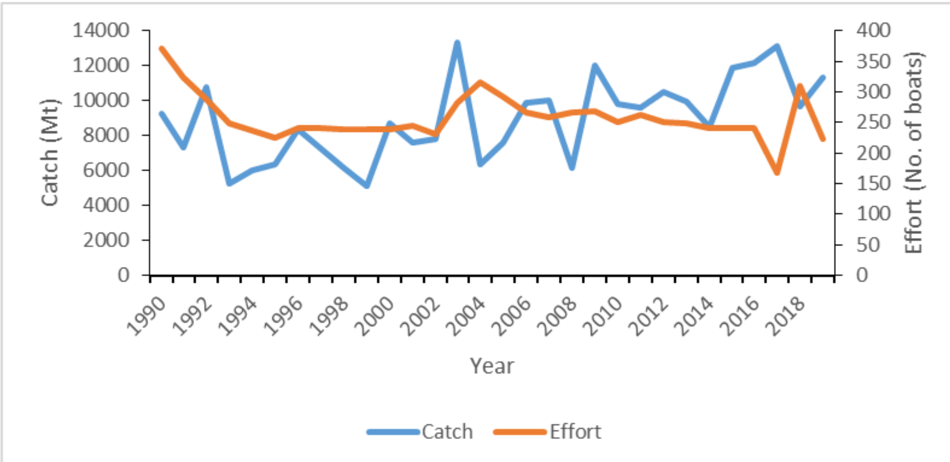
Source: Lazar et al., 2020.

Artisanal fleet CPUE



Source: MFMP, 2021.

Inshore fleet CPUE



Source: MFMP, 2021.

Biomass:

Hydroacoustic Estimates of Relative Biomass of Sardinella in Ghana (1990-2018) from EAF-Nansen Program, R/V Fridjoft Nansen

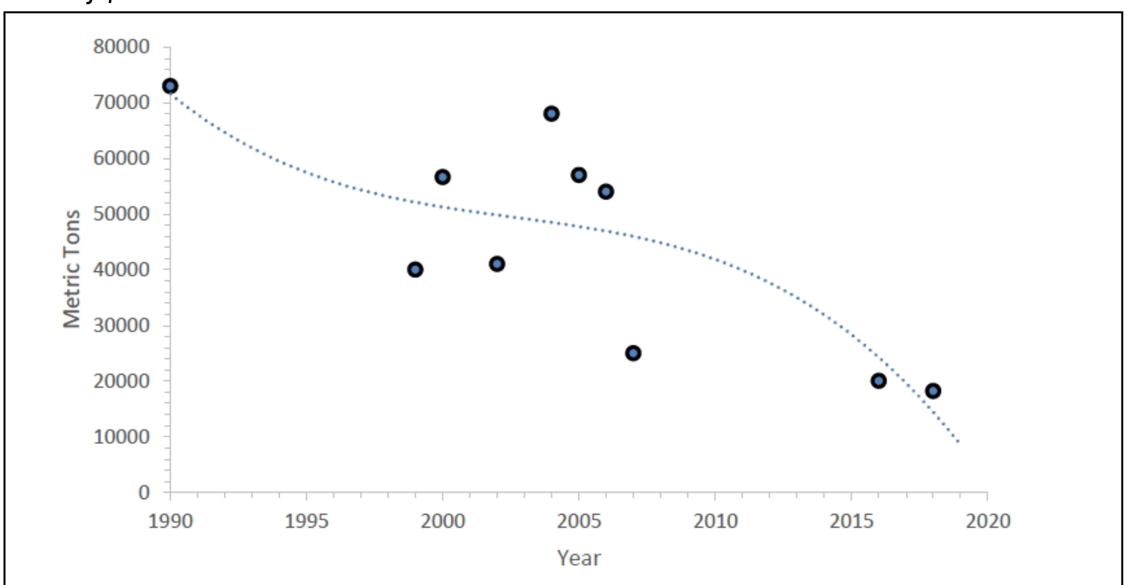
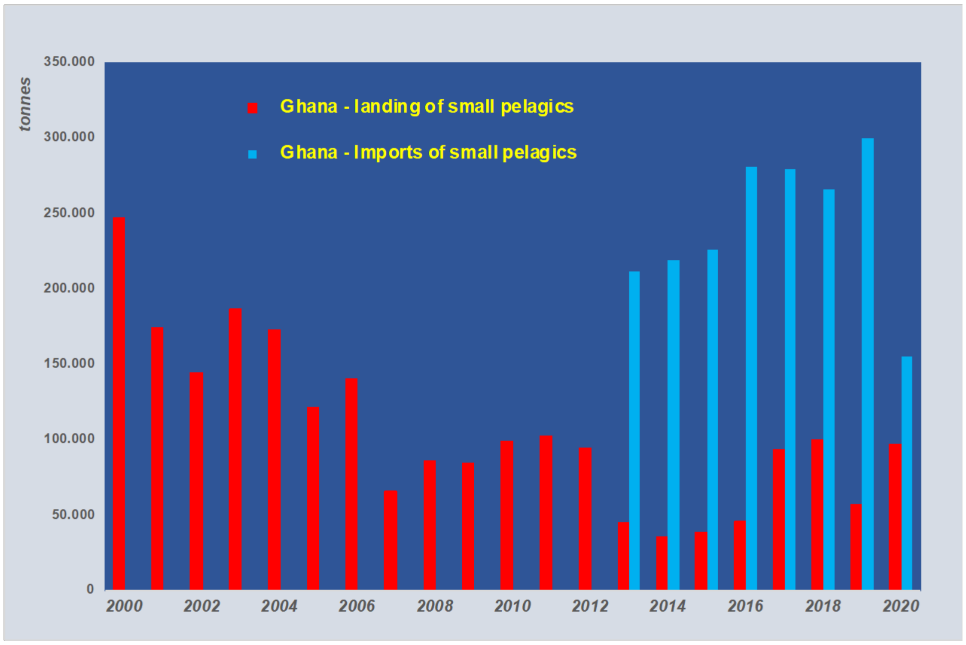


Figure 4 Hydroacoustic estimates of relative biomass of sardinella in Ghana (1990-2018)

Source: Lazar et al., 2020.

Imports:


tonnes
350.000
300.000
250.000
200.000
150.000
100.000
50.000
0
Ghana - landing of small pelagics
Ghana - Imports of small pelagics
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020

ANNEX IV: DETAILES OF STOCK ASSESSMENTS APPLIED

Two sets of stock assessments were conducted this year on data from 2022 and 2023: 1) with support from NORAD, surplus production models were applied to landings data to generate estimates of current yield in comparison with Maximum Sustainable Yield (MSY) as well as current fishing rates (F) for two of the species in comparison with F at MSY, and 2) with support from EDF, length-based models were applied to limited length frequency data to generate additional estimates of F for each species in comparison with F at MSY as well as estimates of the percentage of the catch of each species that is comprised of juvenile individuals. These latter assessments were conducted during a virtual capacity-building workshop with members of the FSSD, as well as members of the NORAD team to ensure maximum coordination. This virtual stock assessment workshop was held on June 21st, 2023, and results of these assessments were presented to the larger group of participants during the workshop the following week.

On surplus production methods:
Surplus production method estimates stock biomass and fishing mortality using data on total catch, effort, and any available indices of relative abundance without the inclusion of stock age or length structure. This model does not reflect any age structure in a population, and the dynamics of natural mortality, growth, and recruitment are aggregated into a single intrinsic rate of population biomass increase, modified by fishing mortality. Estimated biomass and fishing mortality can be examined relative to reference points to determine stock status. Assumptions behind these methods is that total catch is known without error, the stock is undifferentiated (no age, size, or gender differences), catch and/or index is linearly related to the stock abundance, and the entire population covered by catch and index. Recommended application of this model include fishing mortality is adjusted through harvest control methods (e.g. catch limits, seasons, or spatial closures) based on how far apart these values are from reference points. Surplus production models produce relative estimates of MSY and F_{MSY}, reliable estimates of q (the parameter that scales abundance indices into biomass estimates) and are scaled to steepness of the recruitment curve increase the certainty.

On length-based methods:
Length-based data and methods have been widely applied to estimate reference points and to understand stock status in fisheries around the world. Using either fishery dependent or independent length-frequency data, these assessments can add value to understanding and interpreting the outputs of production models and increase certainty in management decisions through the estimation of fishing mortality (F), growth/recruitment overfishing, and spawning potential of the stock. Several length-based methods have been developed and widely used to serve those fisheries where only length data are available, or in addition to catch-only models. These include length-based indicators (LBI; Froese 2004), length-based spawning potential ratio (LBSPR; Hordyk et al. 2015a) and length-based fishing mortality estimators (catch-curve, Thorson and Prager 2011; mean-length /LBAR, Ault et al. 2005). The LBI method is used to screen catch/landings-length composition and to classify the stocks according to conservation, yield optimization and MSY considerations (to assess both recruitment and growth overfishing, ICES 2018). The LBSPR/YPR method assesses the stock status by the spawning potential ratio defined as the proportion of spawning biomass per recruit (SBPR) and yield per recruit (YPR) in an

exploited stock compared to SBPR in an unfished stock (Hordyk et al. 2015b, 2016; Prince et al. 2015). Fishing reduces the size structure of a population, therefore, mean length of the exploited part of the population (catch-curve/LBAR) reflects the rate of fishing mortality (F).

The results of length-based methods are generally compared to international standards for SPR, F_{MSY}, and B_{MSY} to determine current stock health and fishery performance. All of these methods utilize the biology of the targets and observations of what is coming out of the water (e.g., length-frequency data) to understand better how the fishery is impacting a stock.

The purpose of applying these assessments was to gain clarity and reach consensus on where the fishery is with relation to shared goals. Group consensus was developed for the small-pelagic fishery, and for each of the species in the fishery. Several data streams were used to monitor the status of the fishery, including fishery dependent data:

- Vessel Registry System; Inspection reports; Logbooks: used to monitor the goal of aligning fishing effort with estimated annual sustainable levels.
- Landings and effort data: used to monitor if the fishery harvests are in line with maximum sustainable yield.
- Scientific monitoring of the length frequency of catch in the canoe fishery: used to monitor both if the fishery harvests are in line with maximum sustainable yield and if the fishery is catching juvenile fish.

Based on these data sources, the status of each goal was assessed for each sector; Canoes, Inshore, and Trawler. Where data allowed, goals were assessed on a species-specific basis as well.

Yield by sector and fishing rate (F) for round and flat Sardinella were assessed through application of the surplus production model (Schaefer), while the length-based assessments (Catch Curve, LBAR, SBPR, and Froese) generated estimates for the fishing rate (F) for all 4 target species as well as an assessment of the percentage of the catch made up of juvenile individuals.

ANNEX V: COMPRENSIVE ASSESSMENT OF RISK TO ECOSYSTEMS (CARE), AS APPLIED AT WORKSHOP 2

Comprehensive Assessment of Risk to Ecosystems (CARE)

The Comprehensive Assessment of Risk to Ecosystems (CARE) model provides a rapid yet comprehensive ecosystem risk assessment tool, including an explicit climate vulnerability assessment component. The CARE tool facilitates the comprehensive, participatory evaluation of every threat facing any type of system or species, both now and in a climate-impacted future time period.

This tool allows for: 1) for semi-quantitative evaluation and comparison of climate change impacts along with all other system threats, including fishing and non-fishing anthropogenic threats as well as non-anthropogenic threats, both now and in a pre-selected future time period[6]; 2) assessing the interaction (synergistic or antagonistic) of multiple threats with each other (other tools do not factor in synergistic effects)*; 3) allowing for evaluation of any ecosystem and/or species type with the same tool; 4) expanding the analysis of "ecosystem functioning" through a more comprehensive suite of attributes that quantify intrinsic system recovery potential (i.e. "regeneration time" and "connectivity") and resistance to impact (i.e. "removability of system components" and "functional redundancy and diversity"); 5) facilitating participatory decision-making through interactive scoring, using scoring guidance designed to allow for accuracy without necessitating precision; and 6) allowing for rapid risk analysis that can be completed in the field, in under two hours, using expert knowledge where data is lacking.

Process

A multi-stakeholder application of CARE for the Ghanaian small pelagic fishery assessed the impacts of climate change, legal artisanal fishing, illegal artisanal fishing, and pollution on each of the small -pelagic targets: Round sardinella (*Sardinella aurita*), Flat sardinella (*Sardinella maderensis*), Anchovy (*Engraulis encrasicolus*), Atlantic chub mackerel (*Scomber colias*) and the nearshore mangrove ecosystem that the artisanal fishery operates in. This analysis was completed in three phases:

1. First, EDF staff consulted available literature to gather data sufficient to assign scores within CARE for 1) expected climate impacts over the next 50 years; 2) intrinsic ecosystem resilience (ability to resist and recover from change); and 3) intrinsic resilience of each of the four target species.
2. Next, the scores gathered through this literature review, as well as any attributes for which data could not be found in the literature, were discussed with a small group of local experts in the days leading up to the final day of the workshop. Through this process, scores from the literature were either validated or amended, and blanks were filled in with local knowledge.
3. Finally, all participants of the workshop were consulted on key items determining ecosystem and species resilience, as well as additional attributes describing 1) the scale, frequency, and intensity of each of the primary "threats of interest" (legal artisanal fishing, illegal artisanal fishing, and

[6] Note that we have not yet applied asterisked components of the CARE tool in this fishery: examination of current threats as they may be impacted by climate change, and evaluation of interactions of threats with each other. These components of the assessment can be completed after the workshop with stakeholder participation if desired.

pollution, as selected by workshop participants[7]), and 2) the likely effects of climate change on each of these threats during the final day of this workshop. Through this process, we further validated the resilience scores, participatorily selected the suite of "threats" to assess, and collaboratively assessed the relative risk posed by each of these threats to the ecosystem and four target species, both now and in a climate changed future.

Results

Climate Impacts:
Overall, climate change is expected to have a **major impact** on the Ghanaian coastal ecosystem and the small pelagic fisheries therein over the coming 50 years.

The most significant climate change impacts expected for the marine ecosystems in this region include:

- **Temperature increasing** – both the air and the sea surface temperatures are projected to increase significantly in Ghana.
- **Precipitation changes** - rainfall will generally **increase** and may also become more **erratic**.
- **Sea level rise** in Ghana may be well above global average.
- An increase in **wave action and coastal erosion** will continue.
- The **frequency** and **intensity** of major storms may also increase.
- **Ocean acidification** – local data is limited; but available evidence and local knowledge suggest that acidity will increase significantly.
- **Upwelling patterns** and **intensity** will be impacted, but *direction of impact is unclear*
- Major area **currents are** showing signs of **slowing**.
- **Harmful algal blooms** are already increasing.

Climate vulnerability:
Vulnerability to climate change is calculated as the expected *Impact* of the climate-driven changes multiplied by the system's or species' ability to respond to (i.e., resist and/or recover from) impact.

Vulnerability = Impact x Response
The nearshore mangrove ecosystem off the coast of Ghana is predicted to have **moderate** vulnerability to the impacts of climate change over the coming 50 years, with the system's *high biological productivity*, *high species richness*, and *complex, diverse community structure* contributing to its ability to respond to impacts, while its current *unhealthy system status* and *highly modified food web and community structure* are driving the system's resilience down.

This can be seen as a positive result, as the features reducing system resilience are within the control of stakeholders (rather than being intrinsic system characteristics). In other words, **if system and species community health can be restored (e.g., reduction of pollution, restoration of mangroves, ending overfishing) the overall resilience of the system will be increased, and thus the severity of the impacts of climate change can be reduced.**

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[7] Participants also voiced a desire to apply this process to a 4th threat: that of coastal development, which process we would be happy to support.

Of the four small pelagic species, three are also scored as having **moderate** vulnerability to climate change (with round sardinella having the highest vulnerability), and one – the anchovy – scored as having **low** vulnerability. These scores are largely driven by these species' intrinsic life history characteristics, e.g., growth/ mortality rates, reproduction rates, and abilities to tolerate increased temperatures and acidification. However, the current health and status of these four stocks also drive their ability to resist and recover from negative impacts – the round sardinella and the mackerel were both scored as having low current health/ abundance, while the flat sardinella was scored with moderate current health/abundance, and the anchovy was scored as having high abundance/ health.

Also of note is the differential *sensitivity* of these four species to changes in water temperature and pH (acidity). The round sardinella scored *very high* sensitivity to these changes, the mackerel scored *high*, and the flat sardinella and anchovy both scored *low*. These features indicate whether or not the given species is likely to move out of the area to track its preferred temperature ranges, or whether acidification will reduce its productivity.

Table A 5.1: Climate Impact and Vulnerability Results

Anticipated Climate Impact Score (max score = 10)	Qualitative Anticipated Climate Impact Score	Climate Impact Uncertainty	Risk of increase in average sea surface temperature (likelihood x magnitude of change)	Risk of decrease in average pH (likelihood x magnitude of change)
6.94	Major	Low Certainty	Extreme	Extreme

Mangroves with Upwelling Ecosystem Climate Results

Climate Vunlerability Score (Impact x Response) (max score = 100)	Qualitative Climate Vulnerability Score	Species Community Sensitivity to Climate-driven changes in Temp and/or pH	Risk of species community range shifts to track prefered water temps	Risk of species community productivity declining
38.35	Moderate	Very High	Most species' ranges likely to move poleward and/or deeper due to changes in average water temperature	Some species' productivity likely to decline due to impacts of acidification; some may move to track their optimal pH levels and productivity may be limited by ability to find suitable habitat and/or prey

Round sardinella (Sardinella aurita) Climate Results

Climate Vunlerability Score (Impact x Response) (max score = 100)	Qualitative Climate Vulnerability Score	Species Sensitivity to Climate-driven changes in Temp and/or pH	Risk of species range shifts to track prefered water temps	Risk of species productivity declining
29.48	Moderate	Very High	Species' range likely to move poleward and/or deeper due to changes in average water temperature	Species' productivity likely to decline due to impacts of acidification and/or lack of suitable prey

Flat sardinella (Sardinella maderensis) Climate Results

Climate Vunlerability Score (Impact x Response) (max score = 100)	Qualitative Climate Vulnerability Score	Species Sensitivity to Climate-driven changes in Temp and/or pH	Risk of species range shifts to track prefered water temps	Risk of species productivity declining
24.57	Moderate	Low	Species' range likely to remain unchanged despite changes to average water temperature	Species' productivity likely to decline due to impacts of acidification; may try to move to track optimal pH levels but productivity may be limited by ability to find suitable prey

Anchovey (Engraulis encrasicolus) Climate Results

Climate Vunlerability Score (Impact x Response) (max score = 100)	Qualitative Climate Vulnerability Score	Species Sensitivity to Climate-driven changes in Temp and/or pH	Risk of species range shifts to track prefered water temps	Risk of species productivity declining
18.89	Low	Low	Species' range likely to remain unchanged despite changes to average water temperature	Species' productivity may decline due to impacts of acidification, and productivity likely to be constrained by ability to find suitable habitat and/or prey

Atlantic chub mackerel (Scomber colias) Climate Results

Climate Vunlerability Score (Impact x Response) (max score = 100)	Qualitative Climate Vulnerability Score	Species Sensitivity to Climate-driven changes in Temp and/or pH	Risk of species range shifts to track prefered water temps	Risk of species productivity declining
23.13	Moderate	High	Species' range may move poleward and/or deeper due to changes in average water temperature	Species may move to track optimal pH levels; productivity not likely to be limited by habitat or prey constraints

Impact of Current Threats on the Ecosystem and Species

The CARE tool also allows users to generate relative "risk" scores for any *current* system threats that they would like to assess. Participants in this workshop selected 1) legal artisanal fishing, 2) illegal artisanal fishing, and 3) pollution as the threats to assess with CARE, although they voiced a desire to also examine coastal development. EDF is happy to support this additional analysis if desired.

A relative risk score can be thought of as *sort of* a proxy for ecosystem or species health in that it tells us how much pressure the system or species is currently under. However, if possible, we recommend more direct measures of ecosystem and species health also be taken – e.g., biological biomass abundance surveys and stock status assessments, respectively.

Risk from each threat is calculated as the current *Exposure*[8] to impact from the threat multiplied by the system's or species' ability to respond to impact. The same Response scores are used for this component of CARE as were used for the climate vulnerability analysis.

Risk = Exposure x Response

As discussed above, the nearshore mangrove ecosystem has a **moderate** ability to Respond to impact, as does the round sardinella, while the flat sardinella, anchovy and mackerel all have **high/ strong** abilities to Respond (higher numbers are *always worse* in the CARE analysis). This means that these latter three species have greater intrinsic resilience than do the round sardinella or the ecosystem as a whole.

When comparing the three threats examined in this workshop, pollution and illegal artisanal fishing activity have the **highest possible** Exposure scores across all four species. Pollution also has this extreme Exposure score with respect to the ecosystem, while illegal artisanal fishing activity is scored just slightly lower, but still **very high** for the ecosystem. Legal artisanal fishing was given a **moderate** Exposure score across all five analyses. Together, these Response and Exposure scores generate the suite of relative risk scores shown below. In general, **illegal artisanal fishing and pollution come out as the most critical risks** to both the ecosystem and the four small pelagic species – these threats require immediate action to reduce and remediate their impacts. The **legal artisanal fishery is presenting a medium level of risk to the ecosystem and the round sardinella, and low risk to the other three species**.

These results indicate that **if all illegal fishing activity could be removed, and the pollution problems addressed, the legal fishing activity should be relatively sustainable for this system and these species.** On the other hand, if not addressed, these two threats could significantly damage both the ecosystem and these target species, potentially undermining any efforts to implement sustainable fisheries management, and to preserve the livelihoods and food provisioning provided by these important fisheries.

[8] Note that Risk is different from Vulnerability because the *current Exposure* (i.e., what is actually happening to the system or species) is used as the measure of effect, rather than the *expected Impact*, which includes an evaluation of the *likelihood* that a certain change will actually take place.

Table A 5.2: Relative Risk Scores for Current Threats

Legal Artisanal Fishing	Response Score (max score = 10)	Exposure Score (max score = 10)	Risk Score (max = 100) (Exposure x Response)	Qualitative Risk Score
Mangroves with Upwelling	5.53	5.63	31.10	Medium
Round sardinella (Sardinella aurita)	4.25	5.63	23.91	Medium
Flat sardinella (Sardinella maderensis)	3.54	5.63	19.92	Low
Anchovey (Engraulis encrasicolus)	2.72	5.63	15.31	Low
Atlantic chub mackerel (Scomber colias)	3.33	5.63	18.75	Low
Total			108.99	

Illegal Artisanal Fishing	Response Score (max score = 10)	Exposure Score (max score = 10)	Adjusted Risk Score (max = 100) (Adjusted Exposure x Response)	Qualitative Risk Score
Mangroves with Upwelling	5.53	8.75	48.37	High
Round sardinella (Sardinella aurita)	4.25	10.00	42.50	High
Flat sardinella (Sardinella maderensis)	3.54	10.00	35.42	Medium
Anchovey (Engraulis encrasicolus)	2.72	10.00	27.22	Medium
Atlantic chub mackerel (Scomber colias)	3.33	10.00	33.33	Medium
Total			186.84	

Pollution	Response Score (max score = 10)	Exposure Score (max score = 10)	Adjusted Risk Score (max = 100) (Adjusted Exposure x Response)	Qualitative Risk Score
Mangroves with Upwelling	5.53	10.00	55.28	High
Round sardinella (Sardinella aurita)	4.25	10.00	42.50	High
Flat sardinella (Sardinella maderensis)	3.54	10.00	35.42	Medium
Anchovey (Engraulis encrasicolus)	2.72	10.00	27.22	Medium
Atlantic chub mackerel (Scomber colias)	3.33	10.00	33.33	Medium
Total			193.75	

ANNEX VI: COMPREHENSIVE LIST OF MANAGEMENT MEASURES SUGGESTED AT WORKSHOP 3

Organized by 1) Sector, and 2) Biological Goals for the Fishery. Items in bold were prioritized by participants at Workshop 3 for action this year.

Canoe sector

To reduce the number of fish coming out of the water, and the overall fishing rate (F):

- Add an additional fishing holiday – 1 more day/ week
- Enforce existing fishing holidays
- **Evaluate the July closed season – determine if it is the right *length* and *time of year***
- **Implement the moratorium on new entrants for three years**
- Enforce existing gear restrictions
- Introduce sector-wide catch limits (fishery would close for this sector when limit reached)

To reduce the number of vessels fishing:

- Introduce licensing requirement for all canoes
- **Reclassify vessels currently operating in the canoe sector by size and capacity**

To reduce the number of juvenile fish coming out of the water:

- Ban gears that target juveniles – prescribe a specific mesh size limit
- **Identify at least 2 areas to be classified as MPAs designed to protect spawning/nursery areas**
- **Carry out gear audit and implement recommendations to protect juveniles (and also reduce the total number of fish caught)**
- Implement a size limit – limiting the number of fish caught below a certain size (limit on the whole sector, fishery would close for this sector when limit reached)

To prevent illegal fishing:

- Implement the landing beach enforcement committees (LBECs)
- Improve training of on-board observers and shore side monitors

Inshore sector

To reduce the number of fish coming out of the water:

- **Develop and implement a fisher education program, targeting >50% of the fishers, to increase compliance with regulations**
- **Implement the moratorium on new entrants for three years**
- Enforce existing gear restrictions
- Introduce new gears to protect most vulnerable/ overfished species
- Introduce sector-wide catch limits (fishery would close for this sector when limit reached)

*To reduce the fishing rate (F), or "pressure," **per vessel**:*

- Introduce individual vessel catch limits (each vessel can fish only until it has caught its limit)

- Implement effort limits (limits on number of vessels) based on assessment of economic value

To reduce the number of juvenile fish coming out of the water:

- **Conduct a gear audit in order to prescribe gear restrictions on mesh size/ monofilament nets**
- Implement the 2-month closed season (targeting juvenile and spawning periods)
- Implement the MPAs designed to protect spawning/nursery areas

Trawl sector

To reduce the number of fish coming out of the water:

- **Enforce the existing IEZ border; discuss extending the border**
- **Implement the moratorium on new entrants for three years**
- **Develop and implement a fisher education program with certification that can be criteria for licensing**
- Enforce existing gear restrictions (net opening 10 meters above sea floor)
- Introduce new gears to improve selectivity of the fishery and protect most vulnerable/ overfished species
- Restrict unlicensed vessels from fishing
- Restrict the number of vessels and individual can own
- Redirect trawl fishing effort toward more abundant species
- Introduce sector-wide catch limits (fishery would close for this sector when limit reached)
- Enforce at-sea inspections and monitoring of discards (including during trans-shipment)

To reduce the fishing rate (F), or "pressure," ***per vessel****:*

- Introduce individual vessel catch limits (each vessel can fish only until it has caught its limit)
- Reduce number of fishing hours per trip per day allowed
- Enforce limit of 30 days at sea
- **Implement effort limits (limits on number of vessels) based on assessment of economic value**

To reduce the number of juvenile fish coming out of the water:

- Implement a size limit – limiting the number of fish caught below a certain size (limit on the whole sector, fishery would close for this sector when limit reached)
- **Enforce existing gear restrictions, especially net size restriction of > 60 mm**
- Implement the MPAs designed to protect spawning/nursery areas

Table A 6.1: Other interventions beyond direct fishery management actions:

Measures / Objectives	Alt livelihoods	Data	Enforcement	Implementation	Pollution
Reduce number of fish being caught	• Incentivize Fish farming	• Researchers must include the fishers • Improve data collection • Improve quality of catch data provided by the fleet	• Strict monitoring and enforcement of IUU • More enforcement and regulation of fish coming out of the water	• Monitoring at-sea • Quarterly training on monitoring protocols • receiving landings data as a condition of licensing	• Reduce waste/ lost fishing gear left in the sea
Protect juveniles	• Farming to produce juveniles in hatcheries	• Researchers must include the fishers • Improve data collection		• Prosecute those that are no complying • Enforce measures	• Reduce pollution, especially in spawning and nursery grounds
Reduce number of vessels on the water		• Improve data collection • Research into the economic value of fishery to the country		• Monitoring at-sea • Revisit modality of re-registration • Remove subsidies • receiving landings data as a condition of licensing	

ANNEX VII: REFERENCES

Lazar N., et al., 2020. Status of the Small Pelagic Fish Stock in Ghana 2019. Scientific and Technical Working Group. Sustainable Fisheries Management Project (USAID). GH2014_SCI083_CRC. 17 pp.

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