SEDAR

Southeast Data, Assessment, and Review

SEDAR 104
Management Strategy Evaluation Stock Assessment Report

Atlantic Dolphinfish

September 2026

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

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Southeast Data, Assessment, and Review

SEDAR 104

Atlantic Dolphinfish Management Strategy Evaluation

SECTION I: Introduction

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Introduction

SEDAR 104 addressed the management strategy evaluation for Atlantic Dolphinfish. The process consisted of a management strategy evaluation conducted internally by the lead assessment agency and an in-person Review Workshop coordinated by SEDAR.

The Stock Assessment Report is organized into 5 sections. Section I – Introduction contains a brief description of the SEDAR Process, Assessment and Management Histories for the species of interest, and the management specifications requested by the Cooperator. Section II is the Assessment Process report. This section details the operating model. Consolidated Research Recommendations from all stages of the process can be found in Section III for easy reference. Section IV documents the discussions and findings of the Review Workshop (RW). Finally, Section V – Addenda and Post-Review Workshop Documentation consists of any analyses conducted during or after the RW to address reviewer concerns or requests. It may also contain documentation of the final RW-recommended base model, should it differ from the model put forward in the Assessment Report for review.

The final Stock Assessment Report (SAR) for Atlantic Dolphinfish Management Strategy Evaluation was disseminated to the public in September 2026. The South Atlantic Fishery Management Council's' Scientific and Statistical Committee (SSC) will review the SAR for the stock within their management jurisdiction. The SSC is tasked with recommending whether the assessments represent Best Available Science, and whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their Fishing Level Recommendations (e.g., Overfishing Limit and Acceptable Biological Catch).

1 SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR is managed by the three Regional Fishery Management Councils in the Southeast in coordination with NOAA Fisheries, the Interstate Marine Fisheries Commissions (Atlantic States MFC and Gulf States MFC), and the Florida Fish and Wildlife Conservation Commission (FL FWC).

SEDAR seeks to improve the quality and reliability of stock assessments, improve the quantitative basis of fishery management actions, and increase the relevance of research and monitoring programs in the Southeast Region. It emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is often organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and

compiled. The second stage is the Assessment Process, which is conducted via a workshop and/or a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. The final step is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 stages and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Cooperator. Workshop participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

2 ATLANTIC DOLPHINFISH MANAGEMENT OVERVIEW

1. Management Overview

1.1 Management Overview SAFMC Fishery Management Plan and Amendments

Dolphin and wahoo were originally a part of the fishery management plan (FMP) for Coastal Pelagic Resources in the Gulf of Mexico and South Atlantic Region (SAFMC 1983b). Under that plan, a control date of May 21, 1999, was established for the commercial dolphin and wahoo fishery in the South Atlantic for possible future limited entry. Regulations were first implemented in 2004 and have been revised multiple times since then. The following summary provides an overview of the history of dolphin management in the Atlantic EEZ and describes only those management actions that likely affect the dolphin portion of the Dolphin Wahoo fishery.

Original Dolphin Wahoo Fishery Management Plan
The FMP, Regulatory Impact Review, and Final Environmental Impact Statement for the Dolphin Wahoo Fishery of the Atlantic Region, implemented June 28, 2004, established a management regime for the Dolphin Wahoo fishery in the United States Atlantic Ocean exclusive economic zone (EEZ) extending from the Maine/Canada border through the Atlantic side of the Florida Keys to 83° W longitude (Figure 3.1). Regulations apply only to federal waters unless otherwise adopted by states. The South Atlantic Fishery Management Council (Council) is the lead council, but the FMP is managed in cooperation with the Mid-Atlantic Fishery Management Council and the New England Fishery Management Council. The original FMP established:

- A separate management unit for dolphin and wahoo in the U.S. Atlantic,
- Dealer, for-hire, and commercial permits,
- For-hire and commercial operator card requirements,
- Reporting requirements,
- Maximum sustainable yield and optimal yield, and a definition of overfishing,
- A management framework,
- A prohibition on recreational sale of dolphin or wahoo except by for-hire vessels with a commercial permit,

- A 1.5 million pounds (lbs) (or 13% of the total catch) soft cap on dolphin landings for the commercial sector,
- A recreational bag limit of 10 dolphin per person, 60 dolphin per vessel maximum,
- A minimum size limit for dolphin of 20 inches fork length off Georgia and Florida,
- Allowable gear for dolphin and wahoo in the Atlantic EEZ (longline; hook and line gear including manual, electric, or hydraulic rod and reels; bandit gear; handline; and spearfishing gear, including powerheads),
- A prohibition on the use of surface and pelagic longline gear for dolphin and wahoo within any "time or area closure" in the Council's area of jurisdiction (Atlantic Coast) which is closed to the use of pelagic gear for highly migratory pelagic species,
- A fishing year of January 1 to December 31,
- Essential Fish Habitat (EFH) for dolphin and wahoo, and
- EFH-Habitat Areas of Particular Concern (HAPC).

FMP Amendments Affecting Dolphin

Description of Actions	FMP/Amendment	Effective Date
Established ABCs, ACLs, AMs, and allocations for both commercial and recreational sectors; established annual catch targets (ACTs) for the recreational sector; prohibited bag limit sales of dolphin from for-hire vessels; and established a minimum size limit of 20 inches fork length for dolphin caught in the EEZ off South Carolina.	Amendment 2	4/16/2012
Required electronic reporting for federal dealers and changed the frequency of reporting.	Amendment 3	7/7/2014
Revised the ABCs, ACLs (including sector ACLs), recreational ACTs, and AMs; modified the sector allocations for dolphin; revised the framework procedure.	Amendment 5	7/9/2014
Required electronic logbook reporting for headboat vessels recording dolphin and wahoo landings.	Amendment 6	1/27/2014
Allowed dolphin and wahoo fillets to enter the U.S. EEZ after lawful harvest in The Bahamas.	Amendment 7	5/1/2015
Modified sector allocations for dolphin by increasing the commercial sector allocation from 7.54% to 10% of the total ACL.	Amendment 8	2/1/2015

The action added approximately 377,000 lbs ww to the commercial ACL.		
Established a 4,000 lbs ww commercial trip limit for dolphin once 75% of the commercial sector ACL is reached.	Regulatory Amendment 1	3/21/2017
Required weekly electronic reporting for charter vessel operators with a federal for-hire permit in the dolphin wahoo fishery; reduced the time allowed for headboat operators to complete their electronic reports; and proposed requiring location reporting by charter vessels with the same detail required for headboat vessels.	Amendment 9	1/4/2021
Revised the ABCs, ACLs, sector allocations, AMs, and management measures including allowing commercial retention of up to 500 lbs gw of dolphin when trap, pot, or buoy gear is onboard a vessel, removed the operator card requirement, and reduced the recreational vessel limit for dolphin from 60 fish to 54 fish per vessel.	Amendment 10	5/2/2022

1.1.1 Emergency and Interim Rules (if any)

N/A

Secretarial Amendments (if any)

N/A

Control Date Notices (if any)

Notice of Control Date effective 5/21/1999: Anyone entering federal Dolphin Wahoo commercial fishery after 5/21/1999 was not assured of future access if limited entry program was developed.

Notice of Control Date effective 6/15/2016: Fishermen entering the federal for-hire recreational sector for the Dolphin Wahoo fishery after June 15, 2016, will not be assured of future access should a management regime that limits participation in the sector be prepared and implemented.

Notice of Control Date effective 12/8/2023: Federal permit holders that have not reported catch from the for-hire component of the recreational sectors of these fisheries, to the Southeast For-Hire Integrated Electronic Reporting (SEFHIER) program in the Atlantic on or prior to December 5, 2023, will not be assured of future access if the South Atlantic Fishery Management Council decides to limit future participation in these fisheries.

1.1.2 Management Program Specifications

General Management Information

Species	Dolphin
Management Unit	Atlantic
Management Unit Definition	All waters within in the United States Atlantic Ocean exclusive economic zone (EEZ) extending from the Maine/Canada border through the Atlantic side of the Florida Keys to 83º W longitude
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	SAFMC: John Hadley SERO: Nikhil Mehta
Current stock exploitation status	Unknown
Current stock biomass status	Unknown

1.1.3 Quota Calculation Details

Amendment 10 (2022) implemented a total ACL for dolphin equal to the ABC (24,570,764 lbs ww). This is based on the ABC recommendation from the Council's Scientific and Statistical Committee (SSC) that chose the third highest landings from 1994 to 2007 for dolphin to set the ABC. Within this amendment, the Council chose a sector allocation of 93% of the revised total ACL for dolphin to the recreational sector and 7% of the revised total ACL for dolphin to the commercial sector. The resulting recreational sector ACL was 22,850,811 lbs ww and the resulting commercial sector ACL was 1,719,953 lbs ww.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

1.2 Management and Regulatory Timeline

- See tables 2.2.1 and 2.2.2

Closures Due to Meeting Commercial Quota or Commercial/Recreational ACL

- See tables 2.2.1 and 2.2.2

References

SAFMC. 2022. Amendment 10 to the Fishery Management Plan for the Dolphin and Wahoo Fishery for the Atlantic with Final Environmental Assessment, Regulatory Flexibility Analysis, Regulatory Impact Review, and Fishery Impact Statement. South Atlantic Fishery Management Council, 4055 Faber Place Drive, Ste 201, Charleston, S.C. 29405. https://safmc.net/documents/dolphin-wahoo-amendment-10/

Table 2.2.1. Commercial regulatory history. Prepared by John Hadley.

Year	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season End Date (last day effective)	Min Size Limit (inches FL)	Min Size Limit Start Date	Min Size Limit End Date	Retention (Trip) Limit	Retention (Trip) Limit Unit	Retention Limit Start Date	Retention Limit End Date
2004-2012	N/A	365	open	N/A	1-Jan	31-Dec	20*	1-Jan	31-Dec	None	N/A	N/A	N/A
2012-2014	1,065,524	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	None	N/A	N/A	N/A
2014	1.157,001	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	None	N/A	N/A	N/A
2015	1.157,001	180	closed	ACL met	1-Jan	30-Jun	20**	1-Jan	31-Dec	None	N/A	N/A	N/A
2016-2022	1,534,485	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	None	N/A	N/A	N/A
2022-2026	1,719,953	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	None	N/A	N/A	N/A

*Only applicable in the EEZ off Georgia and Florida.
**Only applicable in the EEZ off South Carolina, Georgia, and Florida.

Table 2.2.2. Recreational regulatory history. Prepared by John Hadley.

Year	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season End Date (last day effective)	Minimum Size Limit (inches TL)	Minimum Size Limit Start Date	Minimum Size Limit End Date	Daily Retention Limit (fish/person/day)	Retention Limit Start Date	Retention Limit End Date	Daily Vessel Retention Limit (fish/vessel/day)	Aggregate Retention Limit Start Date	Aggregate Retention Limit End Date
2004-2012	NA	365	open	N/A	1-Jan	31-Dec	20*	1-Jan	31-Dec	10	1-Jan	31-Dec	60	1-Jan	31-Dec
2012-2014	13,530,692	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	10	1-Jan	31-Dec	60	1-Jan	31-Dec
2014-2016	14,187,845	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	10	1-Jan	31-Dec	60	1-Jan	31-Dec
2016-2022	13,810,361	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	10	1-Jan	31-Dec	60	1-Jan	31-Dec
2022-2026	22,850,811	365	open	N/A	1-Jan	31-Dec	20**	1-Jan	31-Dec	10	1-Jan	31-Dec	54	1-Jan	31-Dec

*Only applicable in the EEZ off Georgia and Florida.
**Only applicable in the EEZ off South Carolina, Georgia, and Florida.

1.3 . State Regulatory History

1.3.1 North Carolina

North Carolina state regulations according to FF-30-2022 Dolphin- Recreational Vessel Limit- Coastal Fishing Waters proclamation effective 2022 are currently:

- 10 fish per person daily creel limit
- No minimum size limit
- Not to exceed 54 per boat, except headboats, which are allowed 10 per paying customer
- Season open year round

This proclamation is issued under the authority of N.C. G.S. 113-134; 113-134.1; 113170.4; 113-170.5; 113-182; 113-182.1; 113-221.1; 143B-289.52 and N.C. Marine Fisheries Commission Rules 15A NCAC 03H .0103 and 03M .0512.

1.3.2 Georgia

Georgia state regulations for dolphin are currently:

- 10 fish per person daily creel limit
- 20 inch FL minimum size limit
- Not to exceed 54 per boat, except headboats, which are allowed 10 per paying customer
- Season open year round

The law with these measures was originally enacted on July 1, 1989 with regulations following on September 13, 1989. The Official Code of Georgia Annotated (O.C.G.A.) and regulations sections have changed over time, but management measures have not. The current regulations are found in O.C.G.A 27-4-10 and DNR Rule 391-2-4-.04. Both documents are available upon request.

1.3.3 South Carolina

Sec. 50-5-2730 of the SC Code states:

(A) Unless otherwise provided by law, any regulations promulgated by the federal government under the Fishery Conservation and Management Act (PL 94-265) or the Atlantic Tuna Conservation Act (PL 94-70) which establishes seasons, fishing periods, gear restrictions, sales restrictions, or bag, catch, size, or possession limits on fish are declared to be the law of this State and apply statewide including in state waters.

(B) This provision does not apply to:

…

(2) dolphin (Coryphaena hippurus) whose lawful catch limit is ten fish per person per day. The lawful minimum size for dolphin is twenty inches total length and there is no closed season.

As such, South Carolina dolphin regulations allow up to 10 fish of at least 20 inches total length caught in state waters per person per day.

1.3.4 Florida

Year	*Minimum Size Limit*	*Recreational Daily Harvest Limits*	*Commercial Daily Harvest Limits*	*Regulation Changes*	*Rule Change Effective Date*
1980	None	None	None		
1981	None	None	None		
1982	None	None	None		
1983	None	None	None		
1984	None	None	None		
1985	None	None	None		
1986	None	None	None		
1987	None	None	None		
1988	None	None	None		
1989	None	None	None		
1990	None	None	None		
1991	Commercial only: 20” FL	10 fish per person	None	Established a recreational bag and on-the-water possession limit of 10 fish. Established a commercial size limit of 20” FL for commercial fishermen and all sale, must be landed in whole condition. Defined allowed gear as hook and line, and longline (Only for incidental capture, limited to 10 fish).	January 1, 1991
1992	Commercial only: 20” FL	10 fish per person	None		
1993	Commercial only: 20” FL	10 fish per person	None		
1994	Commercial only: 20” FL	10 fish per person	None		
1995	Commercial only: 20” FL	10 fish per person	None		
1996	Commercial only: 20” FL	10 fish per person	None		
1997	Commercial only: 20” FL	10 fish per person	None		
1998	Commercial only:	10 fish per person	None		

Year	***Minimum Size Limit***	***Recreational Daily Harvest Limits***	***Commercial Daily Harvest Limits***	***Regulation Changes***	***Rule Change Effective Date***
	20” FL				
1999	Commercial only: 20” FL	10 fish per person	None		
2000	Commercial only: 20” FL	10 fish per person	None		
2001	Commercial only: 20” FL	10 fish per person	None		
2002	Commercial only: 20” FL	10 fish per person	None		
2003	Commercial only: 20” FL	10 fish per person	None		
2004	Commercial only: 20” FL	10 fish per person	None		
2005	20” FL	10 fish per person, 60 fish per vessel	None	Designated a restricted species. Established a minimum size limit of 20” FL for all Atlantic coast harvest. Established a statewide recreational vessel limit of 60 fish (Except 10 fish per paying passenger on for-hire vessels). Required a federal permit for commercial vessels harvesting dolphinfish. Prohibited the sale of recreationally caught dolphinfish, apart from for-hire captains that also have the commercial license to harvest them. Required all fish to be landed in whole condition.	January 3, 2005
2006	20” FL	10 fish per person, 60 fish per vessel	None		
2007	20” FL	10 fish per person, 60 fish per vessel	None		
2008	20” FL	10 fish per person, 60 fish per vessel	None		
2009	20” FL	10 fish per person, 60 fish	None		

Year	***Minimum Size Limit***	***Recreational Daily Harvest Limits***	***Commercial Daily Harvest Limits***	***Regulation Changes***	***Rule Change Effective Date***
		per vessel			
2010	20” FL	10 fish per person, 60 fish per vessel	None		
2011	20” FL	10 fish per person, 60 fish per vessel	None		
2012	20” FL	10 fish per person, 60 fish per vessel	None		
2013	20” FL	10 fish per person, 60 fish per vessel	None	F.A.C. Chapter reorganization	September 1, 2013
2014	20” FL	10 fish per person, 60 fish per vessel	None		
2015	20” FL	10 fish per person, 60 fish per vessel	None		
2016	20” FL	10 fish per person, 60 fish per vessel	None	Created an exemption to land dolphinfish as fillets, if harvested in The Bahamas and meeting specified requirements.	September 13, 2016
2017	20” FL	10 fish per person, 60 fish per vessel	None		
2018	20” FL	10 fish per person, 60 fish per vessel	None		
2019	20” FL	10 fish per person, 60 fish per vessel	None		
2020	20” FL	10 fish per person, 60 fish per vessel	None		
2021	20” FL	10 fish per person, 60 fish per vessel	None		
2022	20” FL	5 fish per person, Private vessel: 30 fish per vessel For-hire: # of customers fishing	None	Revised the daily bag limit to 5 fish per person. Reduced the private recreational daily vessel limit to 30 fish per vessel. Established a for-hire vessel limit to be limited to the number of customers fishing multiplied by the bag limit. Prohibited captain	May 1, 2022

Year	***Minimum Size Limit***	***Recreational Daily Harvest Limits***	***Commercial Daily Harvest Limits***	***Regulation Changes***	***Rule Change Effective Date***
		multiplied by bag limit No captain and crew retention		and crew retention.	
2023	20” FL	5 fish per person, Private vessel: 30 fish per vessel For-hire: # of customers fishing multiplied by bag limit No captain and crew retention	None		
2024	20” FL	5 fish per person, Private vessel: 30 fish per vessel For-hire: # of customers fishing multiplied by bag limit No captain and crew retention	None		
2025	20” FL	5 fish per person, Private vessel: 30 fish per vessel For-hire: # of customers fishing multiplied by bag limit No captain and crew retention	None		
2026	20” FL	5 fish per person, Private vessel: 30 fish per vessel For-hire: # of customers fishing multiplied by bag limit	None		

Year	***Minimum Size Limit***	***Recreational Daily Harvest Limits***	***Commercial Daily Harvest Limits***	***Regulation Changes***	***Rule Change Effective Date***
		No captain and crew retention			

Florida Atlantic Dolphinfish Regulation Changes by Chapter and Date

DOLPHIN, CH 46-41, FAC (Effective Jan. 1, 1991)

- Established a recreational bag and on-the-water possession limit of 10 fish.
- Established a commercial size limit of 20 inches fork length for commercial fishermen and all sale. Must be landed in whole condition.
- Defined allowed gear as hook and line, and longline (Only in the instance of incidental capture, limited to 10 fish).

DOLPHIN AND WAHOO, CH 68B-41, FAC (Effective Jan. 3, 2005)

- Designated dolphinfish as a restricted species.
- Established a minimum size limit of 20 inches fork length for all harvest on the Atlantic coast.
- Established a statewide recreational vessel limit of 60 fish per vessel (Except 10 fish per paying passenger on for-hire vessels).
- Required a federal permit for commercial vessels harvesting dolphinfish.
- Prohibited the sale of recreationally caught dolphinfish, with the exception of for-hire captains that also have the commercial license to harvest dolphin.
- Required all dolphinfish to be landed in whole condition.

DOLPHIN AND WAHOO, 68B-41, FAC (Effective Sept. 1, 2013)

- Wahoo removed from chapter 68B-41, placed into the new chapter 68B-58.
- Chapter reorganized and reformatted as part of a rule cleanup process.

DOLPHIN, 68B-41.003, FAC (Effective Sept. 13, 2016)

- Created an exemption to allow recreational anglers to land dolphinfish as fillets, as long as: the fish were recreationally harvested in The Bahamas, the fillets have skin intact, the Florida bag and possession limits are followed, valid Bahamian fishing and cruising permits are on the vessel, each person on the vessel has a valid passport stamped from The Bahamas, and all fishing gear is stowed. These fish cannot be sold or purchased.

DOLPHIN, 68B-41.004, FAC (Effective May 1, 2022)

- Reduced the recreational bag limit and possession limit for Atlantic dolphinfish to 5 fish.
- Reduced the private recreational vessel limit for Atlantic dolphinfish to 30 fish per vessel, regardless of number of anglers onboard.
- Established a for-hire vessel limit to be limited to the number of customers fishing multiplied by the bag limit.
- Established a bag limit of 0 for captain and crew on for-hire vessels.

3 ASSESSMENT HISTORY AND REVIEW

Assessment history of US Atlantic dolphinfish

Stock Assessment History

No comprehensive stock assessment has been conducted for dolphin (dolphinfish; *Coryphaena hippurus*) in the western North Atlantic. Dolphin are highly migratory species, subjected to international exploitation, where not all fishing nations collect and report removal data (Merten et al. 2022; FAO 2026). Further, no fishery independent survey exists for dolphin in the North Atlantic Ocean. This data limitation, combined with the sporadic, r-selected life history strategy of dolphin, largely precludes the development of a comprehensive stock assessment (Mahon and Oxenford 1999).

In 2000, Prager (2000) attempted an exploratory assessment of dolphin only in US waters (South Atlantic and Gulf). Prager's (2000) surplus production model suggested that the stock was not overfished but emphasized that the results were exploratory and highly uncertain. Further investigations attempted to assess dolphin in the Caribbean, finding that yield-per-recruit analyses are inappropriate, that surplus production analyses were unable to estimate maximum sustainable yield (MSY), and that stock-recruit relationships were largely inestimable (Mahon and Oxenford 1999 and references therein; Kleisner 2008 and references therein). Moreover, Kleisner (2008) fit a Bayesian surplus production model for dolphin (including pompano) throughout the US and Venezuela. Despite noting that the intention of the study was not to conduct a stock assessment, Kleisner (2008) found that results were largely uncertain and that results were heavily dependent on informative priors, indicating that the associated CPUE and catch data were largely uninformative. Narváez and Arocha (2024) used data-limited Bayesian approaches (catch-based method for MSY and the Bayesian Schaefer model) to estimate status in the western central Atlantic (FAO area 31; from North Carolina to northern Brazil). Results indicated that the stock was either fully exploited or significantly overexploited as measured by both relative biomass and fishing mortality rates; although, these estimates were largely uncertain and varied notably by estimation method (Narváez and Arocha 2024).

Biology and Life history

Dolphin life history is characterized by fast growth, early maturity at size (Schwenke and Buckel 2008, Perrichon et al. 2019), high fecundity (Moltó et al. 2020), high natural mortality (Oxenford 1999, Moltó et al. 2022), and high and environmentally-influenced productivity (Schlenker et al. 2021). This life history strategy results in sporadic abundance and local availability from year-to-year. Typically inhabiting warm waters (Farrell et al. 2014, Merten et al. 2014a, Schlenker et al. 2021), dolphin mature within their first year of life and grow quickly (Schwenke and Buckel 2008), and are prolific spawners with a protracted spawning season (Merten et al. 2015, Schlenker et al. 2021). Tagging and genetic studies have generally supported the hypothesis that dolphin in the Western Central Atlantic comprise a single stock due to a high degree of mixing, high movement, and spawning rates (Merten et al. 2014b; 2015; 2016).

Patterns in Relative Abundance

Despite high uncertainty in removals and a lack of fishery-independent data, recent studies have attempted to quantify trends in abundance in dolphin in the US Atlantic. Local reductions in abundance in the US Atlantic have been observed via: recent downward trends in commercial fishery-dependent CPUE over the long-term (Lynch et al. 2018) or recent-term (Damiano et al. 2024), increased effort required to catch a citation-sized dolphin (Runde et al. 2025), reduced mean size of recreational catch (Rudershausen et al. 2024; Peterson et al. 2024), reduced localized abundance or availability (McPherson et al. 2022; Karnauskas et al. 2025), and increased discarding rate combined with relatively high discard mortality rates (Rudershausen et al. 2019). This has seemingly corresponded with increased fishing pressure (Mahon 1999; Merten et al. 2022) and increased regional user conflicts of dolphin fishers within the US Atlantic (McPherson et al. 2022; Peterson et al. 2024).

US Atlantic Fisheries and Management

In the US Atlantic, dolphin are an iconic species of significant demand and importance (McPherson et al. 2022; Peterson et al. 2024; Karnauskas et al. 2025). Across the entire Atlantic coast of the US (Maine to Florida),

dolphin are managed by the South Atlantic Fishery Management Council (SAFMC; see Amendment 10 of the Dolphin Wahoo Fishery Management Plan for a complete management history). Dolphin are managed with a static annual catch limit (ACL) based on the third highest catches observed between 1994-2007 (24,570,764 pounds whole weight; Amendment 10, Federal Register 2022), with 93% allocated to the recreational sector and 7% allocated to the commercial sector. US Atlantic dolphin are managed by a combination of TACs, vessel and bag limits, and size limits. Throughout the coast, the commercial sector ACL is 1,719,954 pounds whole weight. Once 75% of the commercial sector ACL is landed, a vessel limit of 4,000 pounds whole weight is implemented for vessels with a federal commercial vessel permit for dolphin. Non-permitted commercial vessels (i.e., vessels that do not hold a federal commercial permit for dolphin but do hold a federal permit for another fishery) north of 39° N are subjected to a 200 pound whole weight vessel limit for both dolphin and wahoo combined. The recreational sector ACL is 22,850,811 pounds whole weight, and the federal vessel and bag limits are 54 and 10 dolphin, respectively in the US exclusive economic zone (EEZ) from Maine to Florida. There is also a 20 inch fork length minimum size limit for all dolphin captured recreationally and commercially in South Carolina, Georgia, and Florida (Federal Register 2022). Dolphin are currently unmanaged federally in the US Gulf of America. No regional fishery management organizations within the North Atlantic (e.g., International Commission for the Conservation of Atlantic Tunas, ICCAT; Western Central Atlantic Fishery Commission, WECAFC) have any binding reporting or management requirements for dolphin.

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4 REGIONAL MAPS

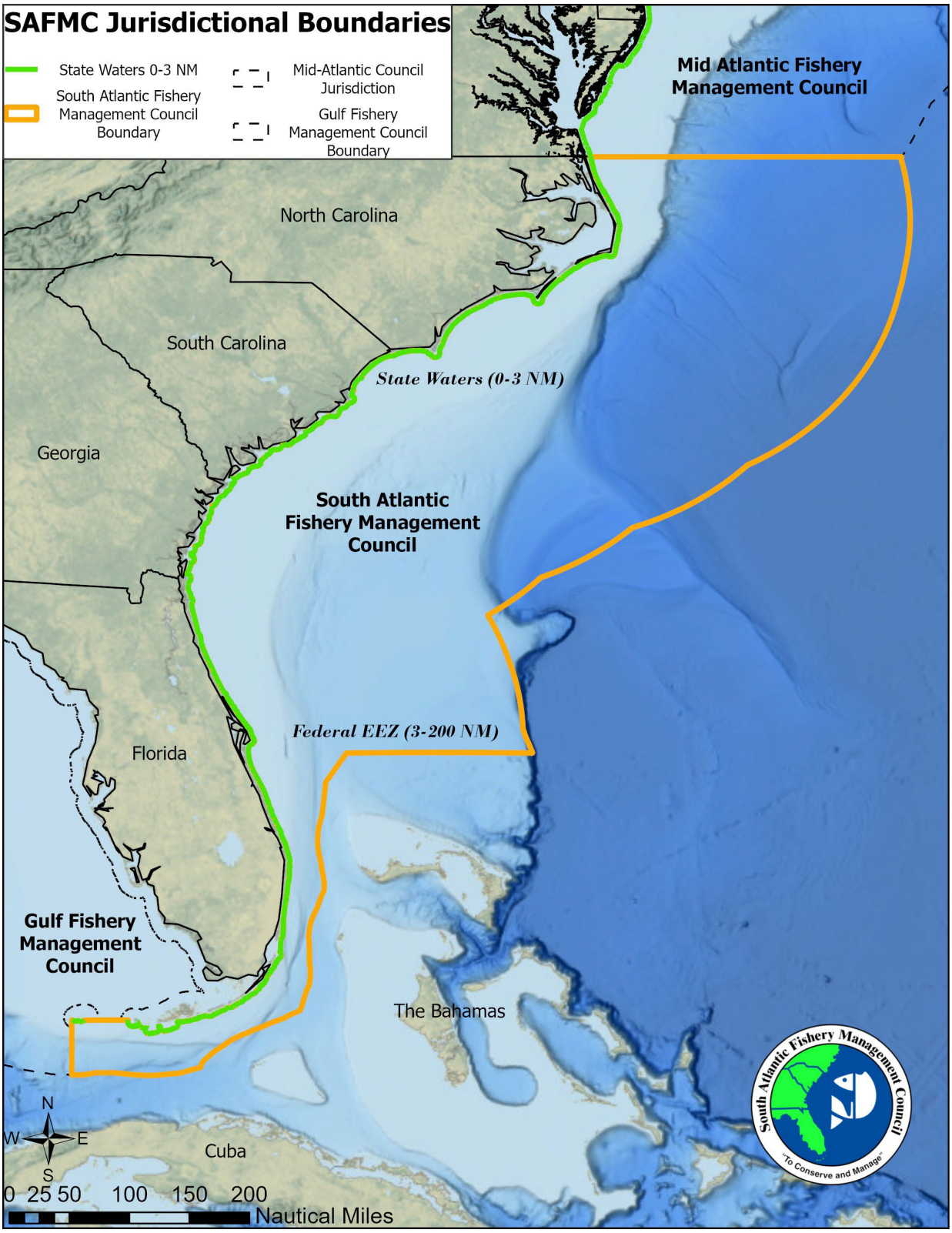


Figure 1. South Atlantic Fishery Management Council Boundaries.

5 SEDAR ABBREVIATIONS

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder (software program)
ALS	Accumulated Landings System: SEFSC fisheries data collection program
AMRD	Alabama Marine Resources Division
APAIS	Access Point Angler Intercept Survey
ASMFC	Atlantic States Marine Fisheries Commission
B	Biomass (stock) level
BAM	Beaufort Assessment Model
Bmsy	B capable of producing MSY on a continuing basis
BSIA	Best Scientific Information Available
CHTS	Coastal Household Telephone Survey
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone
F	Fishing mortality (instantaneous)
FES	Fishing Effort Survey
FIN	Fisheries Information Network
FMSY	F to produce MSY under equilibrium conditions
FOY	F rate to produce OY under equilibrium
FXX% SPR	F rate resulting in retaining XX% of the maximum spawning production under equilibrium conditions
Fmax	F maximizing the average weight yield per fish recruited to the fishery
Fo	F close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	General Linear Model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MARFIN	Marine Fisheries Initiative
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
MFMT	Maximum Fishing Mortality Threshold: value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey: combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSA	Magnuson Stevens Act
MSST	Minimum Stock Size Threshold: value of B below which the stock is deemed to be

overfished	
MSY	Maximum Sustainable Yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OST	Office of Science and Technology, NOAA
OY	Optimum Yield
SAFMC	South Atlantic Fishery Management Council
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Southeast Fisheries Science Center, NMFS
SERFS	Southeast Reef Fish Survey
SERO	Southeast Regional Office, NMFS
SRFS	State Reef Fish Survey (Florida)
SRHS	Southeast Region Headboat Survey
SPR	Spawning Potential Ratio: B relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SS	Stock Synthesis
SSC	Scientific and Statistical Committee
TIP	Trip Interview Program: biological data collection program of the SEFSC and Southeast States
TPWD	Texas Parks and Wildlife Department
Z	total mortality (M+F)

SEDAR

Southeast Data, Assessment, and Review

SEDAR 104

Atlantic Dolphinfish Management Strategy Evaluation

SECTION II: Assessment Process Report

8 July 2026

SEDAR
4055 Faber Place Drive, Suite 201 North
Charleston, SC 29405

Specifications for MSE Trials for Atlantic Dolphinfish

Performance metrics, operating models, management procedures and diagnostics (v1.0)

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1 About This Document

A trial specifications document (TSD) is intended to provide a description of an MSE framework that is sufficiently detailed to ensure reproducibility. This description includes data sources, management performance metrics, operating models, operating model dynamics, operating model conditioning, management procedures, management procedure tunings and exceptional circumstances protocols.

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2 Context

2.1 Problem Statement

Managers of the Atlantic Dolphinfish fishery wish to identify a responsive and robust management strategy that can achieve management objectives for a wide range of plausible scenarios for Dolphinfish population and fishing dynamics (Table 1).

Table 1. Challenges and opportunities identified by Peterson et al. (2024).

Challenges with current management approach
Highly migratory; international distribution
Data limited with no stock assessment
Short-lived and environmentally driven productivity
Static management
Regional differences in management objectives
U.S. management limited to the U.S. EEZ Atlantic Coast
Proposed solutions
Empirical (indicator-based) Management Procedure will allow for adaptive management
In years where more dolphin are available to the fishery, catch limits should increase. In years where less dolphin are available to the fishery, catch limits should decrease.
Spatial management options for equitable opportunity across states or regions
Allocation options to achieve multiple competing objectives

2.2 Aims

Peterson et al. (2024) Describe at least two broad aims of the Dolphinfish MSE:

1. Predict the amount of dolphin the SAFMC will have each year
2. Maximize the usage of those fish across sectors and region

2.3 Conceptual Management Objectives

Peterson et al. (2024) identified at least 6 conceptual management objectives for the fishery operating in northern Florida and southern North Carolina (Table 2).

Table 2. Conceptual management objectives identified by Peterson et al. (2024)

Regionally mixed on willing to accept more restrictions
- South open to reducing trip/vessel limits
- South Pro (or mixed) size limits - open to explore what is viable for the charter fishery
- North maintain status quo or reduce restrictions
- North prefer no size limits
Area-specific management
- Mixed for sector-specific considerations (including private rec v. for hire)
Maintain accessibility / opportunity
- Fishery reliability
Ecosystem considerations
Fishery stability & maximize catches

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3 Basic Concepts and Stock Structure

3.1 Spatial Definitions

Damiano et al. 2024 identify seven discrete areas for characterizing the spatial dynamics of the dolphinfish population and fishery.

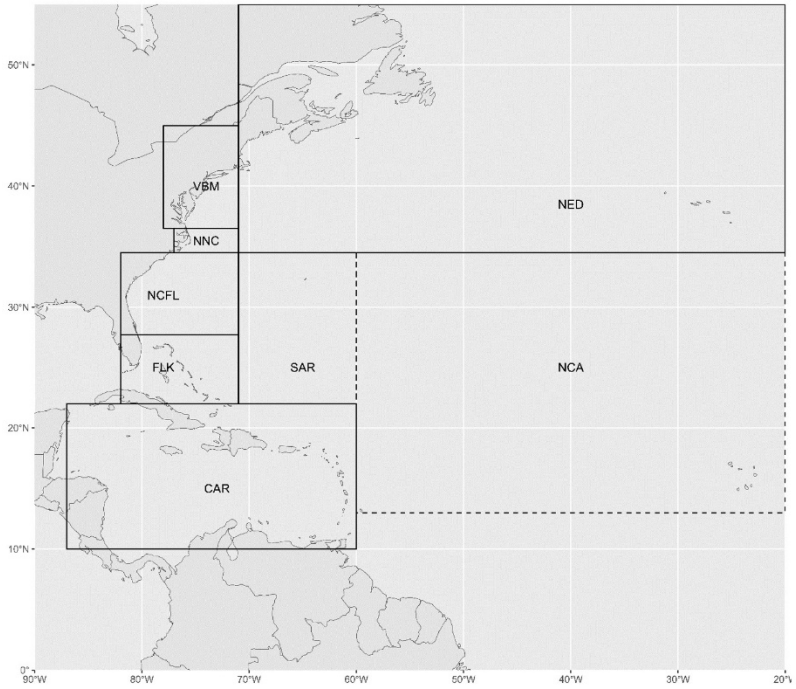


Figure 1. Spatial strata defined in Damiano et al. 2024

The dolphinfish population spans all three of the East Coast regional management councils (New England, Mid-Atlantic and South Atlantic).

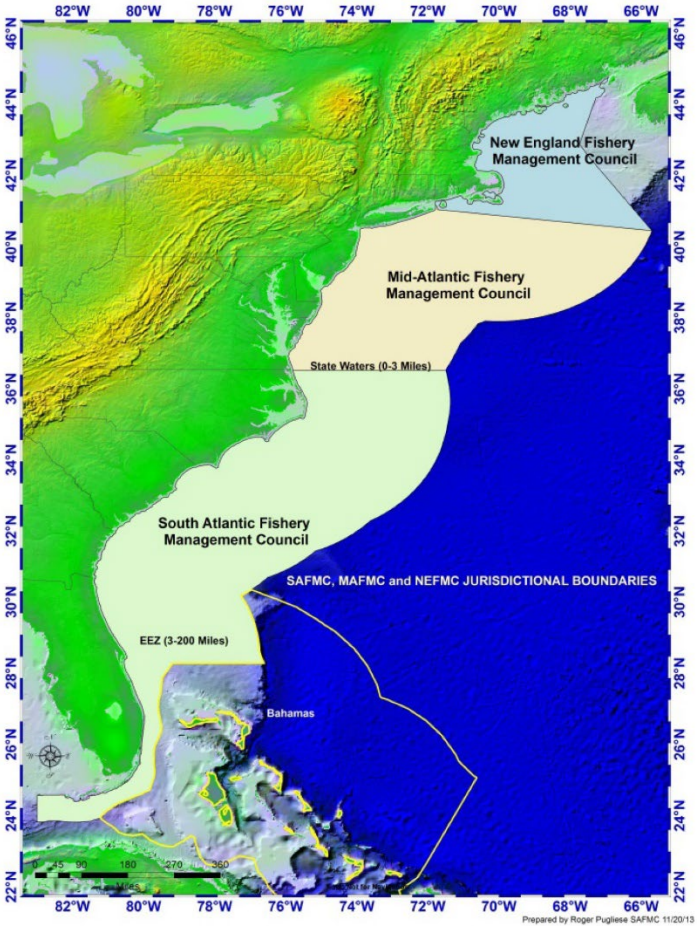


Figure 2. Management jurisdictions as described by Amendment 10 to the FMP for the Dolphin and Wahoo Fishery of the Atlantic Hadley and Mehta, 2021

3.2 Updated Spatial Definitions for the Estimation of Biomass Indices

Damiano et al. 2024 Used spatial catch rate data from the US longline observer program to develop spatial indices of abundance using the VAST modeling framework (Thorson 2023). Similarly to Dolphinfish in other oceans (Marín-Enríquez et al. 2018), Damiano et al. found consistent seasonal patterns in spatial distribution and density.

When confronted with spatial catch data it was apparent that, for areas of smaller geographic size, there was a large mismatch between catch magnitude and the spatial biomass index inferred by the VAST model. This is due to the highly migratory behavior of Dolphinfish: high fishing effort and large catches of fish in their transition through a small area over time scales much shorter than the seasonal time step. In this case, the biomass available to fishing in that season is very large even though the catch rates (the ratio VAST uses to quantify biomass) can remain relatively low.

It was necessary to broaden these areas and to better quantify spatial-temporal distribution of Dolphinfish given their rapid movement. Five areas were defined that are similar to those of Damiano et al. (2024) but follow the U.S. EEZ (Table 3, Figure 3).

Table 3. The discrete spatial strata.

Code	Alternative code	Description
CAR+FLK	CAR+SFL	Caribbean, South Florida and the Keys
NCA	SAR	Off Caribbean, South Florida and the Keys
NCFL	SE	Wilmington down to Mid Florida
NED	NED	Off North coast
NNC+VBM	NC+NE	Wilmington to Montauk

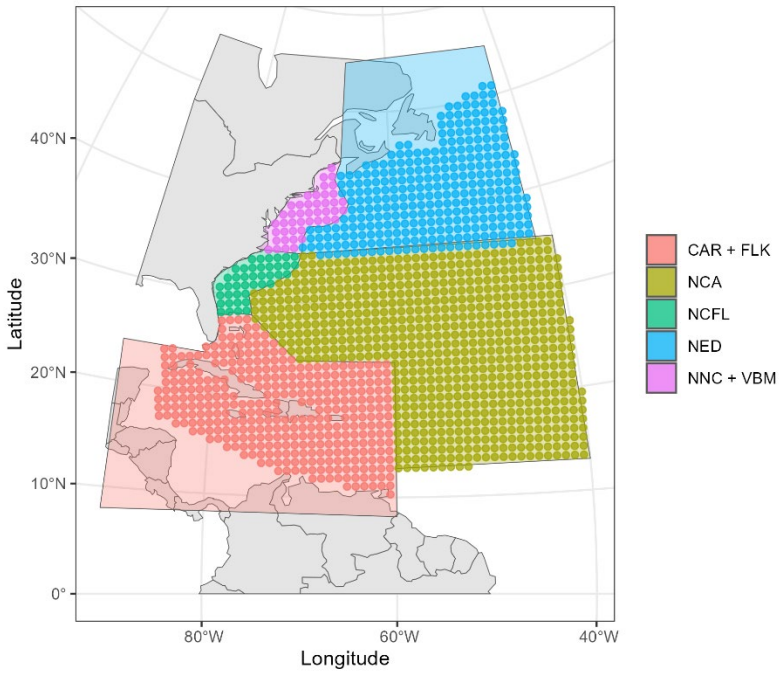


Figure 3. The spatial regions and knots used to define the seasonal - spatial density of dolphinfish.

A ‘total’ VAST index (all areas combined) was used to condition spatially aggregated population dynamics models (Section 7.2 below), the seasonal spatial indices were used to impose seasonal-spatial structure for spatial-seasonal operating models (Section 7.3 below).

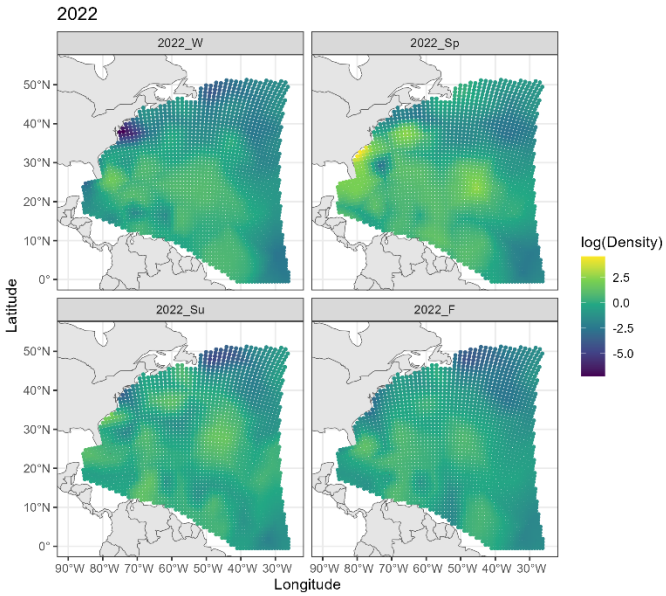


Figure 4. Seasonal spatial distribution predicted by the VAST model in 2022.

3.3 Fleet Definitions

Exploitation was characterized by eight fleets that were selected as the most concise basis for capturing varying fishery selectivity and also providing detail required to reflect regional, multi-sector fishing interests (Table 5).

Table 4. Individual fleets used to partition data for operating model conditioning and projection of fishing dynamics.

Code	Fleet	Areas	Years	Selectivity	Description
USCom	USA commercial longline	All	All	Logistic	US pelagic longline fleet
RecN	Recreational North	NNC+VBM	All	Domed	Private recreational fishing
RecS	Recreational South	CAR+FLK, NCFL	All	Domed	Private recreational fishing
HireN	For hire North	NNC+VBM	All	Domed	Headboat / party boat / charter
HireS	For hire South	CAR+FLK, NCFL	All	Domed	Headboat / party boat / charter
Intl	International	CAR+FLK, NCA, NED	All	Logistic (USCom)	Based on FAO database. Assumed to have the same seasonal distribution as the USCom fleet.
Disc	Discard	CAR+FLK, NCA, NNC+VBM	All	Logistic (USCom)	Based on Sea Around Us database. Assumed to have the same seasonal distribution as the USCom fleet.
UnRep	Unreported	CAR+FLK	All	Logistic (USCom)	Based on Sea Around Us database. Assumed to have the same seasonal distribution as the USCom fleet.

4 Past Data Available

The principle sources of data were seasonal catches by fleet, a spatial VAST index (fitted to fine scale spatial catch and effort data) and catch-length composition data (Table 5).

Table 5. Summary of data available for operating model conditioning.

Type	Resolution	Description
Indices	Fleet, season, area	Derived from a custom 5-area VAST model fitted to U.S. pelagic longline catch and effort data
Catches	Fleet, season, area	NOAA dataset
Effort	Fleet, season, area	NOAA dataset
Length composition	Fleet, year	NOAA dataset, data are sparse for the International fleet and not used. Not avialable for unreported and discard fleets.

4.1 Catches

Arguably the largest historical shift in catches has been a reduction in recreational fishing in the Caribbean and South Florida region (RecS in CAR+FLK) from highs of near 10kt in the 90's to around 3kt in 2022. During that time international catches have more than tripled from 1.5kt to 5.5kt. In 2022 63% of all Dolphin catches were from International, discard and unreported fishing activities (Figure 5).

Of the remaining 37%, the large majority of catches were by the southern recreational fleet (RecS) (26% of the total catches, 70% of the catch of US fleet). The U.S. commercial fleet catches were less than 1% of the total removals in 2022. The large majority of mahi catches were taken in the Caribbean and Southern Florida region (CAR+FLK) (75%).

Operating models are conditioned on season- and fleet-specific catch data from 1986 to 2043. To account for uncertainty in discards and unreported fishing, operating models were conditioned on 50% and 100% of NOAA estimates for these fleets (See section 'Reference Grid Operating Models', below)

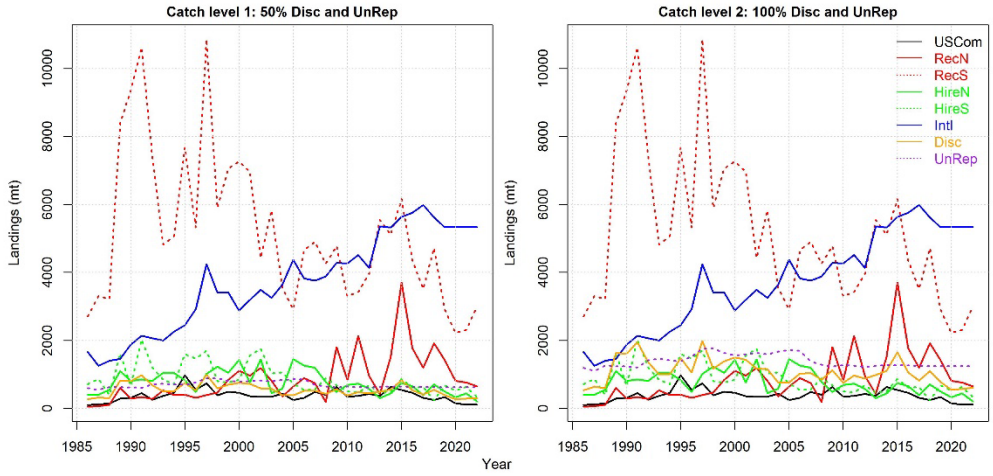


Figure 5. Annual landings by fleet that are assumed in operating model conditioning. Two levels of catches were specified for the discard (Disc) and unreported (UnRep) fleets: 50% and 100% of the NOAA estimates.

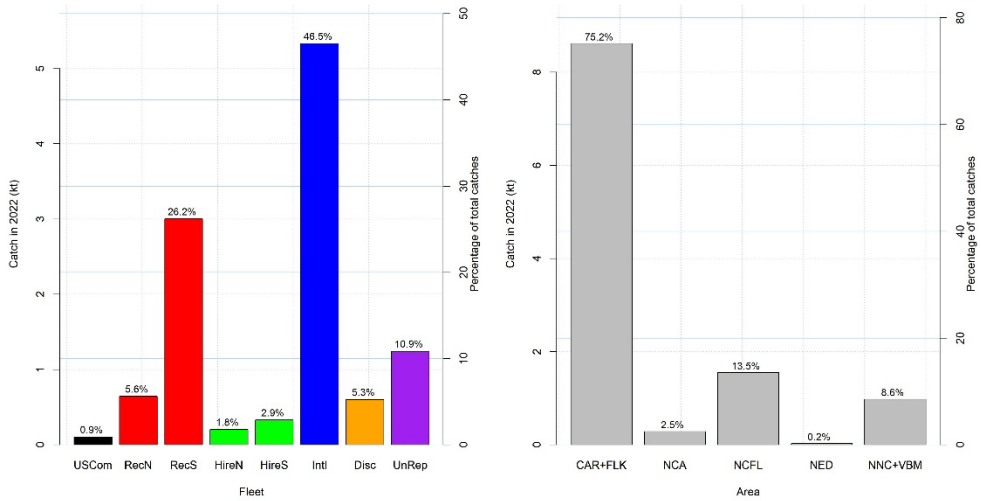


Figure 6. Landings by fleet and area in 2022 (the final year of the operating model conditioning) for the base assumption of 100% catches of Discard and Unreported fleets.

Table 6. Percentage of catches by fishing fleet for all historical years (base assumption of 100% catches of Discard and Unreported fleets).

	USCom	RecN	RecS	HireN	HireS	Intl	Disc	UnRep
Winter	0.1	0.0	2.5	0.0	0.4	10.4	0.4	4.3
Spring	1.3	3.8	16.2	3.6	2.9	8.9	3.7	3.4
Summer	1.1	1.0	13.8	1.1	2.3	4.4	2.6	1.3
Autumn	0.2	1.3	4.0	0.6	0.5	2.4	0.9	0.7

Table 7. Percentage of catches by fishing fleet for the last historical 3 years (2020 - 2022) (base assumption of 100% catches of Discard and Unreported fleets).

	USCom	RecN	RecS	HireN	HireS	Intl	Disc	UnRep
Winter	0.0	0.0	0.8	0.0	0.1	8.7	0.1	1.9
Spring	0.7	3.8	10.0	1.5	2.0	21.3	2.4	5.0
Summer	0.2	1.0	8.4	0.7	1.0	10.5	1.6	2.4
Autumn	0.1	1.7	2.9	0.7	1.3	6.6	0.9	1.6

4.2 Abundance Indices

Spatially aggregated operating models were conditioned on the total abundance index derived from the VAST spatial distribution model of Damiano et al. (2024) but with results summarized by a more concise 5-area definition described above. The VAST index shows considerable variability in abundance among seasons with spring and summer abundance often twice that of the Autumn and Winter (Figure 7). This suggests high overall mortality within year.

At the regional level, the degree of seasonal fluctuation varies. For example, for the NCFL region the VAST index infers very large discrepancies among winter and Summer abundances where as these are much less pronounced in the Caribbean and South Florida region (CAR+FLK). In general, the VAST index suggests that the majority of Dolphinfish abundance is found in the NCA and CAR+FLK regions (Figure 8).

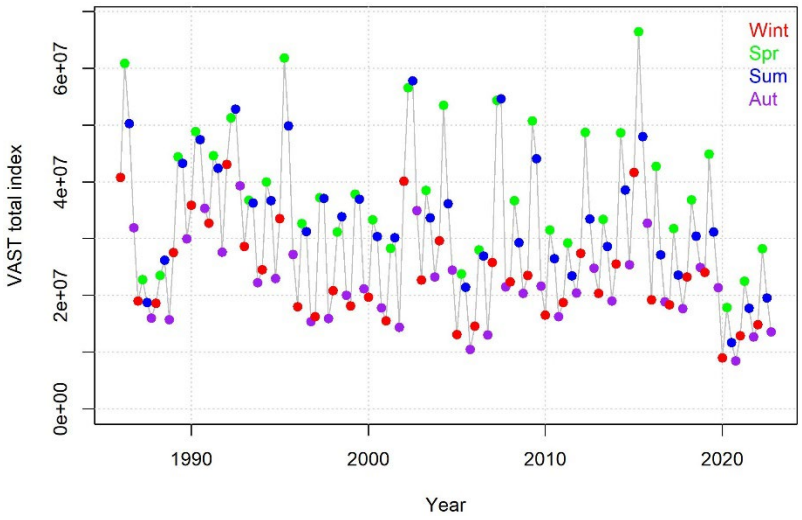


Figure 7. The spatially aggregated (total), seasonal VAST index (5-area revision of Damiano et al. 2024).

The fitted VAST models provide seasonal estimation of regional biomass for determining seasonal movement matrices.

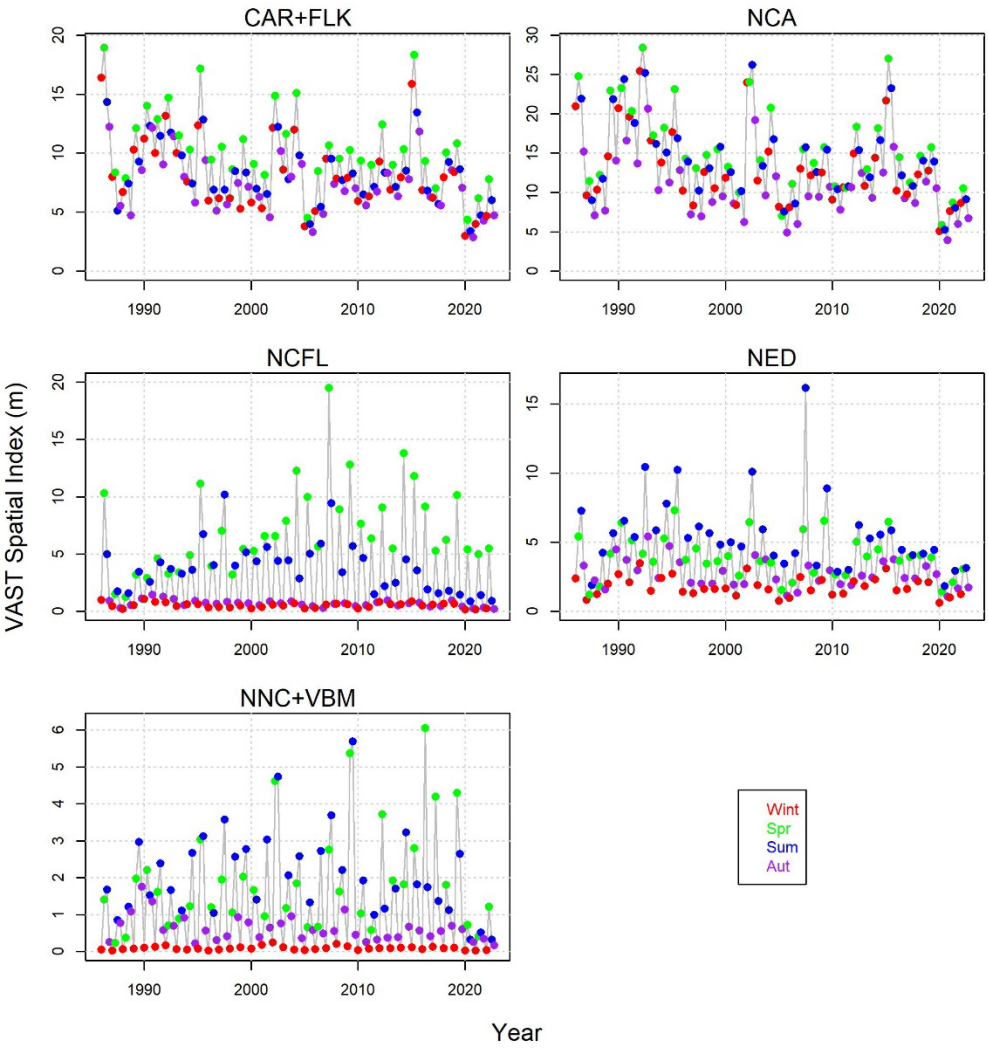


Figure 8. The spatial, seasonal VAST index (5 area summary of the VAST model outputs of Damiano et al. 2024).

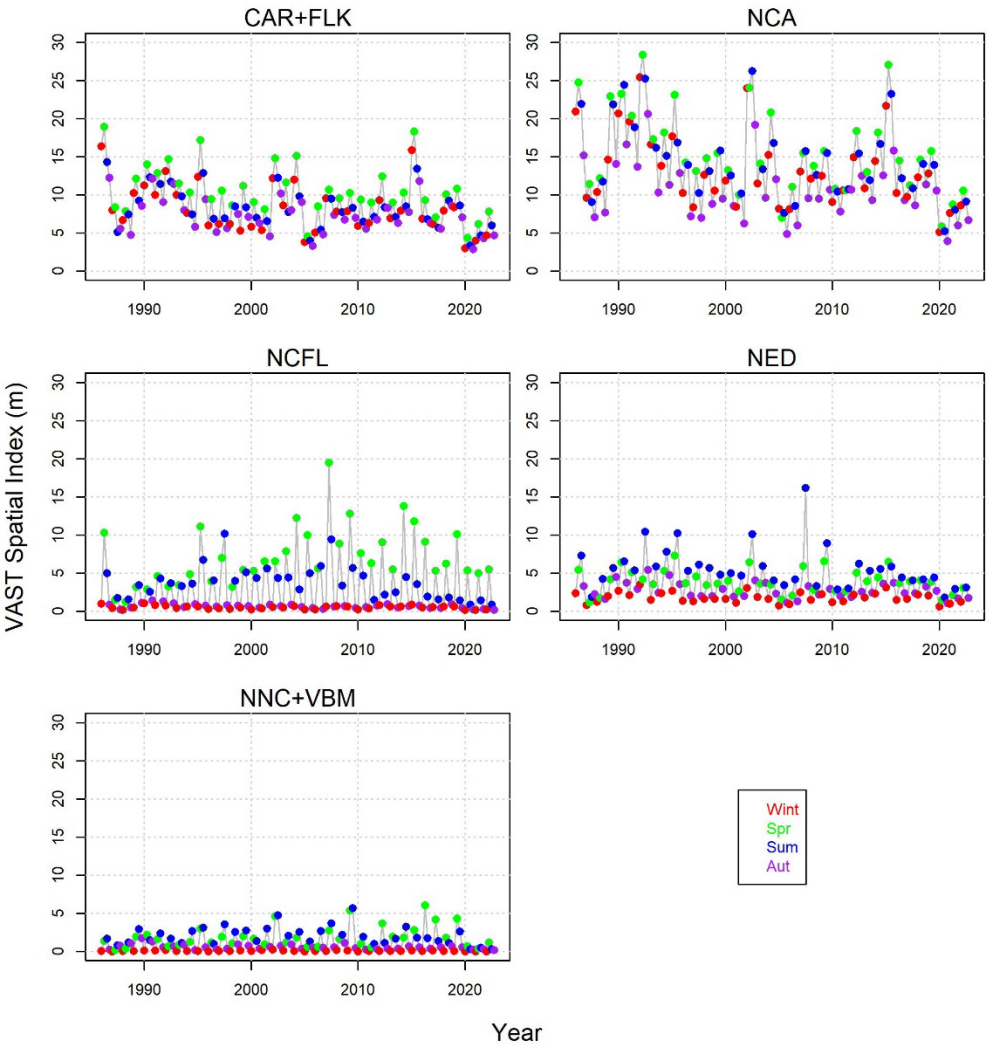


Figure 9. The spatial, seasonal VAST index with consistent y-axis range to demonstrate scale differences (5 area summary of the VAST model outputs of Damiano et al. 2024).

4.3 Length Composition of Catches

Fishing fleets retain fish of varying sizes. RecS, HireN and HireS fleets have comparable catch-length distributions with the majority of fish in the range of 400 - 1000mm with a mode around 550mm (Figure 10) (note that the HireN and RecN fleets have relatively few length observations). The USCom fleet catches larger fish from 700 - 1200mm with a mode around 950mm. The RecN fleet catches a wider range of lengths.

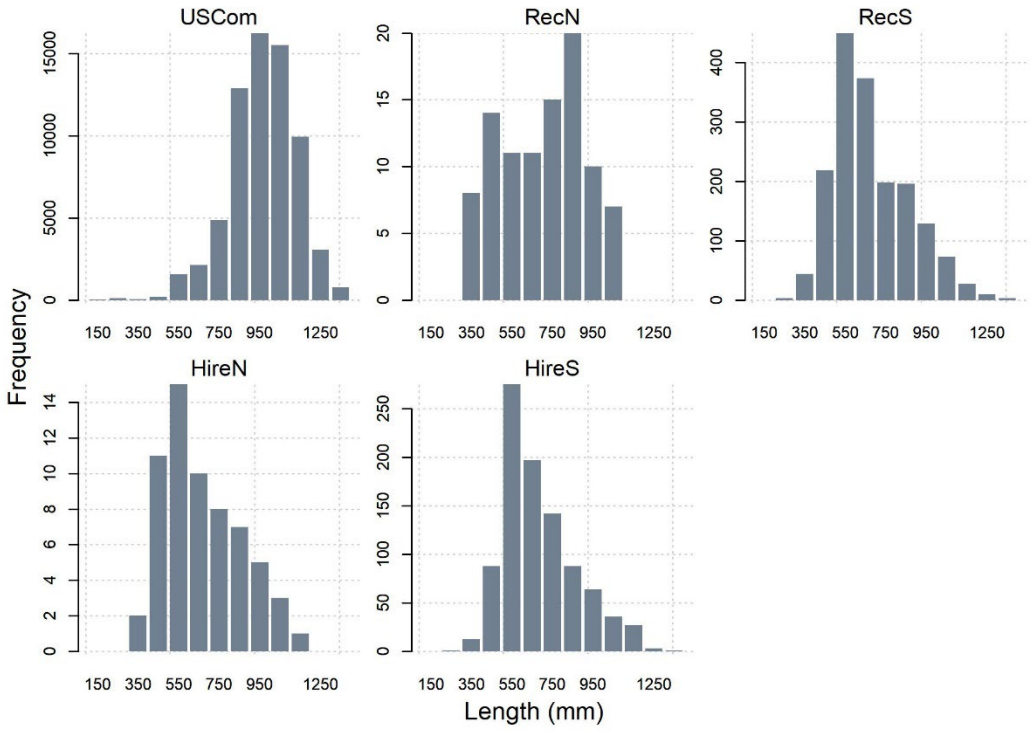


Figure 10. Aggregate (across years) length composition data for the catches of those fleets for which these data are available.

4.4 Data Assumptions

The key assumptions regarding the data are detailed in Table 8.

Table 8. Assumptions made in the processing, presentation and interpretation of data inputs.

Data type	Base assumption (reference case OM)
International annual catches	International catches from the FAO database are accurate.
Unreported annual catches	Unreported annual catches are calculated from the difference between the sum of US commercial, US recreational and international catches and those reconstructed by The Sea Around Us Project. The most recent three years (2020-2022) of unreported caches are based on the mean underreporting from 2010-2019.
Annual discarding	The discarding fleet comes from The Sea Around Us Project and is assumed to have the same seasonality as the US commercial fleet.
Length composition data	The lengths are representative of the fish that are landed.
Abundance indices	The nominal catch and effort data of the US commercial longline fishery are indicative of local fish density. Accounting for available spatial and seasonal covariates these data are representative of regional and seasonal vulnerable abundance.
Maturity and somatic growth data	The data from the regional study of Schwenke and Buckel (2008) are representative of the wider population of the US South Atlantic region.

5 Biological Information

5.1 Input Parameter Summary

Uncertainty in a number of key biological parameters is characterized and later accounted for in operating models. These include maximum growth rate *K*, asymptotic length, instantaneous natural mortality rate *M*, and Beverton-Holt steepness (Table 9).

This approach is a departure from MSE frameworks elsewhere that typically assume point values for such inputs and account for uncertainty in these across a discrete 'grid' of values. The principle reason to avoid this practice is to avoid an unrealistic and indefensible compression of uncertainty when viewing results for a single operating model or across a subset of operating models that hold a particular parameter constant at a point value. This is discussed in more detail in Section 7 below.

Table 9. Biological parameter inputs. Uncertainty is propagated in critical inputs relating to longevity, growth and resilience.

Parameter	Value (mean)	Distribution	Coeff. Var.	Reference
von Bertalanffy maximum growth rate, K (male and female combined) (L-infinity per year)	1.27	Multivariate lognormal	0.08	Schwenke and Buckel (2008)
von Bertalanffy asymptotic length, L-infinity (make and female combined) (mm)	1289	Multivariate lognormal	0.02	”
von Bertalanffy age at length zero, t0 (male and female combined) (years)	-2.6E-2	Deterministic	-	”
Length at 50% spawning fraction (L50) (female) (mm)	458	Deterministic	-	”
Coefficient of variation in lengths at age.	0.15	Deterministic	-	Derived from data of Schwenke and Buckel (2008)
Weight-length parameter a (mm to kg)	8.2E-8	Deterministic	-	Schwenke and Buckel (2008)
Weight-length parameter b (mm to kg)	2.67	Deterministic	-	Schwenke and Buckel (2008)
Instantaneous natural mortality (M) (annual)	1.0, 2.0	Lognormal	0.1	See Section 'Operating Models: Reference Grid'
Beverton-Holt Steepness	0.7, 0.95	Beta	2.5E-2	See Section 'Operating Models: Reference Grid'
Fishery discard mortality rate	0.25	Deterministic	-	Rudershausen et al. (2019)

5.2 Somatic Growth

Growth of individual is assumed to follow a von Bertalanffy growth equation with asymptotic length of 1289mm, a maximum growth rate (*K*) of 0.3175 (per quarter, 1.27 *L-infinity* per year) and age-at-zero length (*t0*) of -0.026, established by Schwenke and Buckel (2008)(Figure 11)

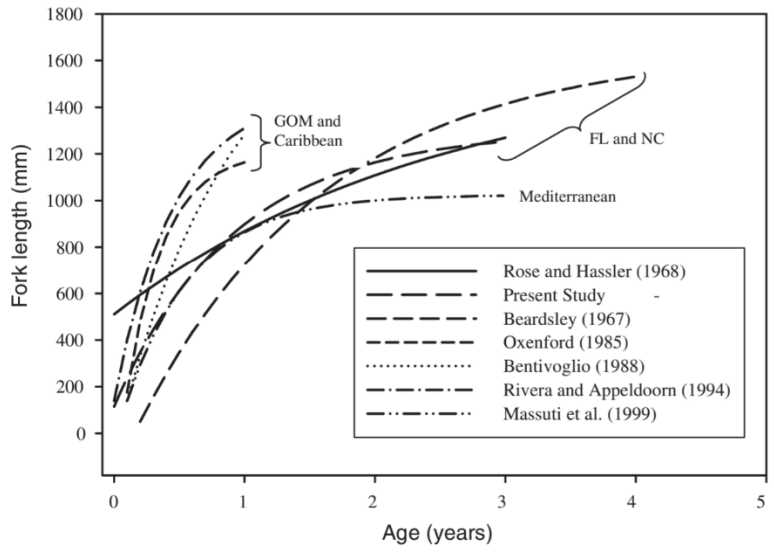


Figure 11. The various regional somatic growth curves for Dolphinfish synthesized by Schwenke and Buckel (2008) (Figure 3 of that paper). The solid dashed line ('Present Study', Florida and North Carolina) was used to specify the reference operating models.

Operating models included stochasticity in the growth model parameters based on estimates of Schwenke and Buckel (2008): a CV of 2% for asymptotic length (St.Dev. of 25.95mm), CV of 6.3% for maximum growth rate (St.Dev. of 0.08). These parameters were sampled with a negative correlation of -0.6 (a value derived by meta-analysis for *Perciformes* (Thorson 2019).

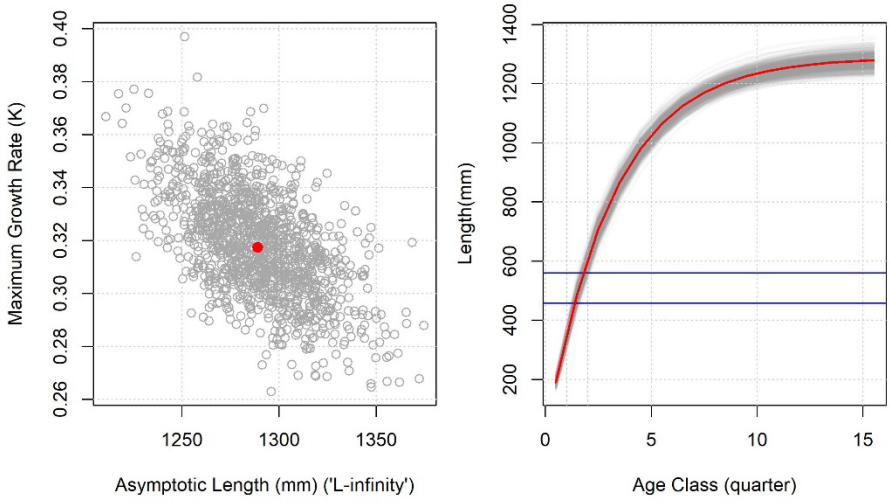


Figure 12. The sampled (grey) and mean growth curves assumed for Dolphinfish. The blue horizontal lines on the righthand plot are the length at 50% maturity (spawning fraction) (458mm) and 100% maturity (560mm) estimated by Schwenke and Buckel (2008)

5.3 Weight-at-Length

MRIP data provides paired observations of weight and length. Fitted exponential curves slightly updated (upward, greater weight at length) the *b* value estimated by of Schwenke and Buckel (2008) (Figure 13).

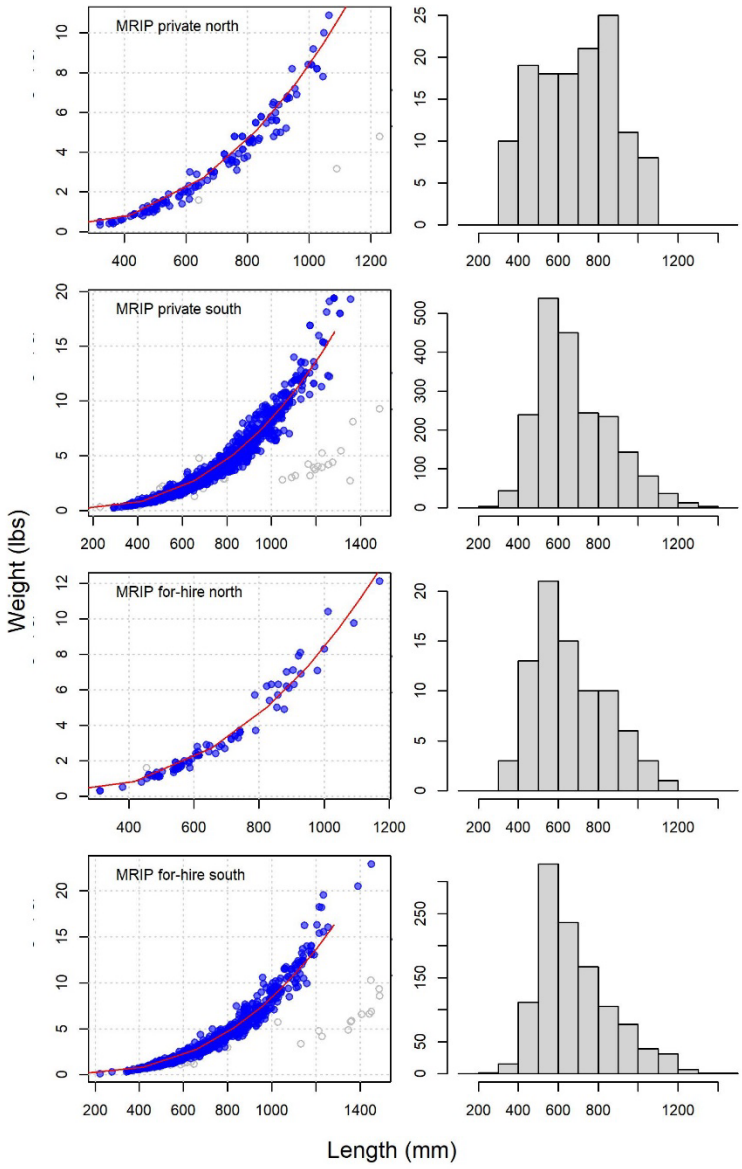


Figure 13. MRIP weight-at-length (b = 0.267, a = 8.2e-8). Schwenke and Buckel (2008) estimated the b value of 0.264 but this did not fit the observed data above. Grey data points were considered outliers (reporting unit error) and not used in fitting of length-weight curves.

5.4 Maturity-at-Age and Maturity-at-Length

From Schwenke and Buckel (2008): "Males reached 50% maturity at 476 mm FL and 100% maturity was reached at 645 mm FL (Table 3). Females reached 50% maturity at a slightly smaller size than males, although confidence limits for this parameter overlapped with those of males. At 458 mm FL, 50% of female dolphinfish were mature, and 100% were mature at about 560 mm FL"

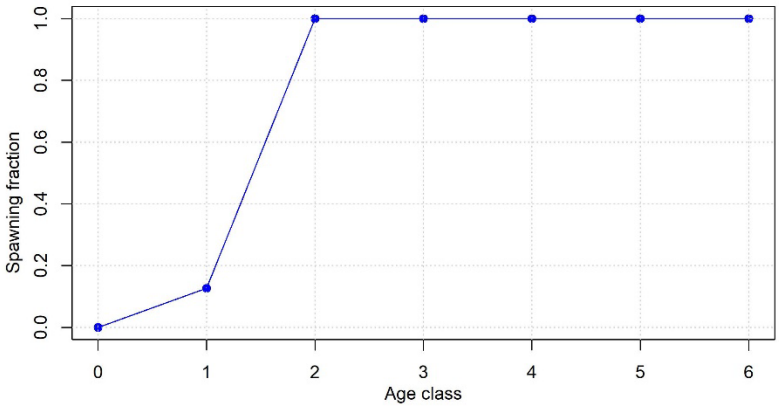


Figure 14. Maturity (spawning fraction)-at-age and -length for the reference operating model, estimated by Schwenke and Buckel (2008)

5.5 Stock-Recruitment and Resilience

The conventional approach for characterizing steepness fits a stock assessment model and either estimates the value within the assessment or derives it post-hoc by evaluating paired estimates of spawning stock biomass and recruitment. Unfortunately, the RCM fits of this study estimate highly variable recruitments and estimated stock biomass (inferred by total VAST index) rarely drops to low enough levels to inform steepness (Figure 15).

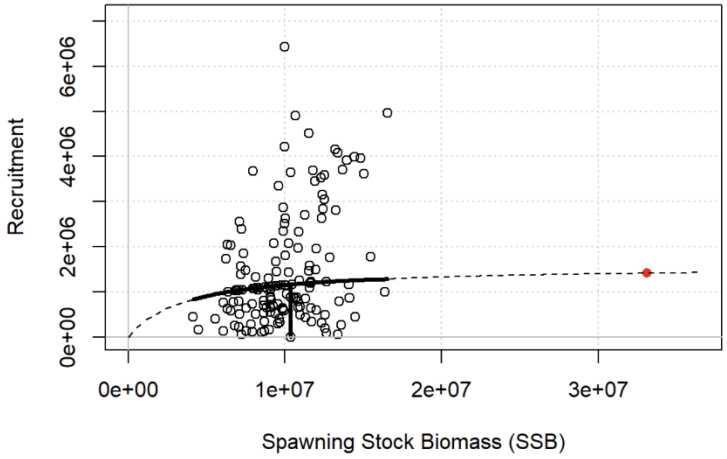


Figure 15. Example maximum likelihood estimates of spawning stock biomass (SSB) and recruitment for OM #1 given the mean values for input parameters.

Given a lack of stock assessment (or informative RCM fit) another approach is to derive age-structured indices and relate those of age-1 recruits to those indicative of mature age classes. In a comparable approach, Mahon and Oxenford (1999) develop a catch-rate based sketch of stock-recruitment for Caribbean Dolphinfish suggesting high steepness but with high uncertainty due to few 'observations' at low stock levels (Figure 16).

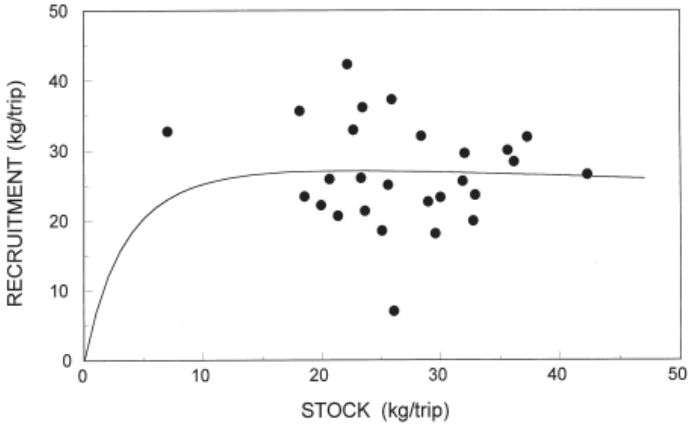


FIG. 8. – Recruitment versus stock for dolphinfish in the eastern Caribbean, based on a detrended catch rate time-series from Barbados. A Shepherd curve is shown.

Figure 16. Molto et al. 2020. Detrended catch rate indices of SSB and recruitment imply high resilience in Caribbean dolphinfish when a Shepherd model is fitted to data.

Stock resilience is determined by both ecology and life-history and is therefore not necessarily informed from similar species elsewhere. However, the approach taken here is to recognize that there is limited stock-specific information and evaluate MP performance over a range of resilience documented for Dolphinfish elsewhere.

In the eastern Atlantic, Aires da Silva et al. (2021) (cited by Roa-Ureta et al. 2021) assume a Beverton-Holt relationship and assumed the highest possible stock resilience with a steepness value of 1 (no impact of spawning biomass on recruitment). Note that MSY refereece points may not be defined at this extreme level. In the north-western Pacific, Wang et al. (2026) present MSE results for a low-steepness scenario assuming a Beverton-Holt relationship with a steepness value of 0.7.

5.6 Natural Mortality Rate

Natural mortality rate (*M*) is highly uncertain for US South Atlantic Dolphinfish. Globally, the species has wide-ranging life-history characteristics relating to growth and survival. Fish of the Gulf of Mexico, Caribbean and Mediterranean have much higher growth rate (e.g., *K* values above 3.0 per year, Molto et al. 2020) and commensurately higher estimated natural mortality rates (e.g., *M* values higher that 4.0 per year). In contrast, the regional study of Schwenke and Buckel estimates much lower growth rates of around 1.27 per year (see section ‘Somatic growth’ above) (Figure 17).

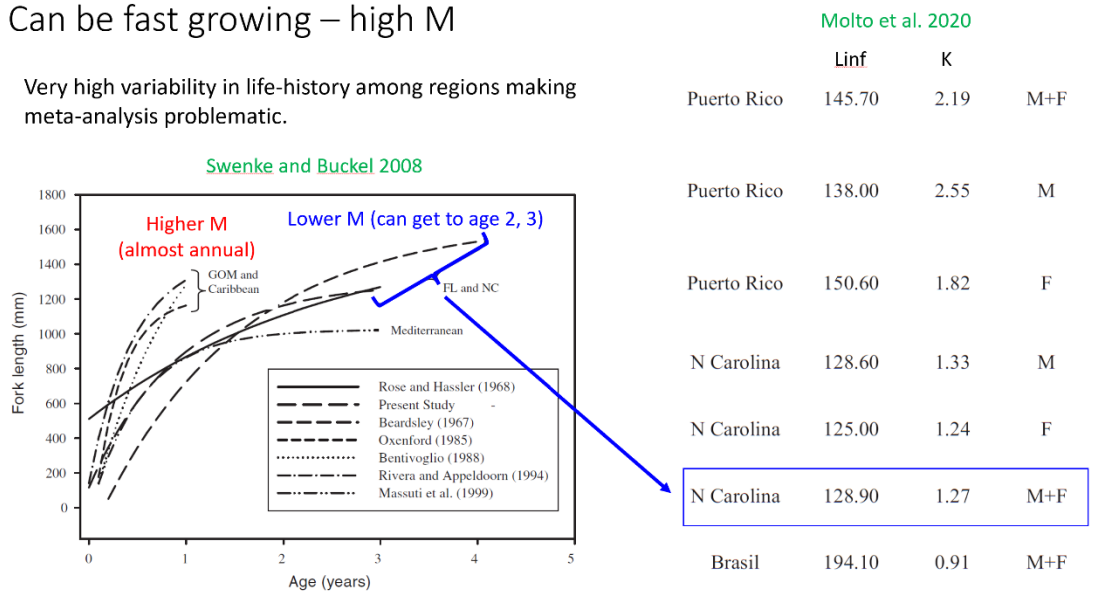


Figure 17. Somatic growth summarized by Schwenke and Buckel (2008) versus *M* estimates presented in Molto et al. (2020).

In the only empirical study directly relevant to the stock of this MSE, the age data collected by Schwenke and Buckel (2008) were from dockside landings in the order of thousands of fish (Buckel personal communication). This would imply relative low natural mortality rates given the relatively large fraction of age 2 and 3 fish that were observed (Figure 18).

	Natural mortality rate (per quarter)							
Fishing mortality rate (per quarter)	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	Sample Nos between
000s, of fish needed to be observed to select the 59 fish age 2+ (25 months or older)								1 20
0.2	1	3	7	16	36	78	172	thousand
0.3	3	7	16	36	78	172	378	
0.4	7	16	35	78	172	378	829	frac. Taken seasonal F
0.5	16	35	78	173	379	832	1820	0.6 0.229073
0.6	35	78	173	381	835	1830	4000	0.9 0.575646
0.7	79	173	382	840	1841	4029	8801	
0.8	174	384	845	1854	4061	8879	19383	
000s fish needed to be observed to select the 13 fish age 3+ (37 months or older)								
0.2	2	5	18	59	193	633	2072	
0.3	5	18	58	192	632	2072	6777	
0.4	18	58	192	632	2073	6789	22184	
0.5	58	192	632	2076	6807	22266	72683	
0.6	192	633	2081	6830	22366	73083	238354	
0.7	634	2087	6859	22483	73539	240071	782378	
0.8	2096	6893	22617	74051	241967	789258	2570443	this is 2.57 billion fish

Figure 18. The number of fish available dockside to obtain the age 2 and 3+ samples observed by Schwenke and Buckel (2008) for various combinations of fishing mortality (row) and natural mortality (column) per quarter. Note that Buckel indicates (personal communication) that a matter of thousands of fish were available (the blue shaded region). Also shaded in yellow if the region where fishing rates correspond with between 60% and 90% annual harvest rates.

Meta analysis of taxonomically comparable species in the Then et al. (2015) database do not strongly distinguish between varying hypothetical *M* values but generally support annual values below 2.0 (Figure 19).

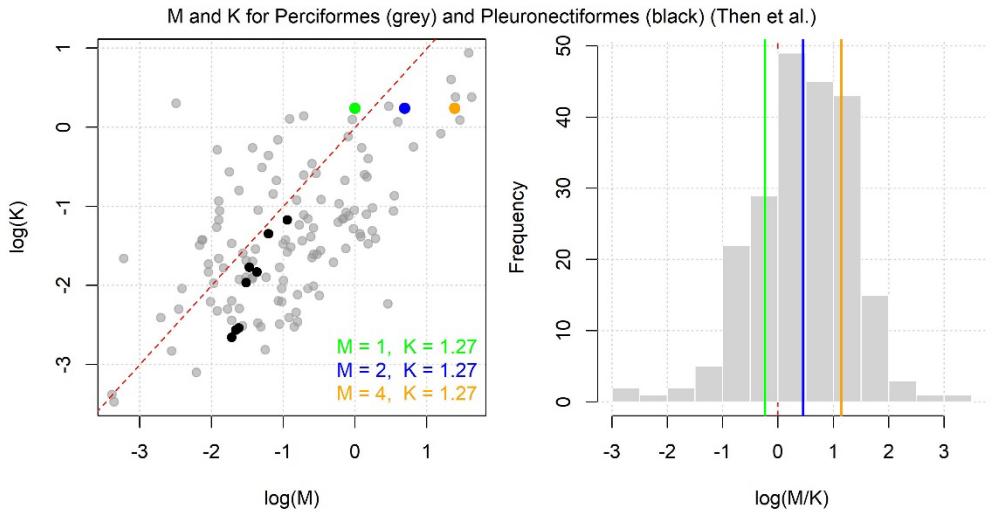


Figure 19. Meta analysis of growth rate *K* and natural mortality rate *M* from the Then et al (2015). dataset for *Perciformes* and the more closely related *Pleuronectiformes*.

A preliminary Bayesian analysis of conventional tagging data from a study by Martin et al. (currently not available for circulation), provided total annual Z (combined natural and fishing mortality rate) estimates of between 1.0 and 2.5 (90% interval) (the range for *M* is hence lower than these values depending on the assumed fishing mortality rate).

Based on these data sets this analysis assumes that *M* is likely in the range of 0.25 and 0.5 per quarter (1.0 - 2.0 per year). Note that higher *M* values are likely to be less consequential for MSE testing as they imply a more productive stock subject to lower current fishing mortality rate (challenges for meeting objectives are generally associated with lower *M* values).

Other MSE frameworks have sought to characterize parameter uncertainty only among operating models of a grid (i.e., two point values of steepness or natural mortality rate. E.g., Atlantic Bluefin Tuna, Southern Bluefin Tuna, North Atlantic Swordfish). There are several potential problems with this approach: Firstly, it dramatically compresses uncertainty among simulations within the same operating model preventing the interpretation of uncertainty for any single operating model or among operating models with the same *M* assumption; Secondly, it precludes post-hoc analysis of the role of natural mortality rate in determining performance for any given operating model; and lastly it is scientifically indefensible assumption within a framework expressly designed to characterize uncertainty.

For these reasons, operating models included multiple simulations for which *M* varied around mean values of 0.25 or 0.5 (depending on the *M* factor level) but with a CV of 10%. This 10% CV matches the most precise assumption that has been previously put forward by meta studies of Then et al. (2015)

5.7 Post Release Mortality Rate (PRM)

The mortality rate of discarded fish was determined by Rudershausen et al. (2019) with a median PRM value of 0.248 (0.053 to 0.389, 95% CI) for the US rod and reel fishery.

This was a weighted estimate based on the fraction of fish released in poor condition (PRM median 0.450, -0.066 to 0.757, 95% CI) and good condition (PRM median 0.138, 0.060 to 0.255, 95% CI).

In these analyses we assume a rate of 0.25 for PRM. Since it may be altered by management intervention PRM is considered a management lever and can be modified within candidate MPs.

6 Uncertainties

In the workshops of Petersen et al. (2021) stakeholders reported on uncertainties within the Dolphinfish fishery management system that should be incorporated into the MSE exercise.

The following uncertainties were identified by the meeting participants.

6.1 Removals

Participants highlighted the uncertainty in total removals and exploitation rate, in both the magnitude and quality of private recreational catch data and the overall magnitude of international exploitation of the stock.

6.2 Alternate Movement Patterns

Dolphinfish movement is generally expected to follow the Gulf Stream from the Caribbean up the US east coast and around the Atlantic Ocean basin back to the Caribbean. Over the past several years, the Dolphinfish population has experienced changes in movement and seasonal residency patterns. Participants suggested that Dolphinfish may be following alternate movement patterns, wherein (1) Caribbean fish are bypassing south Florida as they follow the Gulf Stream, (2) Dolphinfish are moving south from southern New England rather than following the clockwise Atlantic Ocean gyre, and (3) there are populations of resident Dolphinfish in southern New England and off the coast of South Carolina. Participants provided supporting evidence for movement pattern (1), noting that the fish available to North Carolina and surrounding waters match that of Dolphinfish that are caught in Caribbean waters, the clear reduction of Dolphinfish available in south Florida, and the clear increases in water temperature observed off south Florida in recent years.

6.3 Changing Availability and Catchability

Several mechanisms for past and future changes in availability and catchability were postulated by stakeholders. Some participants suggested that climate-driven changes in temperature, shifts in the location of the Gulf Stream, and declines in the health of Sargassum weed and changes in abundance and clustering of Sargassum weed may lead to changes in availability and catchability across regions. For example, an offshore shift in the Gulf Stream would reduce availability of Dolphinfish to fishermen off the coast of South Carolina, increasing distance of Dolphinfish from shore and forcing fishermen to rely on eddies rather than the main Gulf Stream where the fish may be more abundant, but inaccessible to many fishermen.

Further, anthropogenic changes are expected to impact the availability and catchability of Dolphinfish in the future. In the northern region, fishermen often rely on lobster pot buoys to catch Dolphinfish, which, like fish aggregating devices (FADs), congregate Dolphinfish. However, there is a push to move towards lobster pots with ropeless technology to prevent whale entanglements. This shift would likely impact catchability of Dolphinfish in these affected regions. Contrarily, offshore wind farms are being developed or are planned in several regions along the US east coast. These wind farms will result in increased structure out on the water which will undoubtedly congregate Dolphinfish and their forage. The development of these large offshore wind farms will likely increase the catchability of Dolphinfish in the northern region.

6.4 Economic Fishery Drivers

The cost of fishing is increasing in all regions, primarily driven by increasing fuel prices. This increasing cost is also exacerbated by Dolphinfish moving further offshore as reported in Wilmington, NC. This strain has certainly been felt across all sectors of the fishery.

Further, the demand for locally caught Dolphinfish varies regionally (is particularly low in the northeast region of the U.S. region) and is highly impacted by imported Dolphinfish. Imported Dolphinfish are primarily Pacific-caught, and imported Dolphinfish account for the vast majority of U.S. Dolphinfish consumption (McPherson et al. 2022). However, stakeholder participants suggested that importing has resulted in a reduction in demand and price for locally caught Dolphinfish across regions. While we can measure and analyze these economic trends from the past, it is much more challenging to predict trends in the cost of fishing and demand for charter trips and locally caught Dolphinfish in the future. Unknown future economic drivers will correspondingly impact future fishing effort.

Post-release mortality and depredation - The at-vessel and post-release mortality reportedly varies substantially by region and is particularly related to areas of high shark abundance. Shark depredation has been increasing over time, particularly in south Florida and northern North Carolina, and this has strong implications for at-vessel and post-release mortality of Dolphinfish in these regions.

Enforcement challenges - Participants highlighted challenges with enforcement, particularly related to: unlicensed fishermen selling their product to local restaurants, challenges enforcing stricter state regulations in Florida as compared to federal regulations, and for the implementation of size limits in regions where no size restrictions are currently applied. In particular, in the northern North Carolina region, some feedback included the challenges associated with measuring live Dolphinfish and some indicated that any minimum size limit would be disregarded in practice.

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7 Operating Model Dynamics

7.1 Overview

Operating models (OMs) for Dolphinfish were structured by age, fleet, season and area following the definitions outlined above. This structuring aims to capture important population and fishing dynamics including cohort strength, spatial seasonality in abundance and spatial seasonal fishing opportunities which vary among fishing fleets.

The available approaches for characterizing spatial population dynamics of fisheries (e.g., a Stock Synthesis assessment) require relatively complete data to inform movement and distribution such as conventional or electronic tagging data. Such data are not available at the spatio-temporal resolution required by Dolphinfish operating models. To overcome this limitation, a multi-step approach to OM conditioning was applied (Figure 20):

(Step 1) Estimate scale, seasonal reproduction and fishery selectivity in a spatially aggregated model (RCM);

(Step 2) Characterize movement implied by spatial indices (VAST);

(Step 3) Impose spatial structure and solve for spatial-seasonal exploitation rate by fleet;

(Step 4) Characterize and Project Seasonal Recruitment.

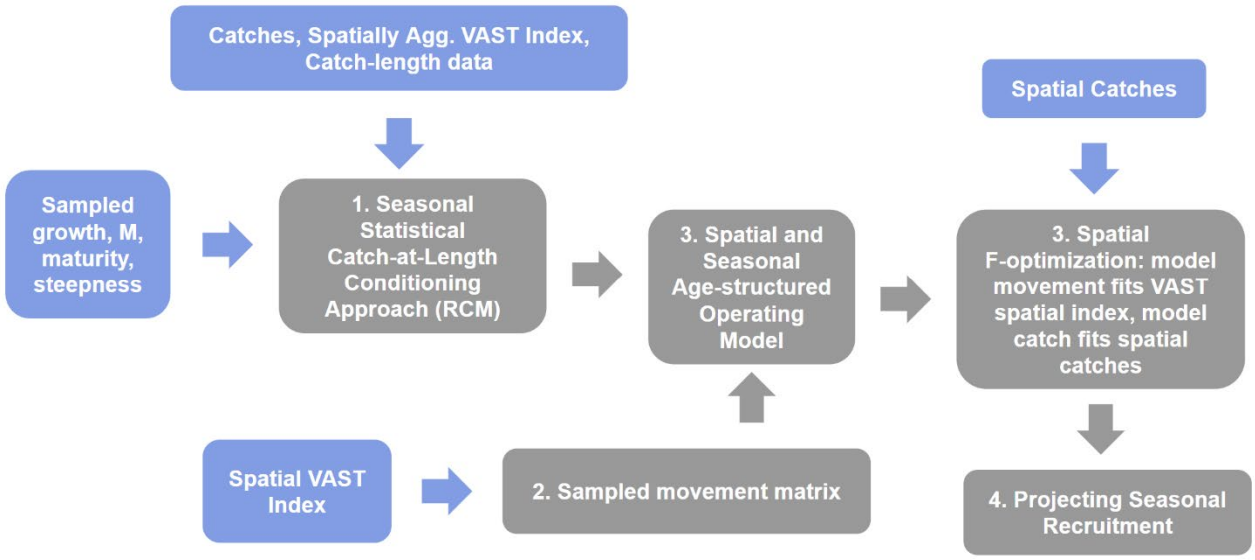


Figure 20. Sequential approach to conditioning the spatial, seasonal, multi-fleet operating model.

7.2 Step 1. Estimate Scale, Seasonal Reproduction and Fishery Selectivity in a Spatially Aggregated Model

7.2.1 RCM

All operating models were conditioned in the R statistical environment (R Core Team 2024) using the Rapid Conditioning Model (RCM, Huynh et al. 2025) of the SAMtool package (Huynh et al. 2026), one of the component libraries of the openMSE R package Hordyk et al. 2026. The RCM is a statistical catch-at-age (or catch-at-length) model similar to stock assessment frameworks such as the Woods Hole Assessment Model (WHAM; Stock and Miller 2021) in that it is implemented in R using the Template Model Builder (TMB) library for non-linear estimation (Kristensen et al. 2016). The RCM designed specifically for the conditioning of operating models in the full range of data-poor to data-rich. A key feature of RCM is the ability to conduct replicate maximum likelihood estimate (MLE) fits across sampled parameters and data sets creating stochasticity in historical dynamics.

The RCM has previously been applied as an operating model conditioning approach in various peer-reviewed applications such as evaluation of rebuilding strategies for B.C. Inside Yelloweye Rockfish (Haggarty et al. 2022), development of management procedures for B.C. Inside Quillback Rockfish (DFO 2023), four species of B.C. invertebrates (Geoduck, Manila Clam, Green Sea Urchin, Giant Red Sea Cucumber)Carruthers et al. 2025 for the Bay of Fundy Herring MSE (Carruthers et al., 2023a) and in support of the MERA approach to data-moderate fisheries management (Carruthers et al., 2023b). The RCM has also been used to demonstrate OM conditioning in preliminary MSE analyses for a range of pelagic species such as South Atlantic Swordfish (Taylor et al. 2022), North Atlantic Blue Shark (Carruthers 2024) and Pacific Neon Flying Squid (Dai 2025).

Using RCM, a multi-fleet spatially aggregated seasonal model was conditioned on annual catches, the total VAST abundance index (all areas summed) and the fleet length composition data to estimate stock-wide productivity and scale (seasonal recruitment, fishing mortality rate at age and numbers at age). The product of this RCM fit was a spatially aggregated OpenMSE operating model.

Table 10. Summary of RCM configuration and assumptions.

Model attribute	**Configuration**
Stock-recruitment relationship	Beverton-Holt
Somatic growth	von Bertalanffy
Initial depletion	Equilibrium catch
Selectivity: USCom (Intl, Disc, Unrep)	Logistic length (‘flat-topped’)
Selectivity: RecN, RecS, HireN, HireS	Double normal length (‘dome-shaped’)
VAST survey selectivity	Mirrors USCom
Maximum seasonal exploitation rate (most selected age class)	2.3 (harvest rate of 90%)
Standard deviation in log recruitment deviations (‘sigma-R’)	2.0 (nearly freely estimated)
Maximum age classes (seasons)	16
Include age-zero calculation	Yes
Include ‘plus group’ calculation	No

7.2.2 Population and Exploitation Dynamics

The operating models assume the standard equations for age-structured population dynamics that include a zero age (season zero in fact) class and a plus group. These equations along with those for fishery selectivity and exploitation rate are fully documented in the openMSE Technical Manual. For RCM, see the RCM manual and RCM model equations

The operating model was structured by season so parameters that reflect rates are 1/4 their annual value and recruitment was estimated to occur in every season. In order to allow for estimation of seasonally varying recruitment, a large value of the lognormal standard deviation on recruitment deviations was specified (‘sigma-R’ of 2.0). Post-hoc, these freely estimated recruitments were characterized to such that seasonal patterns of recruitment strength were preserved in projection years (see Section 7.5).

7.2.3 Model Initialization

The models were fitted to seasonal catches, the spatially aggregated VAST index and catch-length composition data available from 1986 - 2022. Since we know that exploitation occurred prior to 1986 it was necessary to initialize the model assuming some long-term exploitation rate. This was achieved by characterizing an equilibrium catch for each fleet, calculated as the mean of the first two years (Figure 21).

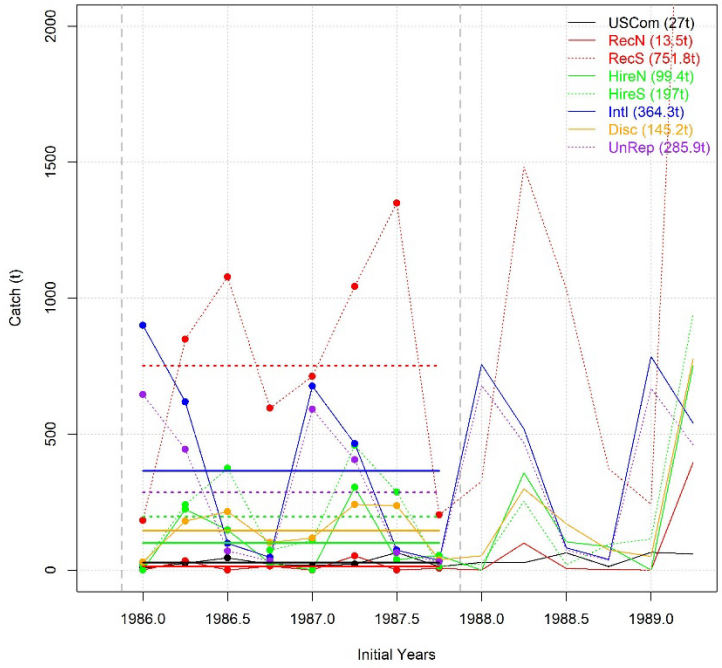


Figure 21. Equilibrium catches prior to 1986 calculated as the mean value over the first 2 years of available data (1986 and 1987).

7.2.4 Parameter Uncertainty

For each draw of model life-history parameters (growth, maturity, steepness, M) RCM conducts a maximum likelihood estimation of seasonal recruitment, unfished recruitment, selectivity parameters and annual fishing mortality rate. In this way, uncertainty in life history (which cannot be reliably co-estimated with exploitation rate, selectivity and recruitment) is captured in the multiple simulations of each operating model.

7.2.5 Objective Function

The equations of the objective functions for priors, data and penalties (e.g., seasonal Fs greater than some specified maximum) are available online from the openMSE website. Operating models were conditioned assuming lognormal likelihoods for catches, the total VAST Index and the length composition data. No ad-hoc reweighting was applied. A maximum seasonal fishing mortality rate (F) of 2.3 (harvest rate of 90%) was specified above which a penalty was applied.

Table 11. Data inputs and related likelihood functions assumed by RCM for purposes of maximum likelihood estimation.

Data Input	**Likelihood function**	**Precision**
VAST Index (biomass)	Lognormal	Annual CV (0.05 - 0.77)
Catch-length	Multinomial	Effective sample size of mean 30 across years
Catch	Lognormal	CV US Comm: 0.05
-	-	CV Rec/Hire Comm: 0.1
-	-	CV Int, Disc, Unrep: 0.15

Table 12. Estimated model parameters.

Parameter	Prior	Details	N
Recruitment Deviations	Lognormal (St. Dev = 2)	148 season-years + n age classes -1	163
Selectivity Parameters	Uninformative Lognormal (St.Dev = 3)	4 Rec fleets are 3 parameter dome (12) plus a 2 parameter logistic for USCom	14
Apical F	None	148 season-years, 8 fleets (note some season-fleets have zero catches and F is not estimated)	982
Unfished recruitment	None	Recruitments 1990 - 2021.75 (first 16 and last 4 seasons are not estimated)	128
Catchability (VAST)	None	Scales VAST index to total biomass	1
-	-	Total	1288

7.2.6 RCM Model Fitting Reports

The RCM model includes standardized reporting that describes inputs, model estimates, likelihood components and visualizes fit to data.

RCM model fitting reports are available for all reference case operating models. Note that reference operating model factors relating to future recruitment and movement are added post-hoc to the fitted spatial aggregated operating models of conditioning step 1. Hence there are eight conditioned operating models spanning two levels for natural mortality, steepness and historical catch levels. The RCM fitting reports for the eight conditioned OMs are available in the following table:

7.3 Step 2. Characterize Movement Implied by Spatial Indices (VAST)

Seasonal movement dynamics that match the distribution of the spatial VAST index (5 areas) were superimposed to create a spatial operating model (adding a spatial dimension to the RCM - estimated OM).

The seasonal spatial predictions of the VAST model can be used to calculate a Markov movement matrix \(\Delta\) for every historical transition (Figure 22). To estimate all movement transitions from each area to each area would require information on each of these transitions (e.g., from a very extensive tagging study). In this case we only have the starting distribution (the fraction in each area going into the movement matrix) \(D_{t-1,from}\), from the previous time step \(t-1\) and the resulting fraction in each area \(D_{t, to}\) in the subsequent timestep \(t\) as a result of the movement.

In this application we use the gravity model formulation of Carruthers et al. (2011) and Taylor et al. (2011) which is suitably constrained. This approach aims for a given level of mean viscosity (probability of staying in each area - the positive diagonal) by adjusting a gravity parameter \(g\) and a viscosity parameter \(v\) by area.

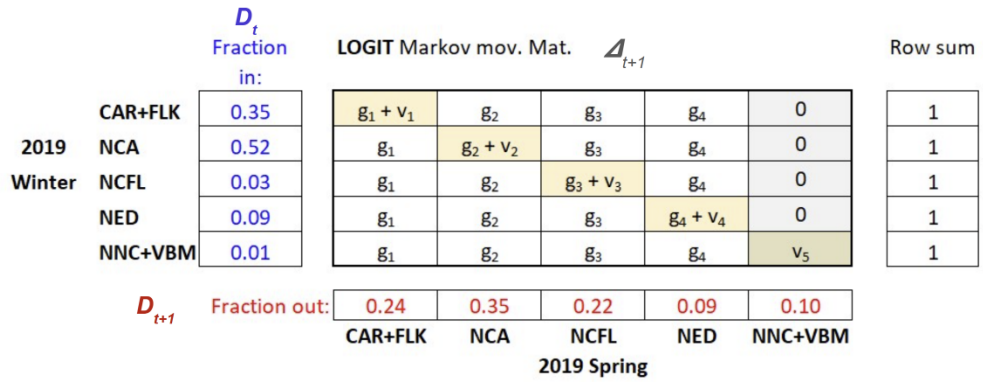


Figure 22. The estimation of a constrained Markov movement matrix for a single year and season, with \(n_{areas}-1\) gravity parameters \(g\), and \(n_{areas}\) viscosity parameters (viscosities \(v\), have an informative prior).

The movement transitions are first calculated in the logit space:

\[m_{t, from, to} = g_{t, to}+v_{t, to}, \quad \text{if } from = to \] \[m_{t, from, to} = g_{t, to} \quad \text{if } from \neq to \] The \(g\) terms are freely estimated. Since each row of the Markov matrix is constrained to sum to 1, there are \(n_{areas} - 1\) degress of freedom, the final gravity term for the last area has a fixed value of zero.

\[g_{t, n_{areas}} = 0 \] These logit-space movement terms are then transformed such that each row of the movement matrix sums to 1:

\[\Delta_{t, from, to} = e^{m_{t, from, to}} / \sum_{to=1}^{n_{areas}}e^{m_{t, from, to}} \]

The predicted distribution \(\hat{D_{t}}\) is given by:

\[\hat{D_{t}} = D_{t-1}\Delta_{t}\]

Estimation of the \(g\) and \(v\) terms was conducted in R using the 'nlminb' function for non-linear estimation. There were three components to the negative log likelihood function: fit to the observed VAST distribution \(D_{to}\), fit to a user-specified level of stock viscosity \(V\) and a weak prior for the \(g\) and \(v\) terms.

Component 1: Fit to the observed distribution \(D_{t}\) was evaluated with a relatively precise normal likelihood function:

\[log(D_{t}) \sim N(log(\hat{D_{t}}), 0.025)\]

Component 2: A user-specified target viscosity (probability of staying) \(V\) was used to estimate movement matrices with varying levels of viscosity:

\[log(\Delta_{t,from,to}) \sim N(log(V), 0.35), \quad \text{where } from = to\]

Component 3: To improve numerical stability of the estimation, all terms were assigned a very weak normal prior (impact on estimated values was negligible):

\[g \sim N(0, 5) \] \[v \sim N(0, 5) \]

This approach was able to characterize the historical predictions of the VAST model relatively well (Figure 23) given varying specification of target viscosity \(V\) (Figures 23 and 24).

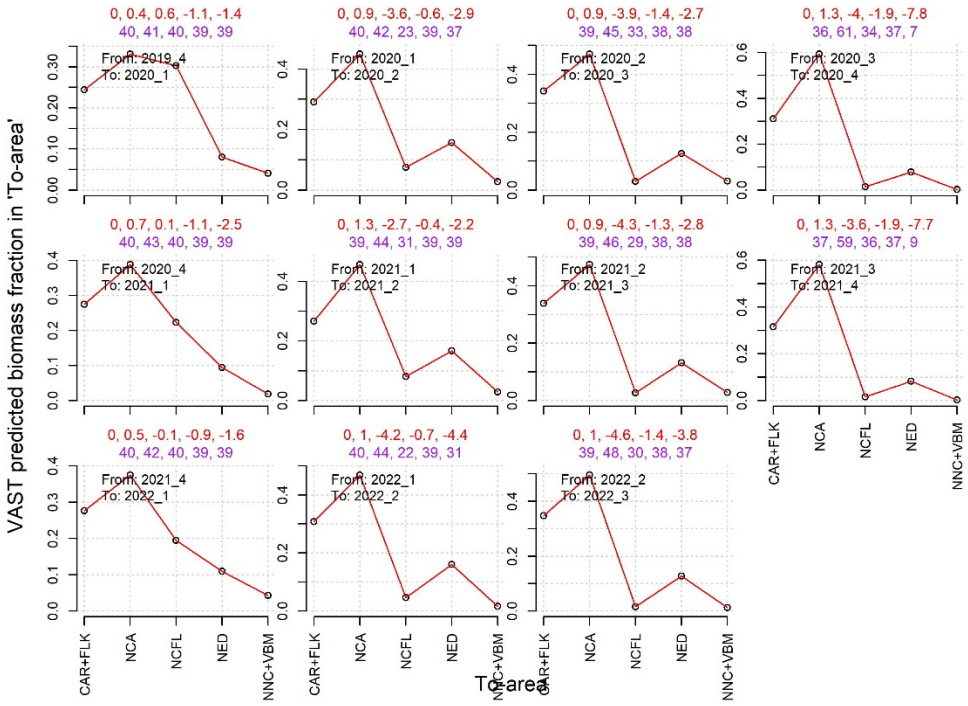


Figure 23. Fit of the markov movement matrix to a series of example transitions with a user-specified target viscosity of 40 per cent. The red numbers at the top of each panel are the estimated gravity terms *g*. The purple numbers are the estimated probability of staying. Note that these may or may not match the target (a prior) specified due to the fraction that remains in the area between time steps.

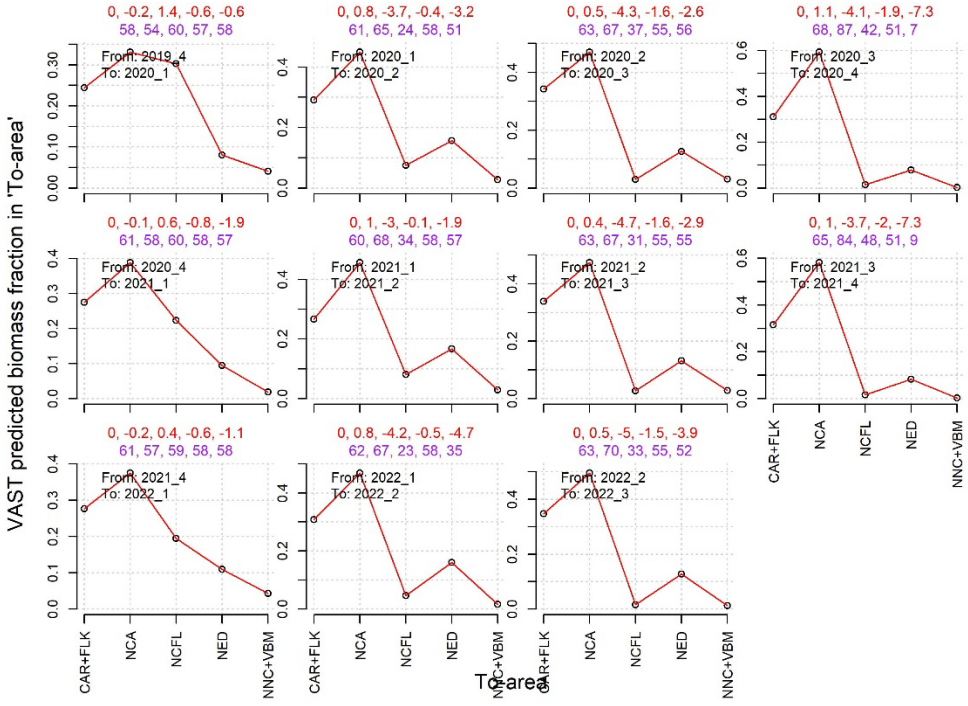


Figure 24. Fit of the markov movement matrix to a series of example transitions with a user-specified target viscosity of 60 per cent.

In order to account for historical uncertainty in movement, \(g\) and \(v\) parameters were drawn from a multivariate normal distribution with the variance-covariance matrix calculated from the nlminb model fit (inverse Hessian matrix).

For projection years, in order to preserve historical patterns of seasonality, individual years (sets of 4 seasonal movements) were sampled at random with replacement to construct the projected movements (Figure 25).

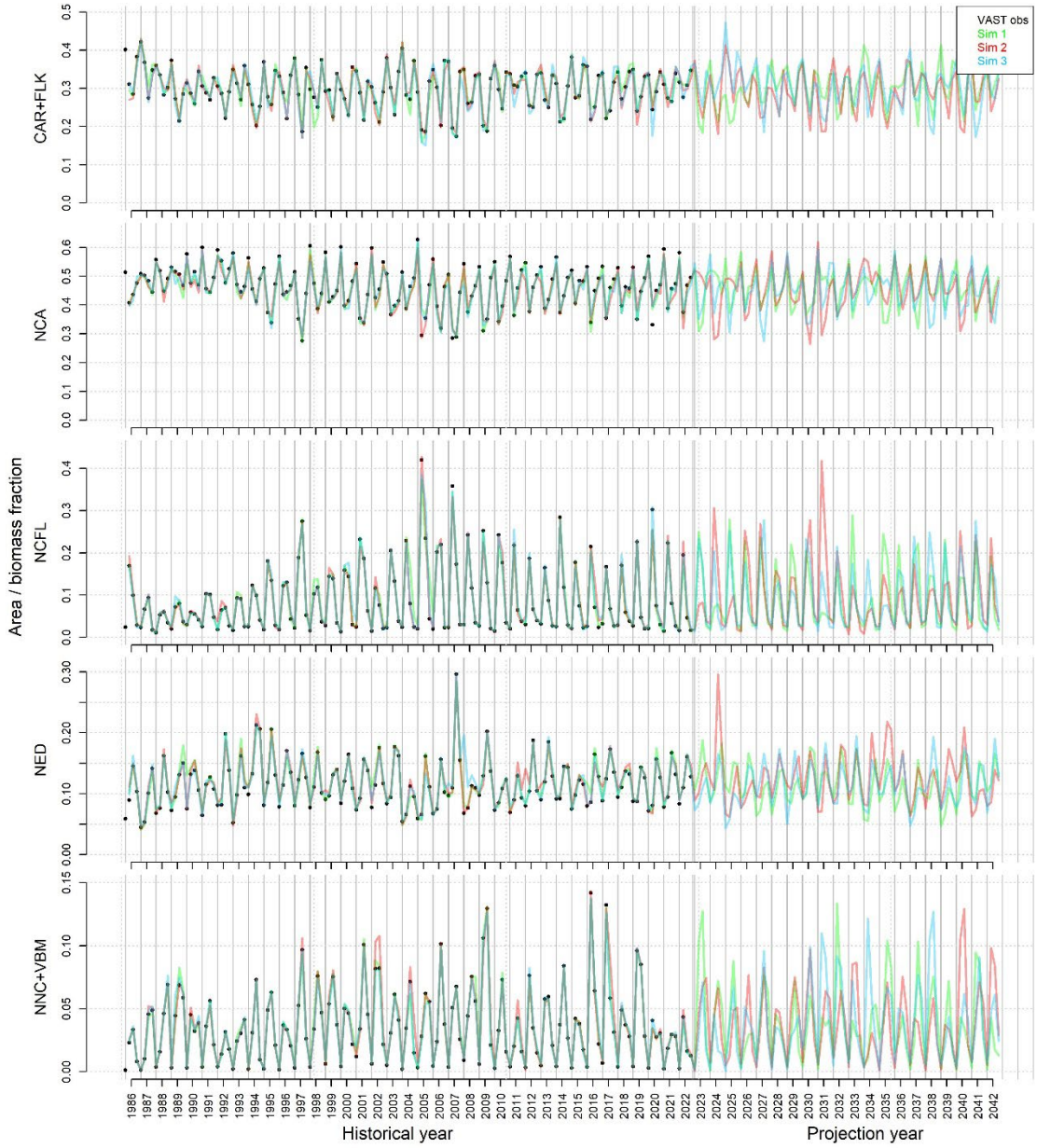


Figure 25. The historical and projected simulation of seasonal-spatial distribution with a user-specified target viscosity of 40 per cent.

7.4 Step 3. Impose Spatial Structure and Solve for Spatial-Seasonal Exploitation Rate by Fleet

The spatially-aggregated RCM operating model was extended to a spatial model by superimposing the movement matrices calculated in step 2 above. These movement matrices provide a distribution of stock

biomass that closely matches the spatial VAST index. A key requirement of the operating models is that they match the historical pattern of spatial exploitation rate.

To achieve this, we employed an iterative numerical approach known as Walrasian Tatonnement which has been used to solve for very complex fishery exploitation dynamics across many hundreds of stocks (Carruthers et al. 2019) and for density dependence within stock assessments (Carruthers and Wang 2026, in review).

An initial distribution of historical exploitation rate (apical F, the exploitation rate of the most selected age class) by time step t, simulation s, fleet f and area r, was proposed. This initial guess is calculated by dividing observed spatial catches C_{obs} by the VAST spatial distribution D multiplied by the spatially aggregated OM estimate of stock biomass B_{agg}:

$$ F_{1,s, t,r,f} = C_{obs,t,r,f}/({B_{agg,s,t} D_{t,r}}) $$ For reasons of numerical stability a maximum value of 0.8 was assumed for the F terms in this initial step.

The spatial operating model can now be initialized providing a prediction of spatial catches C_{pred}. Over 15 iterations, the spatial exploitation rates were updated such that the operating model prediction of spatial catches closely matched those observed. In each iteration i the ratios of observed to predicted catches were calculated:

$$ \delta_{i,s,t,r,f} = C_{obs,t,r,f} / C_{pred,i-1,s,t,r,f} $$ For the next iteration exploitation rate are updated according to this ratio and an adjustment factor. The adjustment factor is needed to slowly move the numerical approach to a stable equilibrium. Immediately updating the historical F distribution according to δ would lead to instability and ‘flip-flopping’ as previous values of F would impact those in subsequent time steps. Here a relatively large (there are few cohorts and reduced impact of F on subsequent biomass compared with longer lived species) adjustment factor of 0.7 was assumed:

$$ F_{i,t, s, t,r,f} = \exp(0.7 \cdot \log(\delta_{i,s,t,r,f})) \cdot F_{i-1,t, s, t,r,f} $$ A maximum F in any time step of 2.3 (harvest rate of 90%) was imposed.

In this application running the algorithm for 15 iterations was to ensure convergence. For most operating models, catches were very close to those observed after just 8 iterations (Figures 26 - 28).

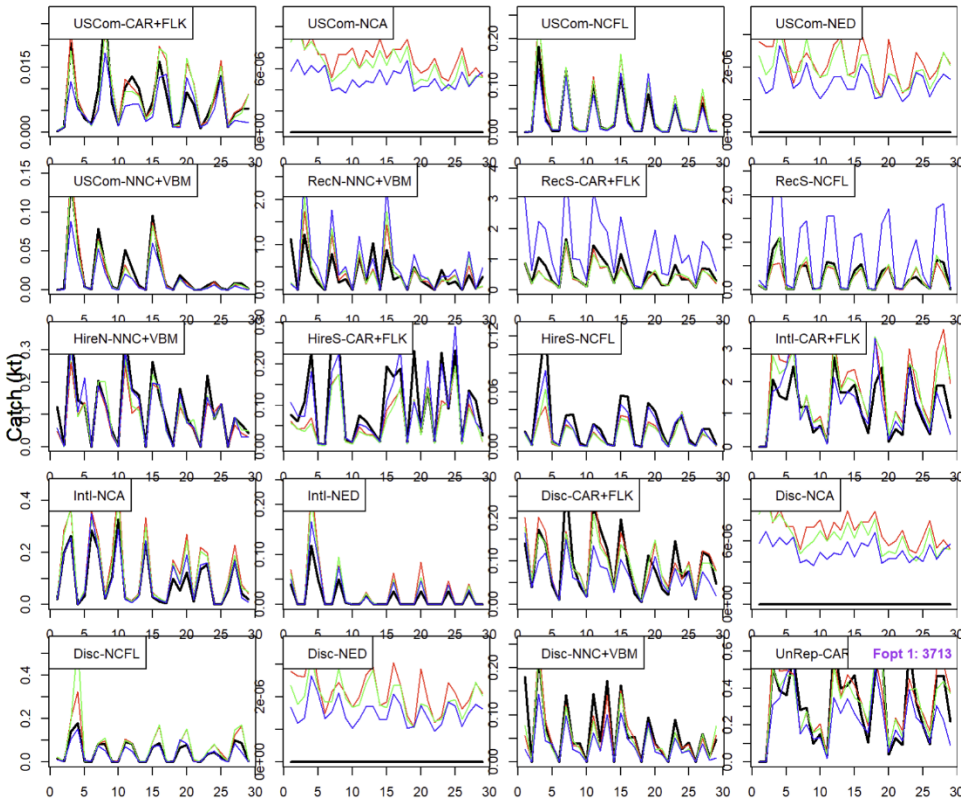


Figure 26. Observed versus predicted catches (x axis is time-step index) for the first iteration of the algorithm based on the initial guess of spatial exploitation rate.

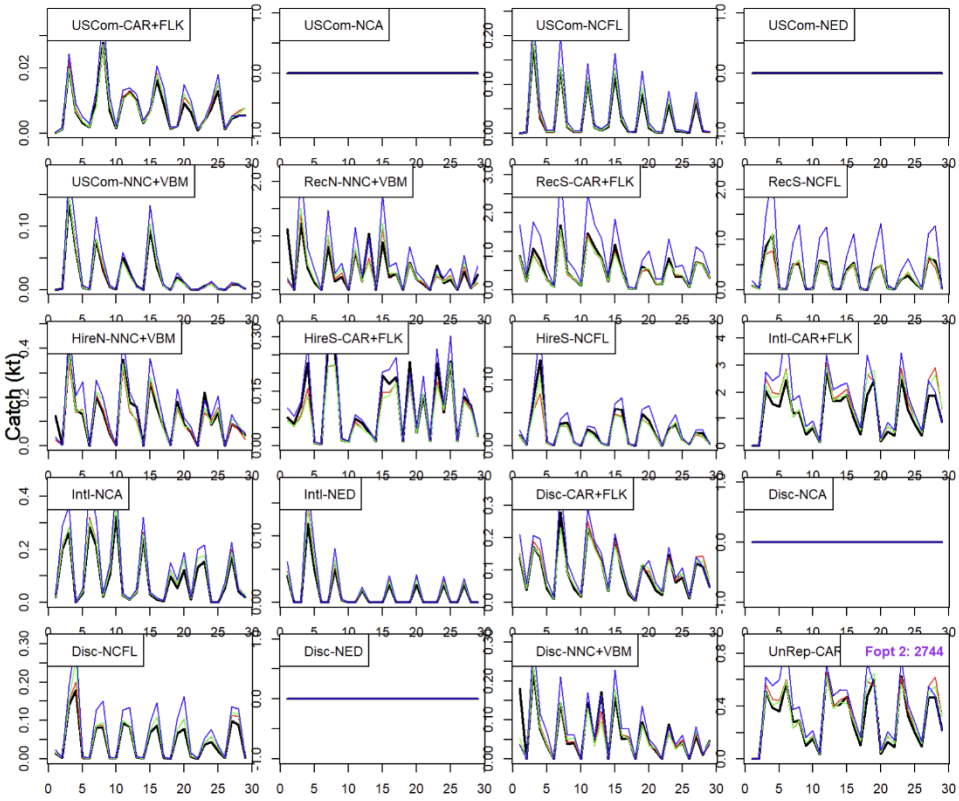


Figure 27. Observed versus predicted catches (x axis is time-step index) for the second iteration of the algorithm in which the initial guess of spatial exploitation rate has been updated once.

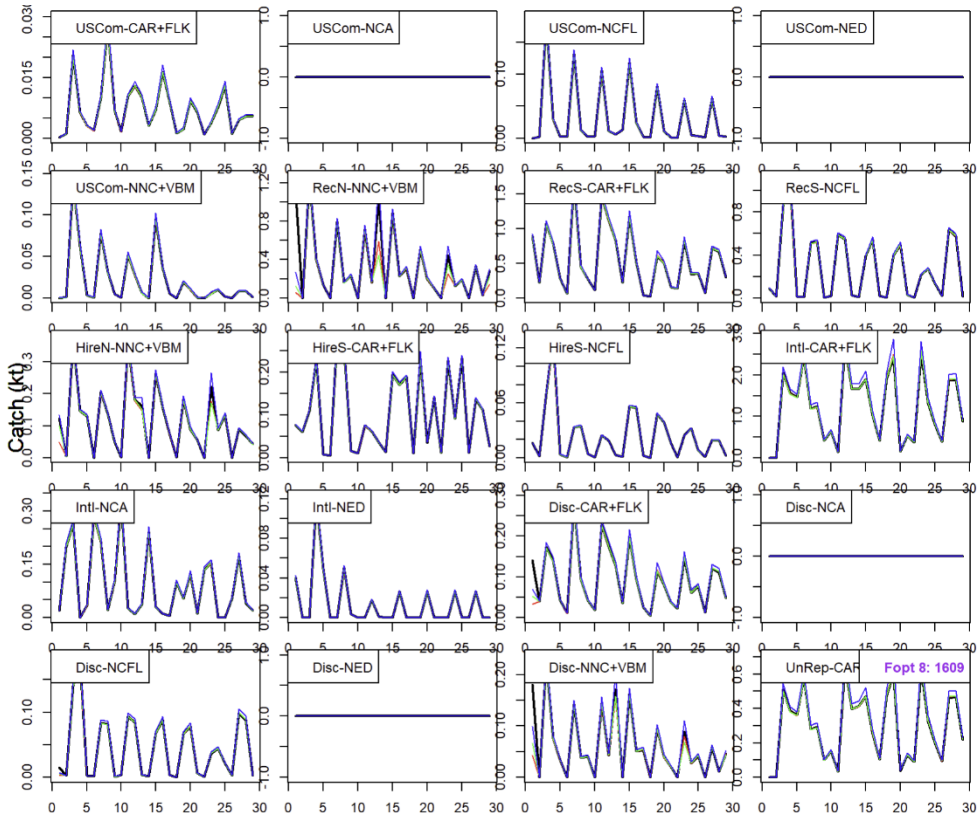


Figure 28. Observed versus predicted catches (x axis is the historical time-step) after 8 iterations of the algorithm in which the initial guess of spatial exploitation rate has been updated seven times.

7.5 Step 4. Characterize and Project Seasonal Recruitment.

Historical recruitment deviations were sampled assuming a multivariate normal distribution specified by the variance-covariance matrix of parameters from the RCM model fitting.

In order to characterize the seasonal pattern in recruitment for use in projections, historical mean and variance were characterized for each season. Future seasonal recruitment deviations were then sampled according to truncated log-normal distributions (deviations greater than 6 were resampled) using those mean and variance estimates. Lag-1 autocorrelation among historical estimates was low for each season and therefore future deviates were sampled independently (Figure 29).

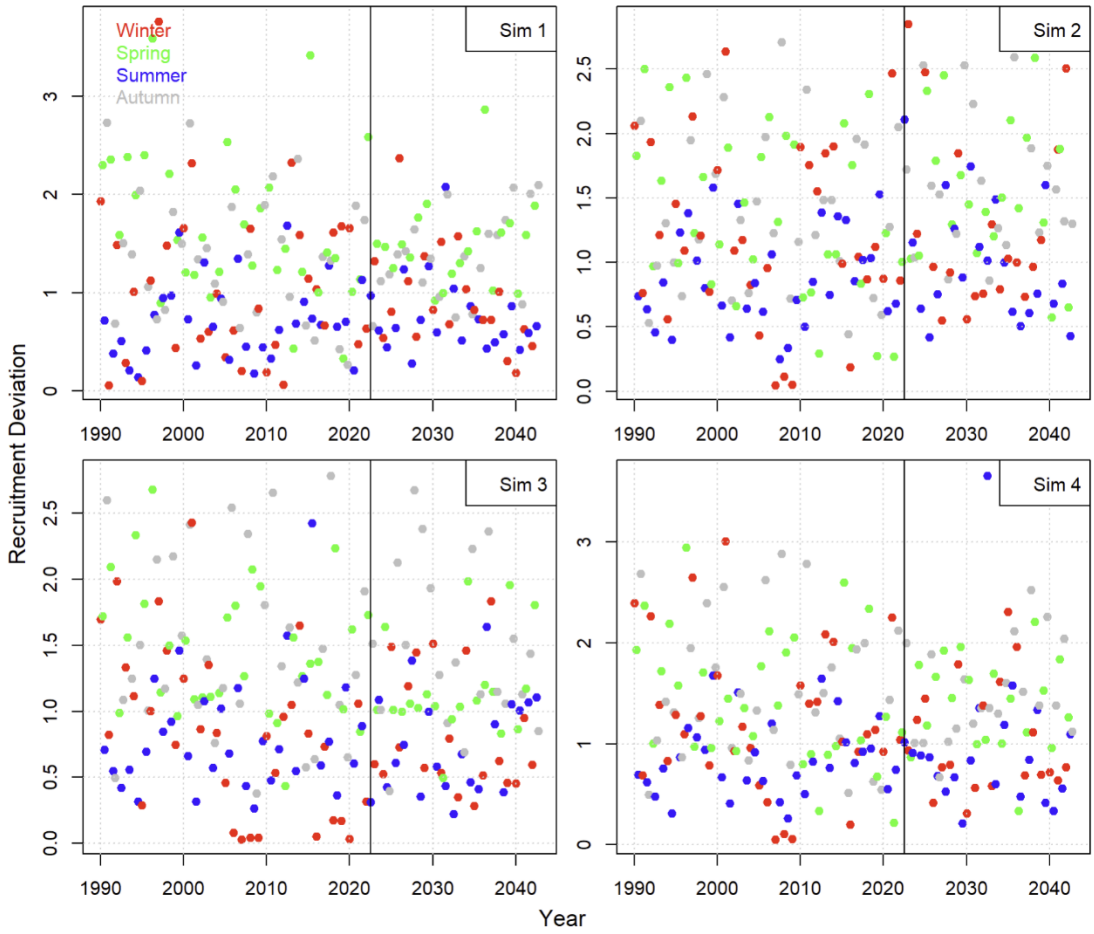


Figure 29. Historical estimated recruitment for four simulations, including simulated projected recruitment.

7.6 Conclusions: The Sequential Operating Model Conditioning Approach.

This sequential approach to conditioning operating models for Dolphinfish captures the important properties of dolphinfish dynamics;

- Plausible scale and recruitment variability (Step 1: Estimate scale, seasonal reproduction and fishery selectivity in a spatially aggregated model)
- Captures uncertainty in stock and fishery dynamics (stochastic inputs for *M*, *K* and stochastic estimates of selectivity, Estimate scale, seasonal reproduction and fishery selectivity in a spatially aggregated model)
- Absolute abundance differences among areas (Step 2: Characterize movement implied by spatial indices (VAST))
- Seasonality in abundance (Step 2: Characterize movement implied by spatial indices (VAST))
- Varying seasonality among areas (Step 2: Characterize movement implied by spatial indices (VAST))
- Matches spatial catches by fleet and season. (Step 3: Imposing Spatial Structure and Solving for Spatial Exploitation Rate)
- Captures and projects seasonality in recruitment (Step 4: Characterize and Project Seasonal Recruitment)

8 Trial Specifications
8.1 Reference Grid Operating Models

8.1.1 Overview of Reference Grid

Reference operating models are intended to capture the primary uncertainties relating to stock, fishery, observation and implementation dynamics. In most MSE settings, typical reference OM uncertainties are similar to common sensitivity analyses for stock assessment models including:

- stock status (e.g., spawning biomass relative to unfished levels)
- productivity (e.g., mean recruitment level, natural mortality rate, somatic growth)
- resilience (i.e., steepness or compensation ratio)
- magnitude of historical observed catches
- weighting of conflicting stock trend information

Reference set operating models serve as the core basis for comparatively evaluating the performance of candidate management procedures (CMPs). These reference set operating models may be weighted to reflect varying plausibility of the simulated scenarios. In general, reference operating models may be empirically derived and are not specified from only expert judgement or other subjective approaches.

For Dolphinfish, spatial considerations of stock distribution, stock mixing and fishing opportunity are additional key uncertainties. Preliminary reference operating models were designed as an orthogonal grid of 5 factors with two levels of each factor. Those factors included natural survival (*M*), magnitude in mean recruitment (based on time periods of historical estimated recruitment), stock resilience (steepness), spatial distribution and stock viscosity. With two levels for each factor this leads to a total of 32 operating models (Table 13). Uncertainty in stock status is included within operating models of the reference grid and characterized by stochasticity among the RCM conditioned simulations in each operating model.

The reference set is a fully orthogonal grid with two levels for each of five factors.

Table 13. The factors and levels of the orthogonal grid of reference operating models.

Uncertainty	**Level 1**	**Level 2**
Natural Mortality	Low (m): 0.25 per season	High (M): 0.5 per season
Resilience (steepness)	Low (s): 0.7	High (S): 0.95
Catch levels of Disc and Unrep	Low (c): half NOAA calculated	High (C):100% NOAA calculated
Recruitment Level	Low (r) 75% historical mean levels	High (R) 100% historical mean levels
Viscosity	Low (v): prob. stay. = 0.4	High (V) prob. stay. = 0.6

These 32 operating models are organized in the general order of most (OM_1) to least (OM_32) challenging test of an MP:

Code	M	Steep	CatRec	Visc
OM_1	0.25	0.70	0.50.75	60
OM_2	0.50	0.70	0.50.75	60
OM_3	0.25	0.95	0.50.75	60
OM_4	0.50	0.95	0.50.75	60
OM_5	0.25	0.70	1.00.75	60
OM_6	0.50	0.70	1.00.75	60
OM_7	0.25	0.95	1.00.75	60
OM_8	0.50	0.95	1.00.75	60
OM_9	0.25	0.70	0.51.00	60
OM_10	0.50	0.70	0.51.00	60
OM_11	0.25	0.95	0.51.00	60
OM_12	0.50	0.95	0.51.00	60
OM_13	0.25	0.70	1.01.00	60
OM_14	0.50	0.70	1.01.00	60
OM_15	0.25	0.95	1.01.00	60
OM_16	0.50	0.95	1.01.00	60
OM_17	0.25	0.70	0.50.75	40
OM_18	0.50	0.70	0.50.75	40
OM_19	0.25	0.95	0.50.75	40
OM_20	0.50	0.95	0.50.75	40
OM_21	0.25	0.70	1.00.75	40
OM_22	0.50	0.70	1.00.75	40
OM_23	0.25	0.95	1.00.75	40
OM_24	0.50	0.95	1.00.75	40
OM_25	0.25	0.70	0.51.00	40
OM_26	0.50	0.70	0.51.00	40
OM_27	0.25	0.95	0.51.00	40
OM_28	0.50	0.95	0.51.00	40
OM_29	0.25	0.70	1.01.00	40
OM_30	0.50	0.70	1.01.00	40
OM_31	0.25	0.95	1.01.00	40
OM_32	0.50	0.95	1.01.00	40

8.1.2 Factor 1: Natural Mortality Rate

The two mean levels of natural mortality rate selected as suitable bounds (0.25 and 0.5 per season, see section ‘Natural Mortality Rate’ above) were imposed on operating models assuming a 10% coefficient of variation to propagate uncertainty across simulations (Figure 30). Adding within-OM uncertainty means that no subset of operating models have a point-value for parameters that are unknown and also provides a range of parameter values for evaluating performance gradients (e.g., “How does yield of a given MP vary across values of natural mortality rate versus steepness”?).

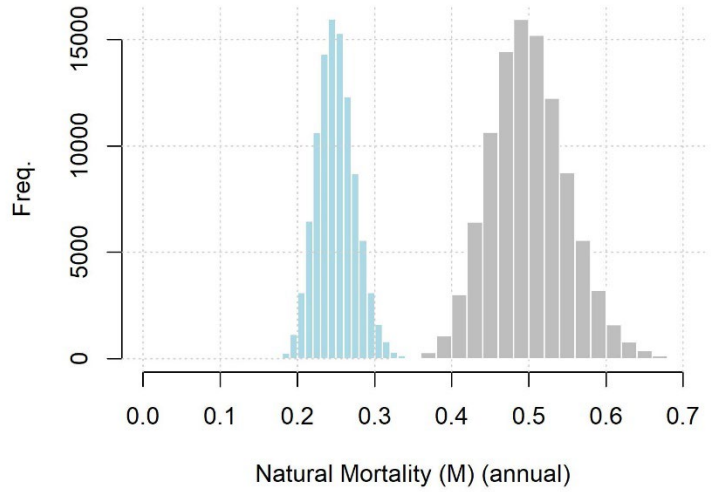


Figure 30. Distribution of seasonal natural mortality rate sampled for operating models of the reference grid (low: mean = 0.25, high: mean = 0.5).

8.1.3 Factor 2: Steepness of the Beverton-Holt Stock-Recruitment Relationship

In this MSE we bracket mean steepness with disparate values of 0.7 and 0.95 (a value of 1 may lead to indeterminate MSY reference points) (See section 'Stock-Recruitment and Resilience' above). As with *M*, steepness was sampled from a distribution of values (sd = 0.025) to impose within-OM uncertainty (Figure 31).

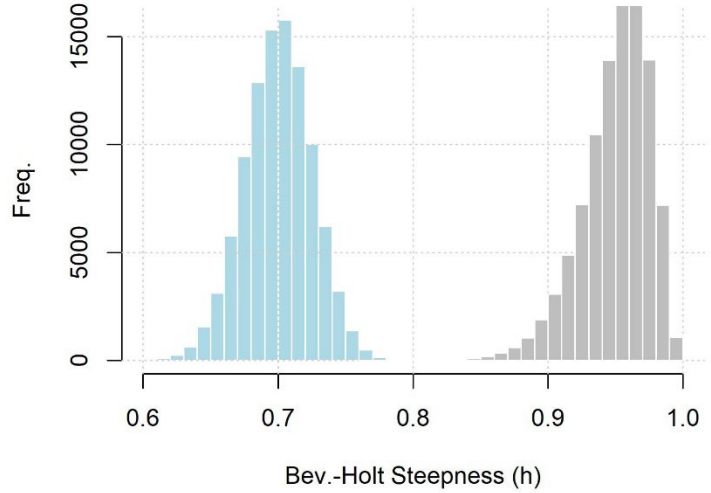


Figure 31. Distribution of steepness (Beverton-Holt stock-recruitment relationship) sampled for operating models of the reference grid (low: mean = 0.7, high: mean = 0.95).

8.1.4 Factor 3: Catch Magnitude of Discard and Unreported Fleets

In order to capture uncertainty in the magnitude of discard and unreported fleets, 50% and 100% of the base catch for these fleets were selected as appropriate levels. Note that lower catches are the relevant direction of uncertainty since these infer a smaller overall stock subject to a higher fraction of exploitation by the US fleets for which MPs are to be tested.

8.1.5 Factor 4: Future Recruitment Strength

RCM model fits followed the reduction in the VAST index over the most recent four years, during which estimated recruitment has declined more than can be predicted by spawning biomass changes. Recruitment deviations (the additional process error not explained by spawning biomass) over the most recent 4 years are approximately 75% of the preceding historical years (Figure 32).

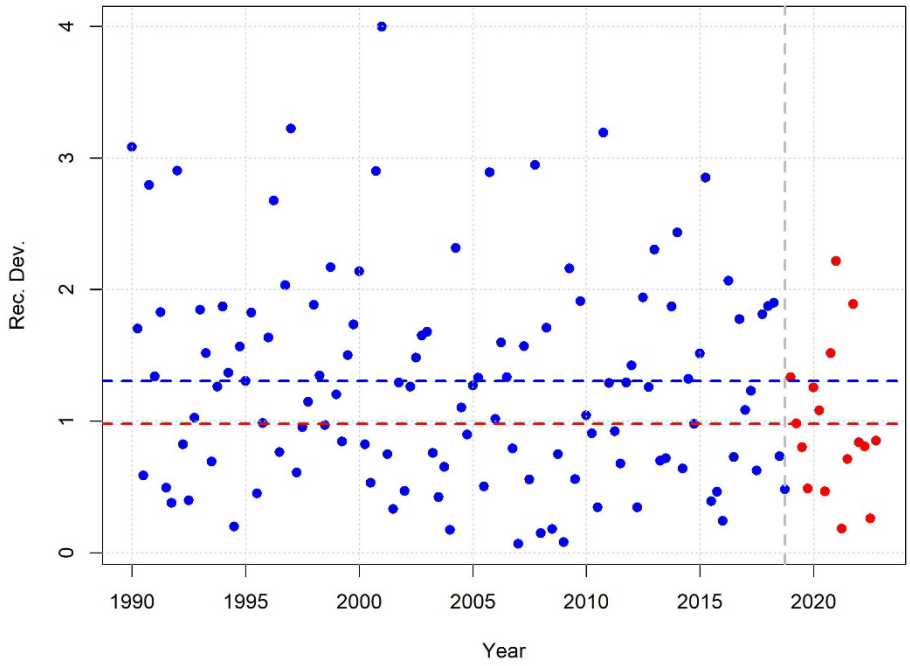


Figure 32. Example of maximum likelihood estimates of recruitment deviations (first simulation of OM #1).

It is not clear whether the stock will revert to the long-term mean recruitment deviations or remain at a lower than expected level. To recognized this uncertainty and characterize it, projections of recruitment assume that these are sampled stochastically with autocorrelation around a mean level that is 75% and 100% of historical levels.

8.1.6 Factor 5: Spatial Mixing and Movement

Using a gravity model, movement matrices were calculated that matched the biomass changes inferred by the VAST spatial index while aiming for a specified probability of the stock staying in the same area among seasons.

Below are two examples where a movement matrix is calculated that correctly moves the distribution of fish inferred by the VAST index in Summer 2022, redistributing this in Autumn 2022 (Figure 33).

```
> fracsin
   CAR+FLK        NCA       NCFL        NED    NNC+VBM
0.30832493 0.46822801 0.04626861 0.16069720 0.01648125
> fracsout
   CAR+FLK        NCA       NCFL        NED    NNC+VBM
0.34726498 0.49513125 0.01671025 0.12810504 0.01278848
> out$mov
          [,1]      [,2]        [,3]       [,4]        [,5]
[1,] 0.3861641 0.5543079 0.002025892 0.05270793 0.004794152
[2,] 0.4066076 0.4770536 0.003959311 0.10301001 0.009369475
[3,] 0.1772700 0.4722960 0.301439631 0.04490959 0.004084839
[4,] 0.1680066 0.4476159 0.001635952 0.37887015 0.003871383
[5,] 0.1601824 0.4267699 0.001559764 0.04058061 0.370907409
> out$predfracsout
          [,1]      [,2]       [,3]      [,4]       [,5]
[1,] 0.3472893 0.4950936 0.01671429 0.1281134 0.01278934
```

Figure 33. Example of a movement matrix derived from the gravity modelling approach that aims for 40% probability of staying (positive diagonal) while correctly moving the distribution of fish in Summer 2022 (fracsin) to match the distribution of fish in Autumn 2022 (fracsout).

```
> fracsin
   CAR+FLK        NCA       NCFL        NED    NNC+VBM
0.30832493 0.46822801 0.04626861 0.16069720 0.01648125
> fracsout
   CAR+FLK        NCA       NCFL        NED    NNC+VBM
0.34726498 0.49513125 0.01671025 0.12810504 0.01278848
> out$mov
          [,1]      [,2]        [,3]       [,4]        [,5]
[1,] 0.6333967 0.3207691 0.001315388 0.04070642 0.003812373
[2,] 0.2399448 0.7013578 0.001684548 0.05213055 0.004882304
[3,] 0.2267722 0.3882402 0.331104680 0.04926866 0.004614273
[4,] 0.1644797 0.2815937 0.001154740 0.54942514 0.003346769
[5,] 0.1633289 0.2796235 0.001146661 0.03548493 0.520416015
> out$predfracsout
          [,1]      [,2]       [,3]      [,4]      [,5]
[1,] 0.3472566 0.4951197 0.01671854 0.1281153 0.0127899
```

Figure 34. Example of a movement matrix derived from the gravity modelling approach that aims for 60% probability of staying (positive diagonal) while correctly moving the distribution of fish in Summer 2022 (fracsin) to match the distribution of fish in Autumn 2022 (fracsout).

Movement matrices were calculated for target probabilities of staying of 20%, 40%, 60% and 80%. Levels of 40% and 60% were used in the reference set for the factor ‘spatial mixing and movement’. Levels of 20% and 80% probability of staying were used to specify robustness operating models.

8.2 Reference Case Operating Model

The reference case operating model is a single well-characterized and well-understood hypothesis that serves as a familiar and concise basis for quickly investigating sensitivities, alternative MPs etc. It is a tool for efficiently obtaining quantitative answers to working group questions (e.g., “does it make a difference to MP selection if historical catches are under reported”?).

The current Reference Case operating model is OM_29 that has low M, low steepness, full historical catches, continuation of historical mean recruitment and high stock mixing.

8.3 Plausibility Weighting

Given the high uncertainty regarding Dolphinfish life history dynamics, fishery exploitation and stock mixing, reference set operating models are currently considered as equally plausible. Future phases of MSE development may include processes to add weighting of operating models which may affect both MP tuning and the presentation of CMP performance outcomes.

8.4 Robustness Set Operating Models

Robustness set operating models represent secondary uncertainties that may not be well informed by data, involve alternative future scenarios that are derived from subjective judgement or represent the viewpoints or experience of particular stakeholders or scientists. The purpose of the robustness operating models is to provide a means of further discrimination among management procedures that perform similarly for the reference set of operating models. Robustness operating models also provide performance outcomes for hypotheses specific to certain stakeholder groups (e.g., "how will northward shifts in biomass affect catch outcomes for Florida fisheries"?).

Table 14. Robustness operating models. Single factor variants of the reference case operating model.

Code	Type	Description
ROM_C1	Catches	IUU increases by 1% every year
ROM_C2	Catches	Catches halved for non-US fleets in area 1 (Florida and Caribbean)
ROM_R1	Recruitment	Future recruitment declines 1% per year
ROM_R2	Recruitment	Future recruitment reduces by 25% after 5 years
ROM_R3	Recruitment	Future recruitment reduces by 25% after 10 years
ROM_R4	Recruitment	Future recruitment is 50% more variable
ROM_S1	Spatial	Two percent decline in CAR and SFL, 1 percent increase in SE, 2% increase in NC and NE
ROM_S2	Spatial	50% greater variability in spatial / seasonal distribution
ROM_S3	Spatial	1% pa. increase in catchability reflecting range contraction
ROM_S4	Spatial	20% target probability of staying
ROM_S5	Spatial	80% target probability of staying
ROM_P1	Productivity	1% pa. decrease in somatic growth rate (k)
ROM_P2	Productivity	1% pa. decrease in condition factor (weight at length)
ROM_P3	Productivity	1% pa. increase in natural mortality rate (all ages)
ROM_F1	Fishery	33% shorter selectivity of all fleets (inflection point)
ROM_F2	Fishery	Projected shift towards 33% younger selectivity of all fleets (inflection point)

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9 Simulating Data

9.1 Historical Data

All historical observations (indices, catches, catch compositions) are considered known and these values do not vary among operating models or simulations. Only future data vary that are the product of population, fishery and observation processes that are part of the closed-loop simulation.

9.2 Generation of Future Data for Input to Management Procedures

When an RCM model is fitted to catches, indices and length composition data, the properties of the observation error model (that generates future data of comparable quality to those observed historically) is calculated from the fit of each simulation to the observed data. For example, if a simulation fits the data well (has low residual error and few runs in residuals) then future observations of those data will be generated with commensurately high precision and low lag-1 autocorrelation (that determines whether data are consistently over or under the true simulated value). Conversely, if a simulation (a fit of the model to the data) does not fit the data well, then those data are simulated with higher precision and, if there are runs in residuals, higher lag-1 autocorrelation. For composition data, the effective sample size of historical data is assumed for future simulations. In this application only index data are used by the candidate management procedures. Future revisions to this MSE framework may introduce model-based MPs that can make use of both catch and catch composition data.

9.3 Simulating Indices

A number of indices have been proposed for use in an empirical management procedure ('empirical' because it calculates advice directly from data without a estimation step, such as a stock assessment model).The primary index for CMP development has been the U.S. pelagic longline index in season 1 (Winter), area 1 (CAR + FLK)

The approach to simulating indices is the same as in MSE frameworks elsewhere. On a simulation by simulation basis, the statistical properties of the index are characterized (Figure 35):

- Constant of proportionality (catchability or 'q')
- Lognormal standard deviation (expressed as a coefficient of variation (CV))
- Lag-1 autocorrelation.

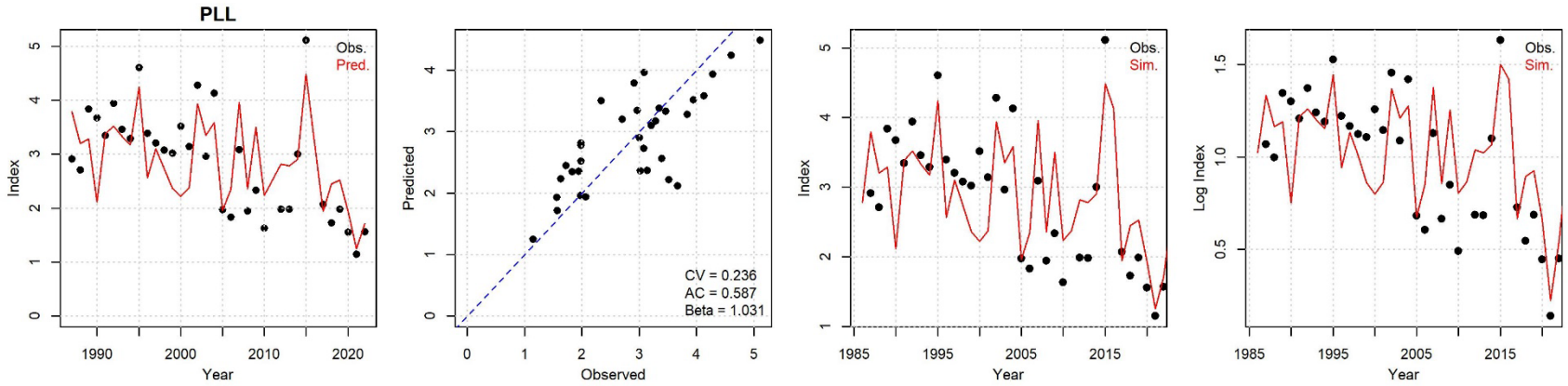


Figure 35. Calculation of statistical properties for a single simulation of the reference case operating model (OM_29). The black dots are the U.S. pelagic longline index, the red line is the true vulnerable biomass from the historical period of the simulation.

The mahiMP management procedure retains the ability to specify statistical properties of indices for exploratory purposes ('value of information' analyses).

9.4 Other Potential Indices

A number of other data inputs to MP have been identified but not yet formalized. These include:

- A Puerto Rico Tournament Index (PLL vulnerable biomass, season 1, area 1).
- The SST-based 'Blue Blob' environmental index - above/below average classifier of stock availability (total biomass, over all areas and seasons)
- The ENSO environmental index - above/below average classifier of stock availability (total biomass over all areas and seasons).
- MRIP Recreational Catch Rate Index (US recreational fleets vulnerable biomass, season 2 & 3, US EEZ areas)

10 Performance Measures / Statistics

10.1 Conceptual Management Objectives

A series of stakeholder workshops were conducted to elicit feedback on suitable management performance metrics (Peterson et al. 2024). The following broad objectives were identified:

1. **Status**
2. **Yield** by fleet and area
3. **Stability**
4. **Catch rate** by fleet and area
5. **Opportunity**
6. **Size** of fish caught by fleet and area

All metrics to be analyzed over all projection years (1-15 years), short (1-5 year), medium (5-10 year), long (10-15 year) time horizons

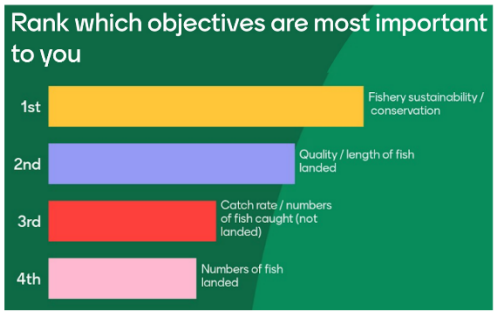


Figure 36. Conceptual management objectives identified during stakeholder workshops.

10.2 Time Horizons for Performance Evaluation

Due to its relatively short life span, management procedures tend to reach equilibrium biomass and yield outcomes before 10 years (40 seasons) of the MSE projection. For this reason the following time horizons were selected for evaluating near, medium and long term performance:

- Full projection period (15 years, 60 quarters)
- Near-term (projection years 1-5, 20 quarters)
- Medium-term (projection years 6-10, 20 quarters)
- Long-term (projection years 11-15, 20 quarters)

10.3 Metrics Currently Available in the mahiMSE R Package

10.3.1 Status

As is typical in other MSE and stock assessment settings, spawning stock biomass (SSB) status is reported relative to MSY levels (SSBMSY). In this seasonal model the numerator is the mean SSB over the year (Figure 37).

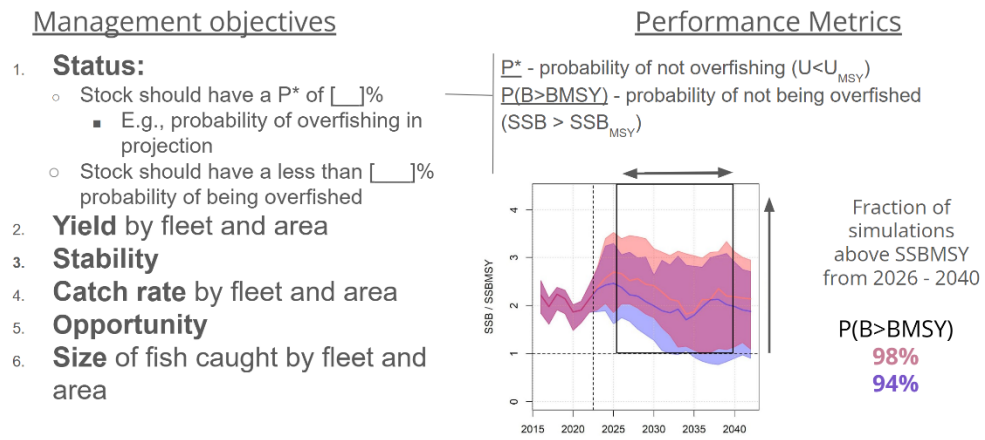


Figure 37. Evaluation of stock status according to spawning biomass relative to MSY levels

10.3.2 Yield

Yield is represented by annual landings (Figure 38) but could also be reported in catches which may be more relevant to recreational stakeholders.

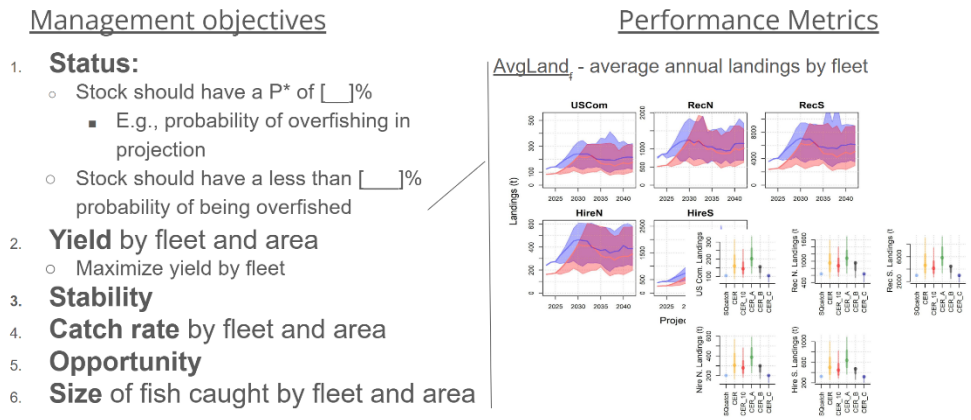


Figure 38. Evaluation of fleet-specific yield

10.3.3 Stability

Yield stability is calculated as the absolute percentage change in annual landings in each management update (it would not be calculated over time steps where management was not updated)(Figure 39).

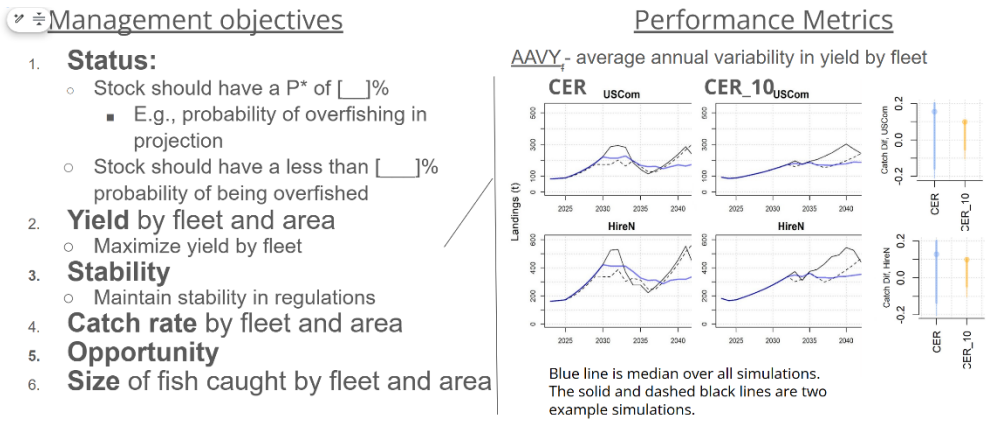


Figure 39. Stability in yield evaluated as the average annual variation (absolute deviation as a fraction)

10.3.4 Catch Rate

The various operators in each fleet have varying catchabilities (catch rates vary relative to vulnerable biomass) based on local scale availability, fishing gear, behaviors, species targeting etc. To provide a metric of catch rate that is meaningful to all operators but independent of their individual catchabilities, catch rate is phrased relative to today (2022). This is simply the mean vulnerable biomass in a given year relative to that in 2022 (Figure 40).

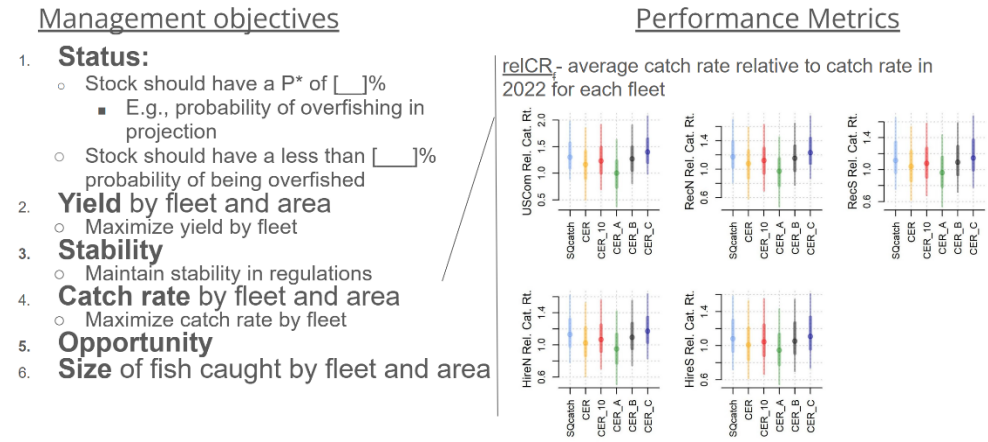


Figure 40. Predicted catch rate relative to 2022 levels (controlling for operator catchability)

10.3.5 Opportunity

In order to model events where a catch limit is met early or never met, it is necessary to include a fleet dynamics model. This is being investigated but not currently available. Until such a model can be implemented it is not possible to calculate fishing opportunity metrics.

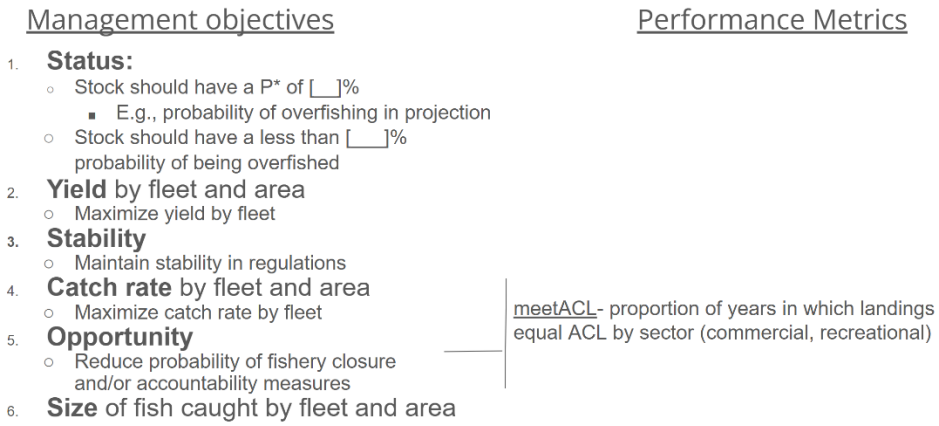


Figure 41. Opportunity in fishing phrased as the fraction of potential catches not realized due to the catch limit.

10.3.6 Size of Catch

For the same reasons as catch rate, size of catch is phrased in terms of mean size relative to 2022 which is independent of the selectivity of individual operators (Figure 42).

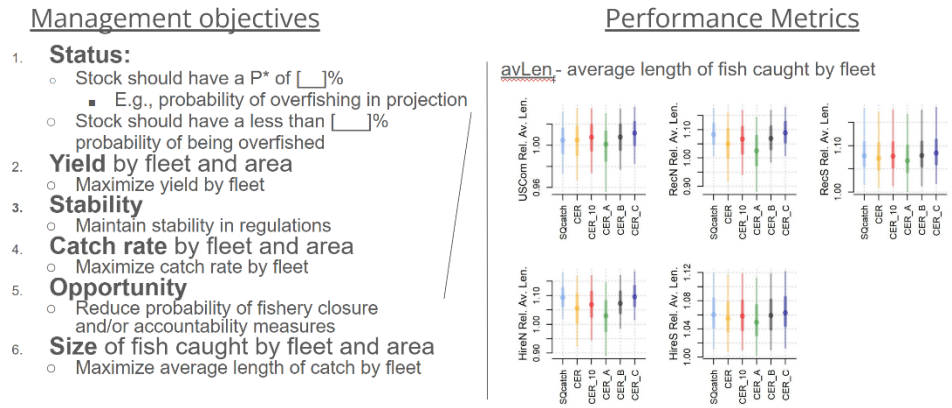


Figure 42. Size of caught fish expressed relative to 2022 levels (controlling for operator-specific selectivity / availability).

10.4 Calculation of MSY Quantities

MSY quantities were calculated using the standard approach of Botsford (1981) and Walters and Martell (2004) (Box 3.2 of that book) which efficiently calculates equilibrium yields for an age-structured population dynamics model using growth, maturity, the stock recruitment relationship and a fishery selectivity at age vector more on OpenMSE MSY reference point calculation.

Future changes in selectivity may be imposed by MPs that test alternative size limits. For this reason static MSY reference points were calculated based on operating model conditions in the final year of the historical simulation (2022).

Since the operating model has multiple fleets, aggregate selectivity was calculated as the mean selectivity across fleets weighted by their catch. Overfishing reference points were calculated on the basis of catch weight divided by total biomass (harvest rate *U*, UMSY). There are two advantages to this exploitation rate metric: (1) MP-driven future selectivity changes affect the interpretation of apical *F* (*F* for the most selected age class); (2) *U* calculation does not require the calculation of asymptotic age-selectivity that is challenging for spatial, seasonal, multistock models where temporal variability in recruitment creates transient effects.

10.5 Results Presentation

The default basis for the presentation of results is the Slick App Hordyk et al. 2025 that provides an interactive summary of MSE results across OMs, MPs and performance metrics. Results are presented in worm plots, spider plots, box plots and Kobe plots in addition to colored performance tables (sometimes referred to as 'quilt plots').

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11 Management Procedures

11.1 Management control options

The following management control options have been identified for the purposes of management procedure testing.

- catch limits
- minimum size limits
- slot limits
- bag/trip limits

More information on current management options is included in Amendment 10 to the Fishery Management Plan for the Dolphin and Wahoo Fishery of the Atlantic

11.2 Implementation of Management Advice

As in other MSE settings, management advice is considered to be followed exactly for all measures including size limits, effort controls and catch limits. Mismatches between recommendations and the implemented exploitation can still occur if the simulated stock reaches low levels and catches are not obtainable, for example.

The operating models all have the option of simulating implementation error (e.g., mismatches between recommended and implemented TAC) and implementation biases (e.g., consistent overages).

11.3 Management Procedure Archetypes

MP archetypes are broad classifications of management procedures that interpret data types in a particular way for the provision of management advice. For example an index rate output MP is one that aims for a constant exploitation rate.

Table 15. Examples of candidate management procedure archetypes.

Archetype	Description
Index rate output	Catch limits are calculated as a constant fraction of the observed index (constant harvest rate)
Index rate input	Effort, size limits or bag limits are adjusted to obtain a target rate of catch per index level
Index target	Catches, effort, size limits or bag limits are adjusted to achieve a target index level
Index slope	Catch limits, effort, size limits or bag limits are adjusted to obtain a particular schedule of index slopes (e.g. rebuild then stable)

11.4 Management Procedure Derivatives

A management procedure archetype can be modified into a derivative by imposing one or more constraints, filters or harvest control rules (Table 16).

Table 16. Examples of candidate management procedure derivatives

Derivative	Description
Constrained management change	Changes in catch limits, effort etc are constrained between minimum and maximum bounds between management cycles
Damped management	Changes in catch limits, effort etc are reduced or exaggerated

Derivative	Description
change	
Maximum extent of management	E.g. a maximum cap on catch limits, effort limits, size limits etc
Alternative management cycle	Updated management advice over a larger or smaller number of time steps
Alternative data lag	Management advice calculated from data up to a given year prior to advice year
Data weighting	Alternative emphasis on data streams entering the management procedure (e.g. indices from various areas)
Data smoothing	Alternative filtering method or strength to reduce noise in input data / increase MP stability
Harvest control rule	Imposition of a hockey-stick, or similar harvest control rule that throttles exploitation below a particular index level

11.5 The MahiMP

The mahiMP is a flexible, empirical management procedure available in the mahiMSE R package. The primary functionality of the mahiMP is to investigate options for setting TAC advice (on aggregate, by fleet or by fleet and area) based on available indices of abundance. The MP also has the ability to prescribe only fishing effort and effort and TAC combined.

The mahiMP is an MP of the archetype 'index rate output' that includes options for all of the various MP derivatives listed above (Figure 43). Additional management measures are accounted for such as minimum and maximum size limits by fleet and trip limits by fleet. Alternative post-release mortality rates can also be explored using the MP.

The mahiMP is configured with status quo management (Table 17) from which changes can be made.

Table 17. Status quo settings for the mahiMP.

Management Lever	Level
Commercial ACL	1,719,953 lbs
Rec. ACL	22,850,811 lbs
Rec. trip limit	54 fish
Min size	20" in SC, GA and FL

The Mahi Management Procedure (OpenMSE v2.0)

Description

A function for emulating status quo mahi management and allowing for a wide range of combined management controls. Fleets (n=8) are: (1) USCom, (2) RecN, (3) RecS, (4) HireN, (5) HireS, (6) Intl, (7) Disc, (8) UnRep. Areas (n = 5) are: (1) "CAR+FLK", (2) "NCA", (3) "NCFL", (4) "NED", (5) "NNC+VBM"

Usage

```
mahiMP(
  Data,
  TAC = NA,
  rel_TAC = NA,
  TAE = NA,
  rel_TAE = 1,
  SLmin = c(0, 0, 500, 0, 500, 0, 0, 0),
  SLmax = c(10000, 10000, 10000, 10000, 10000, 10000, 10000, 10000),
  TL = c(NA, 54, 54, 54, 54, NA, NA, NA),
  PRM = list(0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25),
  HCR_use = F,
  HCR_ICP = NA,
  HCR_LCP = NA,
  HCR_calib = 145:148,
  HCR_fleet = list(NA),
  HCR_sens = 1,
  HCR_lever = "TAC",
  HCR_up_max = 0.5,
  HCR_down_max = 0.5,
  HCR_input = 1,
  HCR_smooth = NA,
  Index_type = "VAST",
  Index_cv = NA,
  Index_ac = NA,
  Index_lag = 1,
  Index_seed = 1,
  TL_empirical = T,
  plot = F,
  ...
)
```

Figure 43. Arguments to the mahiMP included in the mahiMSE R package.

TAC control is implemented via an empirical harvest control rule (HCR). The control points of the HCR can be modified to include both constant exploitation rate and constant catch scenarios (Figure 44).

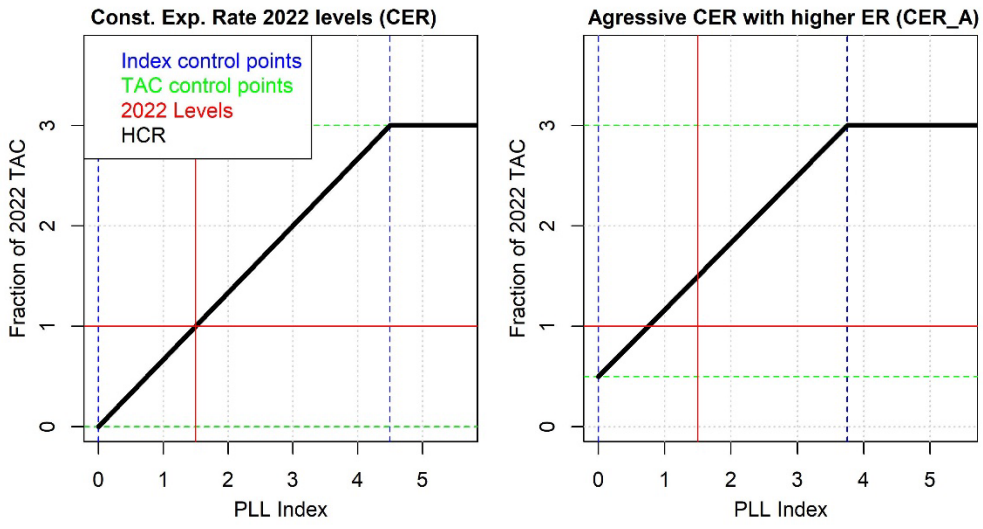


Figure 44. A comparison of two HCR configurations, a constant exploitation rate (CER) calibrated to fish at current catch per index, and a more aggressive derivative (CER_A).

Limits on TAC changes among management cycles are available in addition to options for smoothing indices or dampening TAC changes (Figure 45).

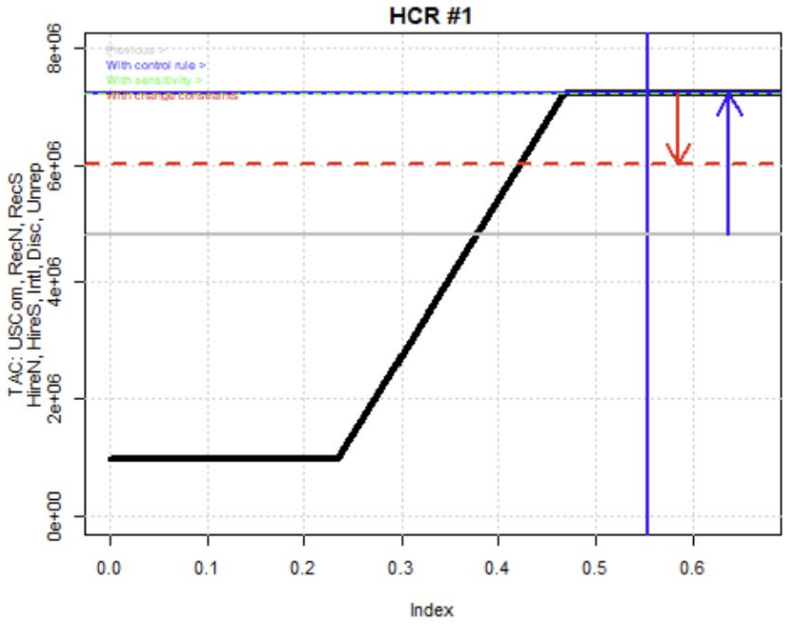


Figure 45. The modifiable 'hockey stick' HCR implemented by the mahiMP.

11.6 Modelling Trip Limits

11.6.1 Characterizing Observed Catch Rate Data

Recreational trip-level catch rate data were summarized over the last five years (2020 - 2024). These catch rate (fish per trip) distributions were strongly positively skewed. In general, very few trips exceeded the existing 54-fish trip limit (Figure 46).

When characterized by a negative binomial distribution (binomial and lognormal models failed to approximate the variance and skew), the upper tail of the distribution was relatively thin leading to lesser predicted impacts of trip limits on release rates.

When characterized by an empirical fit (kernel density) the distribution predicted a larger (but still small) impact of the trip limit on release rate (Figure 46).

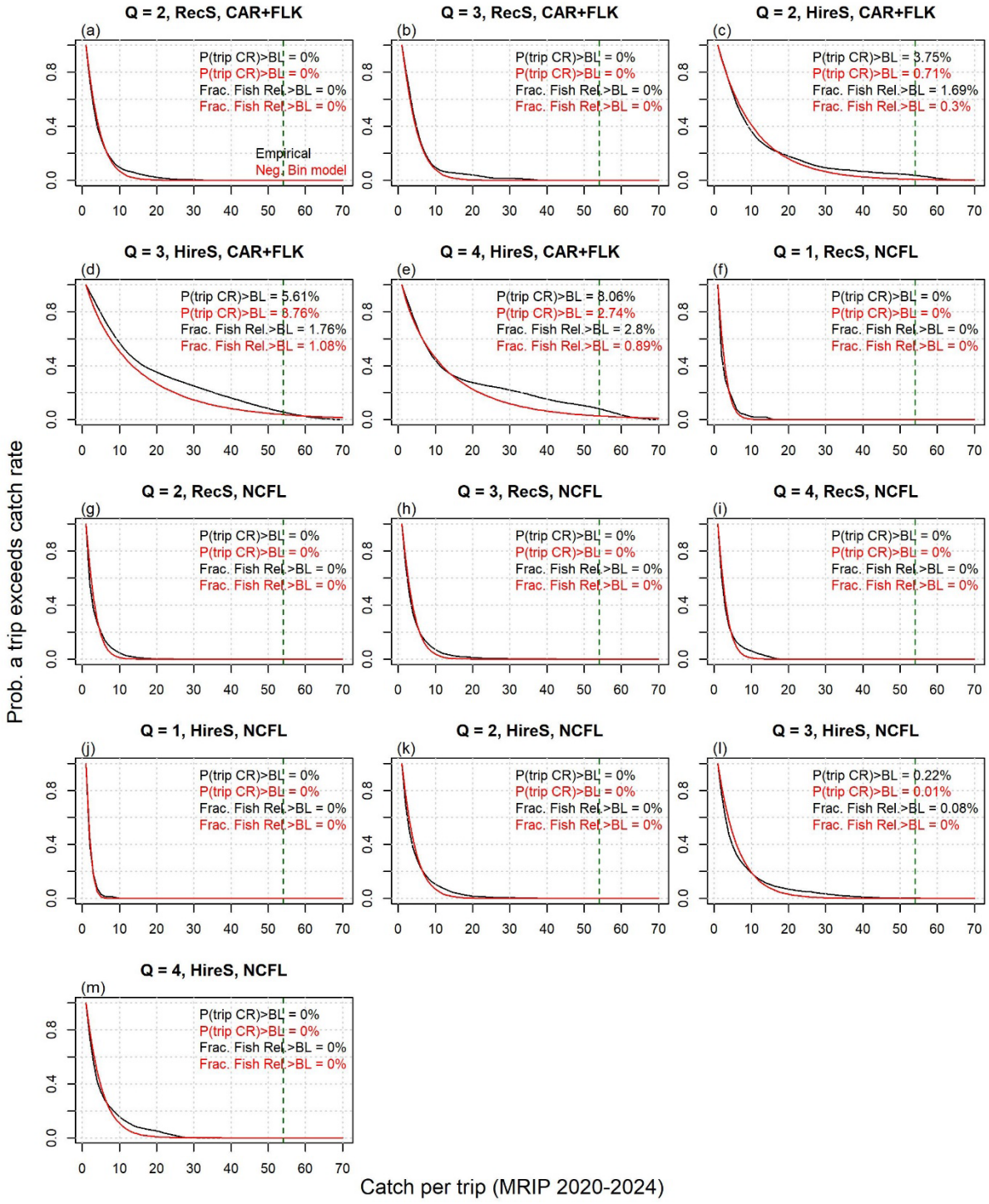


Figure 46. Empirical (black, kernel density) and modelled (red, negative binomial) fish per trip for the RecS and HireS fleets from 2020-2024. Note that in most cases very few trips exceed the current 54 fish limit (vertical dashed line).

11.6.2 Predicting Release Rate

The constant of proportionality (q) was calculated relating the mean of the catch rate distributions to the corresponding vulnerable biomass of the fleet. The expected mean catch rate could then be predicted in any future year of the projection. Given an assumption of constant coefficient of variation (CV), it is possible to predict the fraction of fish released (r) as a product of this predicted catch rate distribution (Table 18, Figure 47).

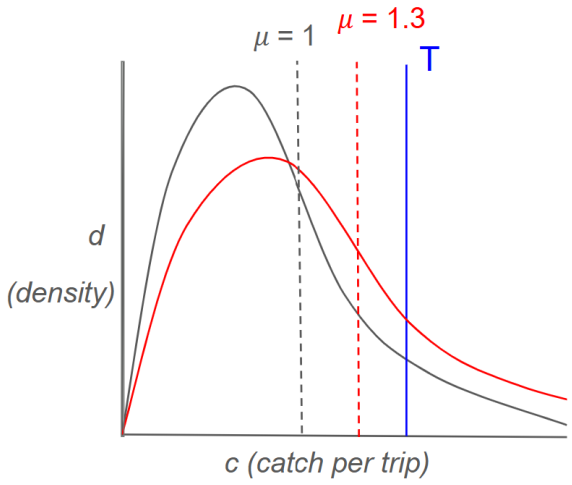


Figure 47. For didactic purposes: a fitted density distribution (d) for catch rates (c) for the historical time period (black) and an expected distribution of catch rates where vulnerable biomass is 30% larger (mean is 1.3) (red). Given the assumption of a constant coefficient of variation, the distribution is stretched such that a larger fraction of catch rates are above the trip limit (T).

Table 18. Equations of the trip-limit model predicting release rate of fish given a distribution of catch rates (d) and a trip limit (T).

Equation	Terms
$r = 1 - k$ $k = \frac{\sum_{i=1}^{n} d_i y_i}{\sum_{i=1}^{n} d_i c_i}$ $y_i = \begin{cases} c_i & c_i < T \\ T & T \leq c_i \end{cases}$	r: release rate of fish (average fraction released). k: proportion of fish retained. d_i: probability density at catch rate c_i. y_i: predicted retained catch rate. c_i: catch rate. n: the length of the c and d vectors i: vector position [1, 2, ..., n] T: trip limit.

11.7 Example MPs

A set of 6 candidate management procedures were specified to demonstrate a range of performance outcomes spanning the trade-offs of yield, stability and safety (Table 19, Figure 48).

Table 19. Description of the 6 demonstration CMPs.

SQ (Status Quo) (tune param: catch)

Constant catch at 2022 levels, up to 20% upward and downward TAC adjustments.

CER (Constant Exploitation Rate) (tune param: catch/Index)

Constant Catch/Index at 2022 levels up to 3x 2022 catch

CER_A (Aggressive) (tune param: catch/Index)

As CER but +50% 2022 Catch

CER_B (Bounded) (tune param: catch/Index)

As CER but bounded to +/- 50% 2022 Catch

CER_C (Conservative) (tune param: max catch)

Min 25%, Max 100% 2022 catches

CER_S (Stable) (tune param: catch/index)

As CER but up to 10% upward and downward TAC adjustments.

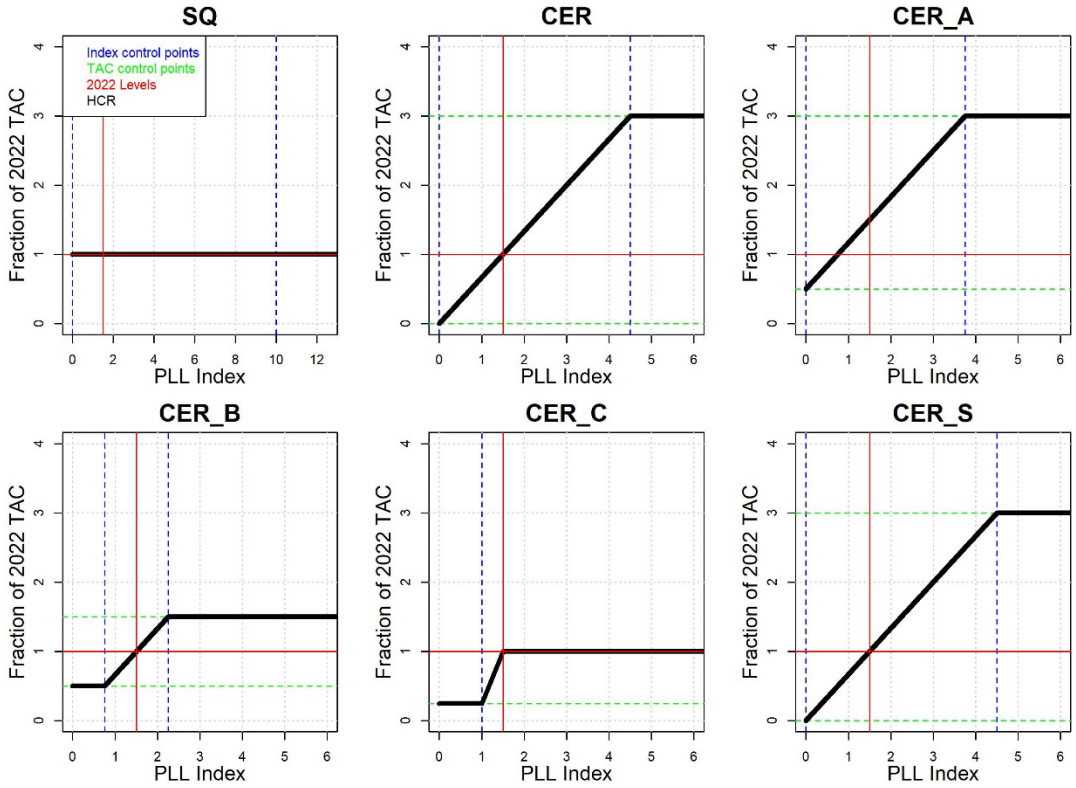


Figure 48. Example empirical CMPs using various empirical HCRs (derivatives of the mahiMP).

11.8 Management procedure tuning

Currently management procedures are not tuned. Candidate options for tuning relate to 'Probability Green Kobe' (PGK) which is probability the stock is both underfished (F<FMSY) and subject to underfishing (SSB>SSBMSY).

Possible target levels for tuning are PGK = 60% and PGK = 70%.

Typically, MPs are tuned to targets over the medium to long time projection horizons so that they are related to asymptotic MP performance and are not affected by near-term transient effects of initial projection conditions. A possible starting point would be the PGK evaluated across all reference grid OMs (or a suitable subset) for the last 5 years of the projection.

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12 Example Results

12.1 The Slick App

MSE results are presented using the Slick App (Hordyk et al. 2026). Slick is a decision analysis Shiny App that can either be installed as an R package and run locally from the R command line or can be accessed online. Slick is currently used as the default app for presentation of MSE results for a number of RFMOs (e.g., ICCAT).

Slick provides a relatively accessible tool for comparing CMP performance across OMs and metrics.

Demonstration results are available in a Slick object for download from here.

The easiest approach is to navigate to Slick online and upload this object.

Alternatively, for a faster approach that also allows for custom results plotting from the R commandline you can use the R package:

```
remotes::install_github('blue-matter/Slick')

library(Slick)

slick = readRDS("where_you_saved_the_object/mahiSlick_1.slick")

App(slick = slick)
```

The App includes a front page that summarizes the object and the purpose of the analysis. On the left-hand side are a column of icons that present results in various ways including time series plots, box plots and trade-off plots (Figure 49).

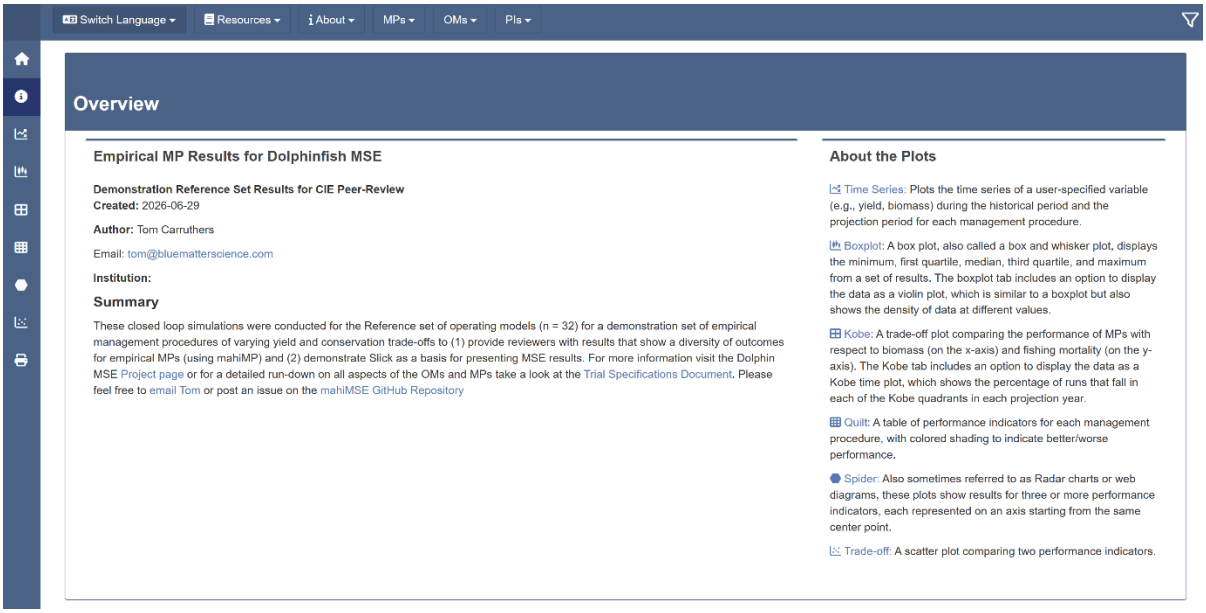


Figure 49. The front page of the Slick App.

12.2 Time Series Plots

Three quantities are currently available in the time-series plots: SSB/SSBMSY, F/FMSY and total Landings (e.g., Figure 50). Time series plots provide an intuition into the trajectory stability of MP performance over the projection period. Behaviors of note include over compensation (periods of systematic overfishing then underfishing), severe trade-offs between short and long term yield, catch stability and the degree of uncertainty in outcomes as the closed-loop projection evolves.

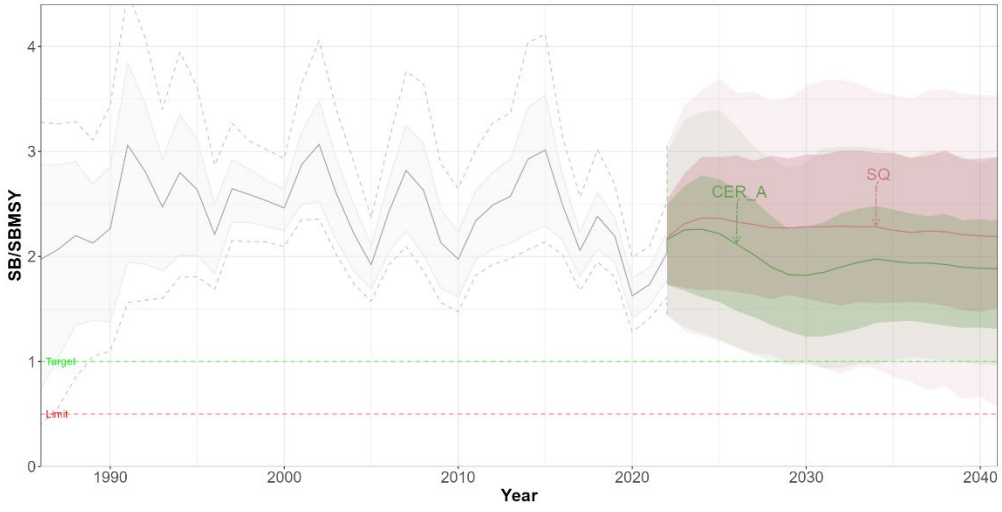


Figure 50. A time series plot of spawning biomass relative to MSY levels for a pair of MPs including the mean, interquartile and 80 percent interquantile ranges.

12.3 Box Plots

In other MSE settings, box plots (sometimes referred to as 'Zeh' plots) provide the primary basis for summarizing the expected performance among MPs, their trade-offs and the uncertainty in outcomes (Figure 51).

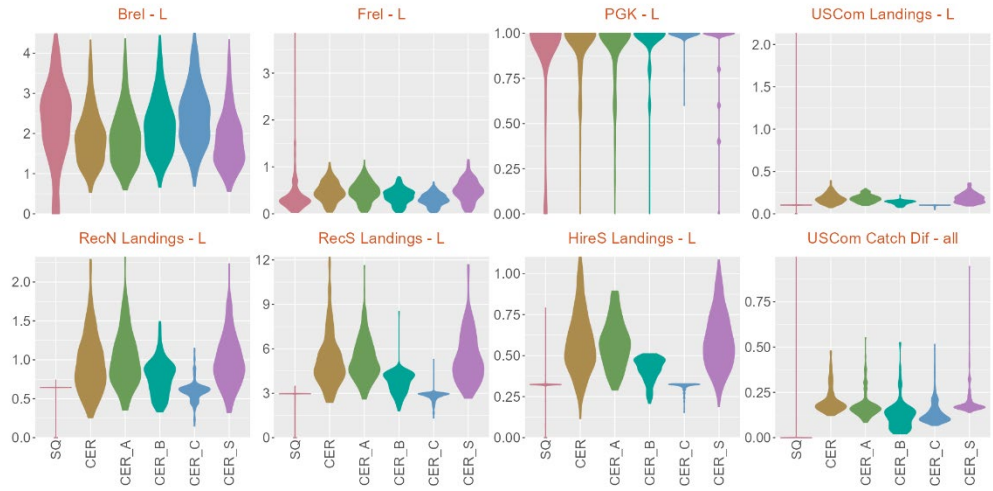


Figure 51. Box plots showing the distribution of mean outcomes (average across years, withing simulation) for 8 metrics across 6 CMPs. 'L' denotes long-term (first 5 years of the projection). 'all' denotes all projection years (first 15 years of the projection).

12.4 Kobe Plots

Kobe plots are commonly presented in performance summaries because they capture two quantities relevant for most RFMOs: the probability of overfishing (F>FMSY) and the probability of overfished status (SSB<SSBMSY) (Figure 52). The probability of green kobe (fraction of simulations where the stock is both underfished and subject to underfishing) is often used as a tuning target (e.g., PGK = 60%).



Figure 52. Kobe time plot showing the fraction of simulations that are overfished subject to overfishing (red), overfished subject to underfishing (yellow), underfished subject to overfishing (orange) and underfished subject to underfishing (green). These are presented for OMs of low productivity (Rec = 0.75) and low resilience (Steepness = 0.7) to enhance the contrast among CMPs.

12.5 Quilt Plots

These shaded tables provide numerical results in support of the other MSE results figures. The results can be reordered to reveal trade-offs among performance metrics (Figure 53).



Reading this Chart

The Quilt plot is designed as a color-coded table showing the values of the selected Performance Indicators (columns) for each Management Procedure (rows).

The color shading indicates values ranging between the highest value to the lowest value for the performance indicator in each column. Higher values indicated better performance.

An exception is if the analyst who built the Slick Object specified maximum and minimum values for each performance indicator (e.g., between 0 and 1 for probabilities).

Use the button below the Quilt table to modify the colors shown in the table.

Note: currently the Report feature is not implemented for the Quilt plot.

Filters

Management Procedures

SQ CER_B

	Brel - L	Frel - L	PGK - L	USCom Landings - L	RecN Landings - L	RecS Landings - L	HireN Landings - L
	All	All	All	All	All	All	All
CER_S	1.87	0.513	0.875	0.191	1.04	5.48	0.672
CER	1.93	0.488	0.893	0.184	1.01	5.29	0.696
CER_A	1.93	0.492	0.897	0.184	1.02	5.3	0.679
CER_B	2.21	0.383	0.968	0.132	0.812	3.73	0.575
SQ	2.23	0.587	0.868	0.114	0.608	2.78	0.191
CER_C	2.43	0.313	0.984	0.0988	0.616	2.78	0.36

Copy CSV

Figure 53. A quilt plot of key performance metrics. Shading denotes level. Results are ordered here in ascending long-term biomass outcome Brel (SSB/SSBMSY in years 11 to 15 of the projection). Frel refers to F/FMSY (U/UMSY).

12.6 Trade-offs

A key objective of MSE is to reveal management performance trade-offs. The principal trade-offs exist between short term yield, long term yield, variability in yield and long-term biomass (e.g., Figure 54).

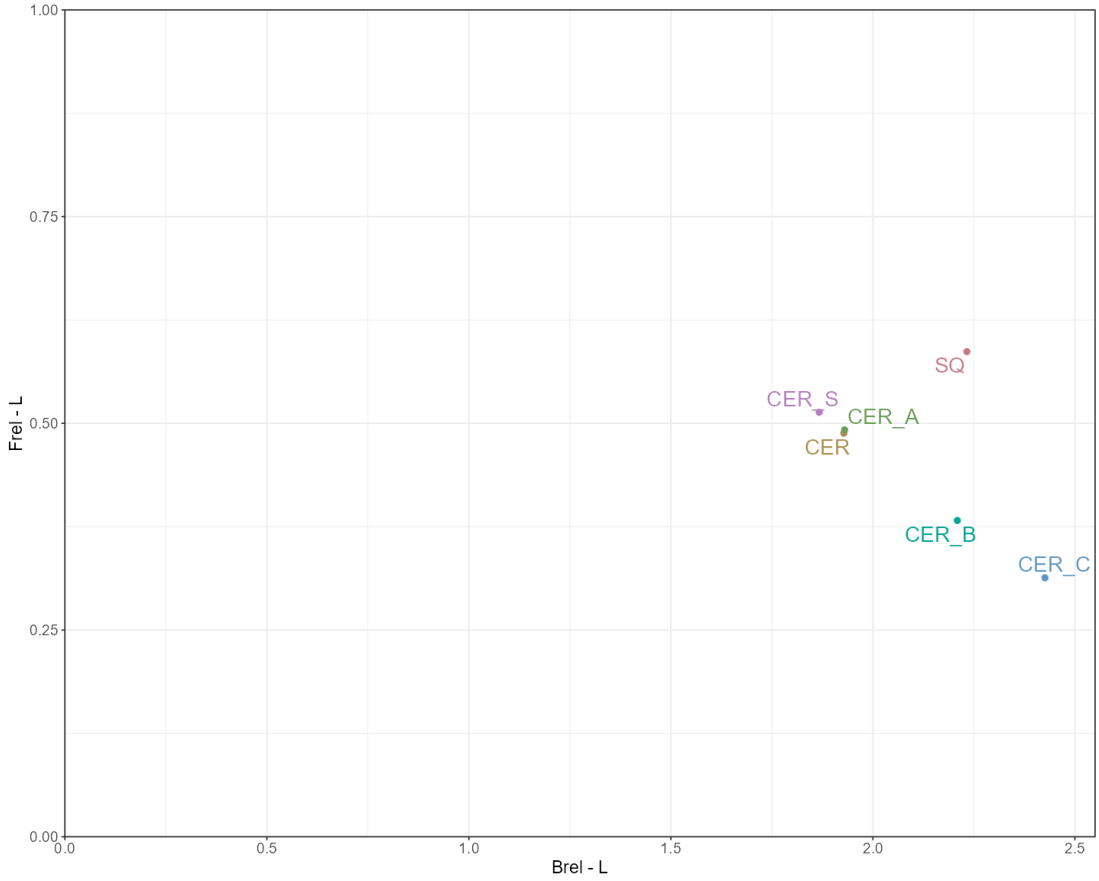


Figure 54. Trade-off plot of long-term (projection years 11-15) SSB/SSBMSY (Brel) and F/FMSY (Frel)

12.7 Conclusions

The Slick App provides a flexible, open and inclusive basis for presenting CMP performance comparisons The App can be run by a wider range of stakeholders and managers than would be possible using R code and functions. By placing results in an interactive App, there is no need for an extensive interaction between managers and an MSE technical team to provide relevant outputs.

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13 Exceptional Circumstances Protocols

13.1 The Role of Exceptional Circumstances

A principal motivation behind management strategy evaluation (MSE) and the management procedure (MP) approach was originally to lessen the need for frequent use of more complex and comprehensive stock assessment processes (and associated 'tinkering', Butterworth 2008). It follows that in most settings, MPs are adopted for an agreed period of time after which a formal review of the MP is scheduled. For example, the 5-year interval for review of MP implementation by the International Whaling Commission, IWC 1999 and the 6-year interval for review of the MP adopted by ICCAT for Atlantic bluefin tuna (ICCAT2022).

It is however considered best practice to establish protocols for detecting situations where the observed system dynamics are not consistent with the range of simulations specified in the operating model, over which the adopted MP was demonstrated to be robust (Butterworth 2008). Exceptional circumstances (EC) protocols typically compare new, updated observations of the data used by the MP with the simulated values from the MSE projections ('posterior predicted data'). They can also involve a check of the assumptions used to condition the models or characterize the axes of uncertainty.

13.2 An example: Northern Atlantic Albacore Exceptional Circumstances

ICCAT recently adopted an EC protocol for North Atlantic albacore (ICCAT 2021a; b). The EC protocol identifies several indicators which may trigger exceptional circumstances if new observed values fell outside the 95% interquantile range of the simulated values for a given year. Other indicators such as growth, maturity, and natural mortality were highlighted as possible triggers of ECs but their criterion for being triggered was less exact, simply indicating when these should be considered (e.g., new research/analysis was presented and accepted by the SCRS leading to new values substantially different from those used in the MSE testing).

The northern albacore EC is not rigidly connected with a specified action: "Triggering an EC does not immediately result in TAC advice from the MP being rescinded; rather, it means that the SCRS needs to examine the indicators and determine if a change in advice is warranted."

The triggering of an exceptional circumstance first requires a determination of how the EC might impact the results of the management procedure currently being used. Triggering EC could be interpreted in several ways, for example: (1) there is conservation concern as indicators/inputs are lower than those tested; (2) yields are potentially too low as indicators/inputs are higher than those tested, (3) there is no appreciable change in conservation concern or potential yield as the EC has little impact on the MP results. Once the impact of the EC has been established the recommended responses to the EC can be developed for consideration by managers.

13.3 Other Examples of Exceptional Circumstances

In the case of Greenland halibut in Subarea 2 + Divisions 3KLMNO, the Northwest Atlantic Fisheries Organization (NAFO 2011) compares observed catches and survey indices with operating model predictions of these data. When observations fall out of the 90% probability interval of posterior predicted data, these are considered indicative of exceptional circumstances. Exceptional circumstances provisions were triggered for Greenland halibut (NAFO 2018) in 2014 when one of the survey index observations fell below the 5th percentile of the predicted posterior distribution for that data type.

Similarly to NAFO, the Canadian Department of Fisheries and Oceans (DFO 2011) identify various data that may be monitored to detect exceptional circumstances in the MSE for Pollock in NAFO area 4Xopqrs5, including survey biomass indices, catches and catch-at-age composition data. DFO (2011) also identified being outside the 90% probability interval of simulated survey data as a possible indicator of ECs and included an absolute level for the posterior predicted indices below which observed data would indicate exceptional circumstances.

For southern bluefin tuna, the EC protocols of CCSBT make use of fishery indicators (relative abundance data not used by the MP) and a range of data types used by the MP including fishery-dependent catch rate indices, estimates of spawning biomass from close-kin genetics and estimates of age-2 numbers from conventional gene tagging (Preece et al. 2021). Similarly to northern albacore, CCSBT outline exceptional circumstances in order to flag possible problem areas to keep under closer scrutiny for the immediate future, rather than rigidly connecting EC to a course of action such as operating model reconditioning and/or MP revision. For example, a very high Japanese longline CPUE estimate for 2018 triggered the CCSBT EC but action was not taken given that there was a relatively low impact on the TAC recommendation (Preece et al. 2021). Similarly to EC in other MSE frameworks, the focus of the EC is not the ability to detect a specified OM condition (e.g., low spawning biomass) but on whether observed data are comparable to those projected by the OM.

The Indian Ocean Tropical Tuna Commission (IOTC) also has a broad definition of exceptional circumstances (IOTC 2021) including: "new knowledge about the stock, population dynamics or biology, changes in fisheries or fishing operations, changes to input data to the MP, or missing data, or inconsistent implementation of the

MP advice (e.g. total catch is greater than the Total Allowable Catch)". Similarly to CCSBT, IOTC does not prescribe a rigid management response to the triggering of EC, and this "can include review of additional information or new research, review of the performance of the MP (via reconditioned Operating Models), or management advice to precautionarily revise the TAC".

13.4 ECP App

ECP are the final component of MSE framework development and are typically explored during the MP adoption phase. ECP design (what indicators, what tails, what Type I and Type II error) and implementation (have ECP been triggered) are to be implemented in the ECP App (Carruthers 2025)

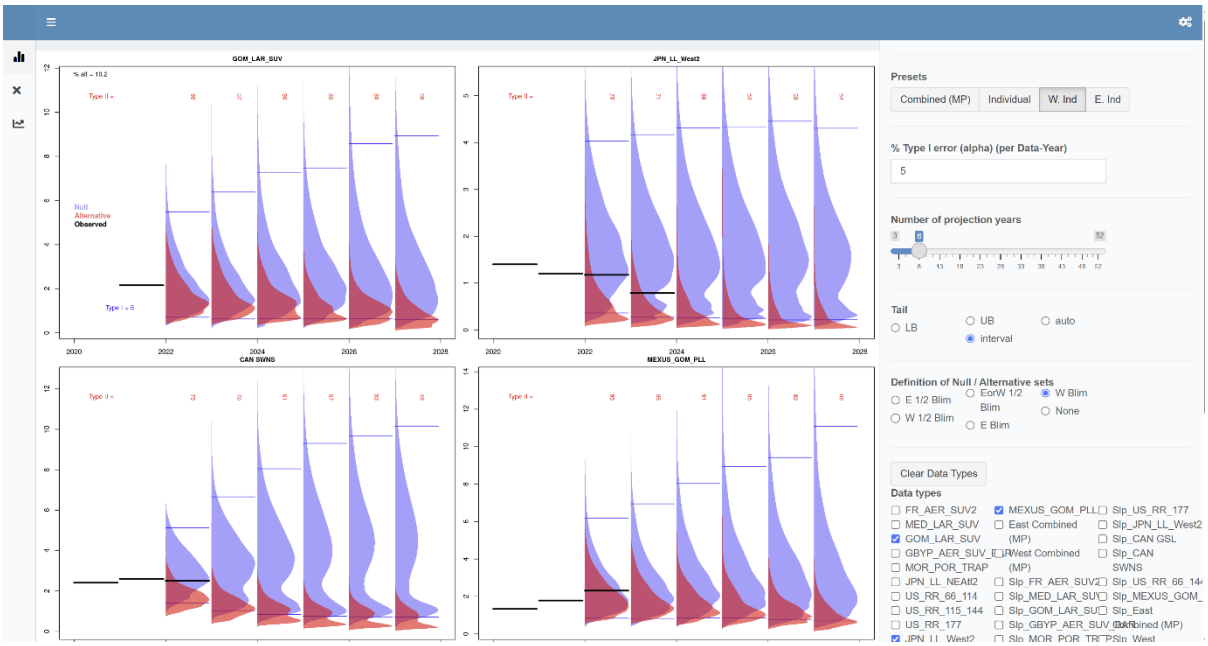


Figure 55. Example of the ECP app showing 4 possible indices of abundance considered for ECP for Atlantic Bluefin Tuna. Blue shaded regions are projected simulations where western biomass did not drop below half of SSBMSY. Red shaded regions are projected simulations where western biomass did drop below half of SSBMSY.

The ECP app follows the principles of Carruthers and Hordyk (2019) in that it uses power analysis to develop suitable ECP indicators.

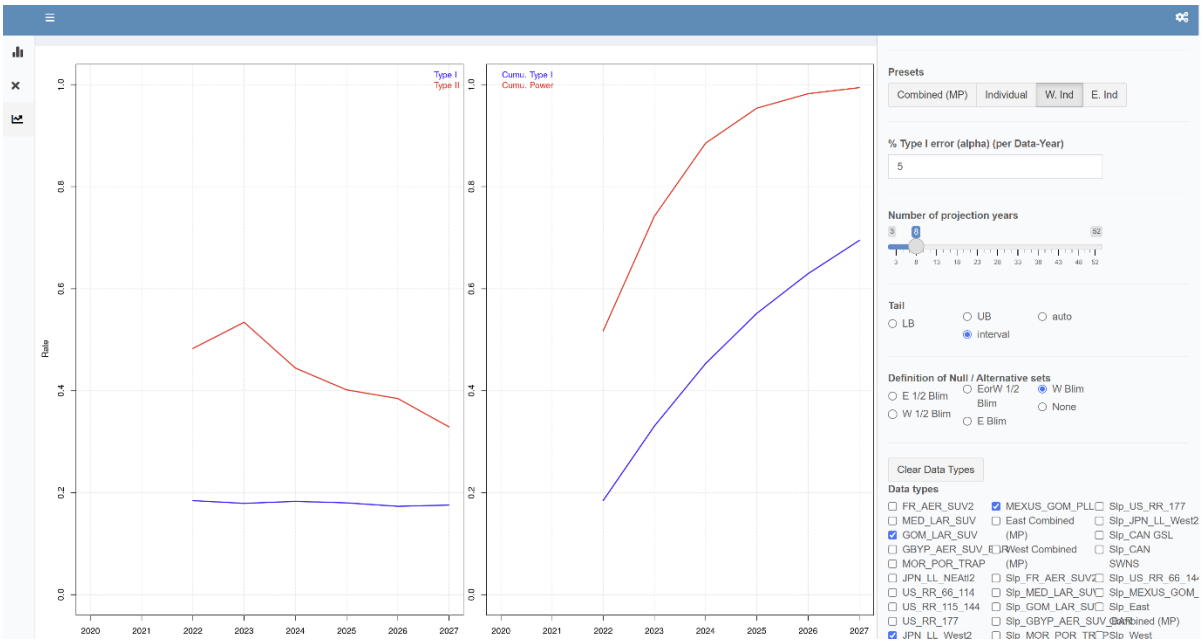


Figure 56. Example of the ECP app showing expected rates of Type I error (probability of falsely triggering ECP for non-problematic simulations) and Type II error (failing to trigger ECP for problematic simulations) for a demo ECP for Atlantic Bluefin Tuna.

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14 Code

14.1 Dolphinfish MSE Code

14.1.1 DolphinMSE Github Repository (Private)

- https://github.com/Blue-Matter/DolphinMSE
- Private 'workhorse' repo with live data and analyses.
- Data, reports, notes
- Code for processing data, spatial modelling (VAST), conditioning operating models
- Supporting analyses (e.g., exploratory tests of trip limits, VAST specifications etc)
- Makes all the inputs to mahiMSE R package (OMs, MPs, etc)

14.1.2 mahiMSE GitHub Repository and R Package (Public)

- https://github.com/Blue-Matter/mahiMSE
- mahiMSE Manual
- Public-facing R package with manuals, documentation
- How to design MPs, use the mahiMP, run MSE simulations and plot results.
- Includes some small demonstration OM objects and example data sets
- Custom code for organizing results and plotting results.

14.1.3 mahiRefSet GitHub Repository and R Package (Public)

- https://github.com/Blue-Matter/mahiRefSet
- Reference Grid OMs (#32)

14.1.4 mahiRobSet GitHub Repository and R Package (Public)

- https://github.com/Blue-Matter/mahiRobSet
- Robustness Set OMs (#16)

14.2 MP and MSE Code

14.2.1 OpenMSE (Hordyk et la. 2026, v1.01)

- www.openMSE.com
- technical manual including equations
- This is the umbrella package for the component MSEtool, SAMtool, DLMtool R libraries

14.2.2 MSEtool (Hordyk et al. 2026, v4.0.0)

- MSEtool GitHub
- OM specification
- Closed loop simulation
- Empirical MPs

14.2.3 SAMtool (Huynh et al. 2026, v1.9.1)

- SAMtool GitHub
- Data-rich stock assessment methods
- OM conditioning using Rapid Conditioning Model (RCM)
- Model-based MPs

14.2.4 RCM (Huynh 2026)

- RCM manual
- RCM equations

14.2.5 Slick (Hordyk et al. 2026, v1.0.2)

- Slick Project Page
- Presentation of MSE results

14.2.6 ECP (Carruthers 2024, v1.0.5)

- ECP GitHub
- ECP App (bluefin tuna)

- Design and presentation of Exceptional Circumstances Protocols

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16 Appendix A. Glossary

Table 20. Glossary of MSE terminology and acronyms

Term	Description
MSE	Management Strategy Evaluation: a participatory process to establish management procedures (harvest strategies) that are robust to uncertainties in fishery and population dynamics.
OM	Operating Model: a mathematical description of fishery and population dynamics codified in a simulation framework for the robustness testing of candidate management procedures.
MP	Management Procedure (harvest strategy): an algorithm that calculates management advice from data (real or simulated).
CMP	Candidate Management Procedure. One of multiple possible management procedures that is to be comparatively evaluated by MSE.
MSE framework	The process, membership, meetings, documents, software package, management objectives and exceptional circumstances protocols that support the adoption of a management procedures.
Closed-loop simulation	The engine at the heart of MSE simulations: a codified representation of fishery and population dynamics (operating model) linked to an observation error model (data generation) a candidate management procedure, an implementation model (controls adherence to management advice) which accounts for feedback between the fishery system, data, recommendations and management actions to quantify management performance.
TSD	Trial Specifications Document: a description of the methodology of the MSE framework that ensures reproducibility including all decisions, background information and equations.
Reference Case	A single operating model familiar to the working group that can be used for didactive purposes such as exploring ideas, demonstrating concepts / sensitivities.
Reference Set	A set of operating models, sometimes represented by an orthogonal grid of operating models that represent the core uncertainties that CMPs should be robust to: the primary basis for the evaluation of CMPs.
Robustness Set	A secondary set of operating models used to further distinguish between CMPs that otherwise perform similarly for the reference set of OMs. These may include hypotheses that have a relatively weak empirical basis or uncertain future conditions for projections.
Data guillotine	A date after which new data will not be accepted for use in operating model or management procedure development.
OM conditioning	The process of fitting operating models to observed data statistically (similar to fitting of stock assessment models).
EC Protocols	Exceptional Circumstances protocols: an empirical check that observed data are consistent with those data expected to be observed when the MP is in use (a basis for detecting departures in systems dynamics away from the operating models for which the MP was demonstrated to be robust).

17 Appendix B. Future Robustness and Ecosystem Considerations

17.1 Introduction

In most fishery management settings there is an impetus to demonstrate that adopted management procedures are responsive and robust to plausible nonstationary impacts.

A review of papers that describe possible climate impacts on fisheries revealed very few examples where defensible forecasts were available (Carruthers 2024a). In theory, it may be possible to develop an 'end-to-end' model that combines sub-models of emissions (e.g., Algieri et al. 2023, Wang et al. 2017), earth systems (Kawamiya et al. 2020), ecosystems (e.g., Beaugrand and Kirby 2018, Lehodey et al. 2010; 2011), behavior (e.g., Bushnell and Brill 1991, Cayré and Marsac 1993) and physiology (e.g., Gooding et al. 1981, Graham et al. 1989, Checkley et al. 2009). Forecasting fishery impacts would therefore combine a complex series of linked projections that include greenhouse gas emissions (least uncertain), response of climate processes (uncertain), linkages with oceanographic conditions (more uncertain) and the expected impact of those on pelagic communities and individual species (most uncertain). It can be argued that any forecast of climate impacts on fisheries should be seen as firmly hypothetical, and the relative credibility of impact scenarios should be considered highly uncertain.

This large uncertainty over future nonstationary impact scenarios poses a problem for the provision of 'future ready' fishery management advice using the contemporary stock assessment and management strategy evaluation (MSE) frameworks. That is because those frameworks rely on the specification of models that represent oceanographic impacts and the frequency (weighting) of those models could strongly affect the advice provided. For example, it may not be clear whether there will be small or large future changes in natural survival (natural mortality, M). Advice arising from scenarios with large M changes would likely lead to the provision of strongly differing advice from scenarios with small M changes, yet their relative credibility is not easily evaluated.

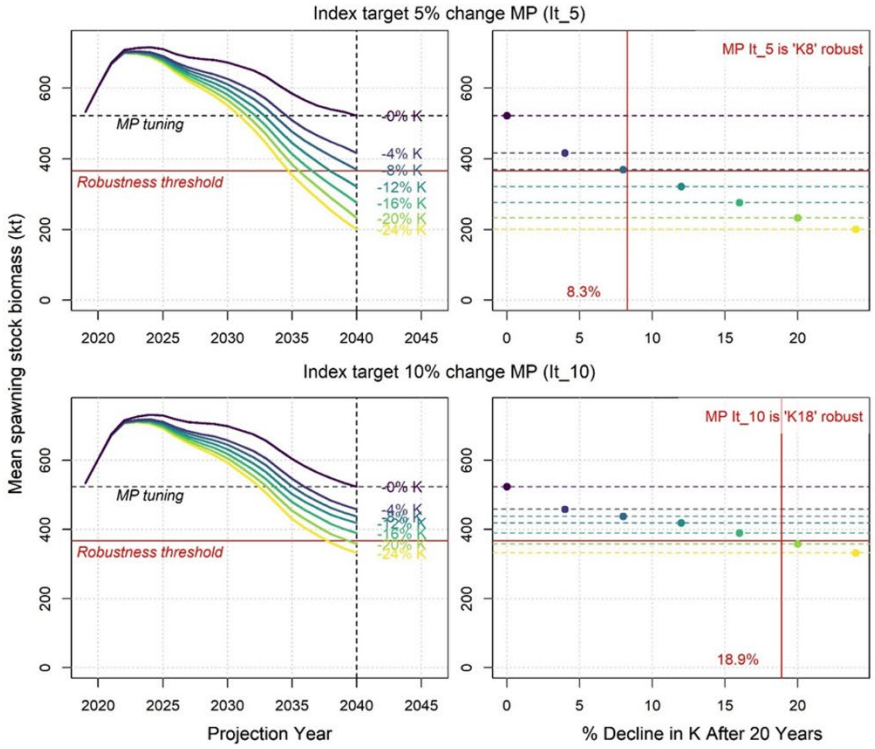
17.2 A proposal using MSE simulations

Although quantitative forecasts of oceanographic impacts on fisheries may not be available, qualitatively, the way in which nonstationarity can impact individual populations is clear. Most papers documenting possible impacts predict changes in recruitment strength (carrying capacity, spawning habitat, larval survival), adult survival (natural mortality rate), somatic growth, spatial distribution (range contraction, catchability) age at maturity and condition factor (fecundity). Additionally, it is generally understood what direction of change in those variables poses a challenge for management procedures: lower recruitment strength, decreased survival, lower somatic growth rate, reduced spatial distribution, older age at maturity and poorer condition factor.

One proposed option (Carruthers 2024b) is to shift the focus from model-based tests of future robustness in favor of performance metrics of future robustness. Such an approach tests how resilient candidate management procedures are to commonly proposed environmental impacts such that their future robustness can be comparatively evaluated. This shifts the emphasis away from forecasting (we think this nonstationary impact will happen) to the inherent robustness of the candidate management procedures (if this impact occurs, this MP is twice as resilient).

17.3 Calculating nonstationary robustness metrics

It is possible to quantify nonstationary robustness with respect to declines in population survival (natural mortality rate M), recruitment strength (R), somatic growth (K) and condition factor (C). To do this MPs are tuned to achieve stable biomass outcomes and then the level of change required to break a threshold is calculated. This then becomes a performance attribute of that management procedure.



The Index target MP is substantially more robust to climate scenarios when it allows for TAC changes of 10%

Figure 57. Calculation of nonstationary robustness metrics. In this example an MP is tuned such that it provides stable SSB over 20 projected years. Given a defined threshold for 'robust' as a decline in biomass of more than 30% after 20 projected years, it is possible to calculate the decrease in somatic growth (K) needed to 'break' the MP such that it drops below the threshold. In this case the index target MP allowing for 10% changes in TAC between years (bottom) was more than twice as robust as the derivative allowing for 5% changes (top) (surviving up to an 18% decline in K vs an 8% decline, respectively).

These types of metrics can then be tabulated across MPs (rows) and nonstationary future tests (column):

Table 21. Example nonstationarity performance metrics. Tabulated numbers are the percentage change in each impact before the robustness threshold is reached. Higher percentages that are shaded green represent higher robustness. Shading is scaled per nonstationary test (by column) according to the maximum robustness (highest %) M = increasing natural mortality rate, R = decreasing recruitment strength, K = decreasing somatic growth, C = decreasing condition factor (weight-at-age).

Management Procedure	Climate Test			
	M	R	K	C
Index target 5% change	7	19	9	26
Index target 10% change	9	24	18	56
Index ratio 5% change	8	20	9	26
Index ratio 10% change	8	22	13	42
Index slope 5% change	7	18	6	20
Index slope 10% change	7	19	7	23

SEDAR
Southeast Data, Assessment, and Review

SEDAR 104
Atlantic Dolphinfish Management Strategy Evaluation

SECTION III: Review Workshop Report

September 2026

SEDAR
4055 Faber Place Drive, Suite 201
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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 104 Atlantic Dolphinfish MSE Review Workshop was held in Charleston, SC July 28-31, 2026.

1.2 TERMS OF REFERENCE

Evaluate the types and ranges of uncertainty used in the MSE. Explicitly consider uncertainty in data, life history, process error, nonstationarity (i.e., environmental variability and oceanographic changes), and if appropriate, fishery dynamics.

1. Were selected axes of uncertainty relevant to the stock and fishery and appropriately characterized? If relevant, were uncertainties highlighted by managers and stakeholders included?
2. Did levels of uncertainty for each axis meaningfully and reasonably encompass plausible uncertainty?
3. Were uncertainties appropriately classified into reference (primary) or robustness (secondary) set and sufficiently explained?

2. Evaluate the strengths and weaknesses of methods used to simulate the stock.
    1. Are methods to generate operating models scientifically sound?
    2. Did methods meet the needs of stakeholders and/or research questions (i.e., appropriate spatial resolution, time-step, ability to measure key performance statistics)?
    3. If data were unavailable to parameterize the model, were the assumptions used to overcome this limitation reasonable and/or multiple assumptions included as an axis of uncertainty?
    4. Was plausibility weighting of reference operating models appropriate and sufficiently justified?
    5. Does the robustness of the operating model grid allow the management procedure to fail?
3. Evaluate operating model conditioning.
    1. Did conditioning the operating model on available data result in simulated data with reasonable statistical properties relative to what would be available to the management procedure?
4. Evaluate MSE projections.
    1. Did the operating models project data that would be available to the management procedure?
    2. Were projection assumptions reasonable and appropriate for the stock (e.g., decisions about future parameter estimates and uncertainty; resampling approaches to generate future data; future nonstationarity, productivity, etc.)?
5. Evaluate performance metrics.

    1. Do performance metrics include all legally mandated management objectives as outlined in the Magnuson-Stevens Fishery Conservation and Management Act (i.e., to include status determination criteria with suitable risk tolerance to measure probability of overfishing and overfished status; and rebuild overfished stock in accordance with rebuilding requirements)?
    2. Did performance metrics sufficiently capture additional manager and/or stakeholder objectives to achieve optimum yield, if relevant (i.e., to include desired management objectives such as: total catch, catch rate, catch size, fishing opportunity/season length, etc.)?
6. Evaluate candidate management procedures.
    1. Did the candidate management procedures only utilize data available for the stock in practice?
    2. Did the management procedure explore management tools and controls that are applicable to the stock (e.g., appropriate management procedure archetype)?
    3. Were top-performing management procedures tuned to minimally achieve all satisfying criteria?
    4. If empirical management procedure, does the MSE include a mechanism to periodically update stock status?
7. Provide or comment on recommendations to improve the MSE.
8. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the MSE and addressing each TOR.

1.3 LIST OF PARTICIPANTS

Review Panel

Daniel Howell.....Institute of Marine Research, Norway/ CIE Reviewer
Ernesto Jardim.....CIE Reviewer
Gary Melvin .....CIE Reviewer
Jeffrey Buckel..... NCSU/ SAFMC SSC
Kelsey Roberts ..... UMass Dartmouth/SAFMC SSC
Matt Damiano (Chair) .....NC DMF/ SAFMC SSC

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Emily Ott .....SEDAR
Judd Curtis..... SAFMC Staff
John Hadley (via webinar)..... SAFMC Staff
Julie A Neer (via webinar) .....SEDAR
Suzanna Thomas (via webinar) ..... SAFMC Staff

Council Representative

Kerry Marhefka .....South Atlantic Council

Appointed Observer

Jon Reynolds .....Industry Representative

Workshop Observers
Nikhil Mehta..... SERO

Workshop Observers via Webinar
Alexandra Schneider ..... University of Maine
Christina Curtis..... SAFMC Staff
David Wamer ..... Industry
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Jennifer Norcross.....FWC
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Manuel Coffill-Rivera .....University of South Alabama
Matthew Bunting.....FWC
Tia Offner.....FWC

1.4 LIST OF REVIEW WORKSHOP REFERENCE DOCUMENTS

Reference Documents		
SEDAR104-RD01	Spatiotemporal dynamics of dolphinfish (*Coryphaena hippurus*) in the western Atlantic Ocean	Matthew D. Damiano[1], Mandy Karnauskas[2], Wessley Merten[3], Jie Cao[4]
SEDAR104-RD02	Characterization of the for-hire fishery in the U.S. South Atlantic and regional policy implications	Mandy Karnauskas [a,*] , Matthew McPherson [a], Anthony Mastitski [b,1], John Hadley [c], Julia Byrd [c]
SEDAR104-RD03	Evidence for declining numbers of large Dolphinfish in the western North Atlantic	B. J. Runde[1] , P. J. Rudershausen [2,*], and G. R. Stilson[3]
SEDAR104-RD04	Age, growth, and reproduction of dolphinfish (*Coryphaena hippurus*) caught off the coast of North Carolina	Kara L. Schwenke and Jeffrey A. Buckel
SEDAR104-RD05	Estimating discard mortality using meta-analysis and fishery-dependent sampling	P.J. Rudershausen [a,*], S.J. Poland [b], J.H. Merrell [a], C.B. Pelletier [a], C.S. Mikles [a], J.A. Buckel [a]
SEDAR104-RD06	A multiannual five-fleet generalized depletion model for the stock assessment of the Mediterranean dolphinfish (*Coryphaena hippurus*) fishery	Vicenç Moltó [1,2,*], Ignacio A. Catalán[2], Andrés Ospina-Álvarez [2], Pilar Hernández[3] and Rubén H. Roa-Ureta[4]

2. REVIEW PANEL REPORT

Introduction

This is a summary of the SEDAR 104 Atlantic Dolphinfish Management Strategy Evaluation (MSE) Review Workshop that took place in Charleston, SC during July 28th-31st, 2026. The MSE analytical team presented the contents of the Assessment Process Report , which included summaries of the project rationale; stakeholder objectives; biology and ecology of Atlantic common dolphinfish (*Coryphaena hippurus*); software developed for the MSE; operating model (OM) conditioning approach; OM reference and robustness grids; data simulation for projections; management procedures (MP); and performance metrics. Presentations from the Review Workshop can be accessed from the mahiMSE GitHub page. The Review Panel provided thoughts and feedback throughout the Review Workshop as they pertain to the successes and weaknesses of the MSE to date, including how or if the exercise satisfied the Terms of Reference. What follows is a summary of the key points made by the Review Panel and an itemized discussion of the Terms of Reference.

Executive Summary

The Review Panel agreed that the Atlantic dolphinfish MSE was methodologically sound given the extreme data limitations and uncertainties relating to the unique aspects of dolphinfish biology. The Review Panel concluded that the MSE satisfied most of the Terms of Reference (TOR) but were limited in their conclusions on specific Management Plans (MPs) based on the range of results that were presented at the Review Workshop. The Review Panel's primary concerns related to uncertainties in life history parameterization within the OM, movement, and international removals; assumptions of spatial structure based on a single index of relative abundance; and the general lack of sensitivity of the empirical MP to the range of projected conditions. It should be noted here that these concerns largely arise from the limited data and knowledge on the stock, rather than the approaches taken by the research team.

Reviewers agreed that the axes of uncertainty represented a plausible range of realities, and that model assumptions were reasonable in lieu of more information. However, reviewers noted some concerns regarding the somatic rate of growth (K), natural mortality (M), and steepness (h). The Review Panel asked for a robustness test in which K and M are treated as being correlated, and a consistent measure of uncertainty (SD) for all three parameters be chosen to propagate life history uncertainty into projections. Concerning movement, the OMs were conditioned on a single index of relative abundance derived using Vector Autoregressive Spatiotemporal model (VAST), which was fit to largely non-directed catch rate data from the United States (US) Atlantic commercial pelagic longline logbook program. Movement in the OM is based on a gravity model that uses the index to generate movement rates between regions. The Review Panel and the analytical team agreed that an additional model-based index of abundance should be used to generate an alternate hypothesis about spatiotemporal structure, and therefore distribution and movement, as part of an additional axis of uncertainty.

International, i.e., uncontrolled removals are responsible for the majority of total removals of dolphinfish within the modeled stock range and therefore represent a substantial source of uncertainty. The Review Panel and analytical team agreed that international removals are an additional axis of uncertainty that needs to be confronted in the future. Reviewer suggestions to that effect included additional robustness OMs (a range of international landings from low to high) and diagnostics relating to what proportion controlled (US) and uncontrolled removals contribute to the total exploitation rate, and what effects this has on the US exploitation rate, which is what is actually controlled by the empirical MP. For example, if the fishing mortality from uncontrolled removals is higher than the fishing mortality reference point, then there are no management strategies for controlled removals that will be effective.

MP performance, though adequately tested for the purpose of the exercise, showed little difference across the range of projected conditions except at extremes. The Review Panel noted that it is useful to rule out those extreme scenarios, but additional options should be built into future OMs to determine the exact extent to which the MP is controlling management of dolphinfish in US waters. Reviewers suggested additional scenarios that include zero catch and high catch, i.e., a rate that would severely deplete the stock. Reviewers agreed these would also be useful in determining the extent to which Atlantic dolphinfish can be managed in

US waters when most removals come from beyond the US exclusive economic zone.

Broadly, the Review Panel agreed that the MSE addressed stakeholder objectives. However, they acknowledged that the spatial extent of the model may make it impossible to meet all objectives. The Review Panel recommended additional performance metrics for stakeholder objectives, e.g., large fish, opportunity to fish, be added in the next iteration.

The Review Panel discussions and deliberations are summarized below for each of the Terms of Reference

1. **Evaluate the types and ranges of uncertainty used in the MSE. Explicitly consider uncertainty in data, life history, process error, nonstationarity (i.e., environmental variability and oceanographic changes), and if appropriate, fishery dynamics.**
    1. **Were selected axes of uncertainty relevant to the stock and fishery and appropriately characterized? If relevant, were uncertainties highlighted by managers and stakeholders included?**

For the most part, yes. The Review Panel was satisfied with the analytical team's efforts to quantify the spatiotemporal dynamics of dolphinfish biology and fisheries while dealing with spatial stakeholder concerns/priorities. The Review Panel expressed three major concerns with respect to uncertainty: movement, life history, and international removals. The concerns persist throughout the TOR but are summarized in the most detail here:

Movement

The distribution of Atlantic dolphinfish is uncertain. Tag-recapture experiments have quantified south to north movement from Puerto Rico and the Florida Keys up to New England, and although an annual movement circuit has been hypothesized, there are no data to fully corroborate this. Additionally, stakeholders have suggested that there is limited north to south movement, and resident dolphinfish in certain regions; there is also no data to corroborate this. Therefore, the Review Panel highlighted the need for multiple different states of movement within the reference grid. Specifically, the Review Panel and the analytical team agreed that viscosity should be removed as a factor level of the OM reference grid in favor of OMs that condition movement on at least two plausible movement hypotheses: those represented by the current VAST index, and on an alternate index of relative abundance or standardization model that generates a different set of spatiotemporal dynamics. This approach would allow for distribution to inform movement instead of viscosity parameters and impose realistic limits on fish movement.

Life History

Life history processes are all highly uncertain with little biological sampling data to inform these characteristics. There is, for example, no information to inform the steepness (h) parameter in the stock recruitment relationship. Natural mortality (M) and somatic growth (K) were treated as independent life history parameters in the OMs. The Review Panel was not in total agreement as to whether the M-K combination chosen by the analytical team was adequately supported by life history relationships or meta-analysis, or propagated uncertainty in those parameters in a consistent way. For example, age and growth studies have found different results depending on the location of the study; Caribbean studies have found higher Ks and no fish older than age-1 while US east coast studies have found lower Ks and fish up to age-3. Most agreed that the approach was reasonable given the paucity of empirical information. The analytical team agreed to investigate a run-in which M and K parameters are correlated, which the Review Panel agreed would partially address the concern.

International Removals

The Review Panel expressed concerns that the MPs tested in the MSE control 46% of the total removals, while the remainder come from international fisheries beyond the extent of US governance. The Review Panel agreed that this represents a substantial source of uncertainty that must be addressed

more thoroughly in the future.

2. Did levels of uncertainty for each axis meaningfully and reasonably encompass plausible uncertainty?

Yes, with the caveats discussed under 1.1, but generally the choices made by the analysts followed standard protocols and were reasonable given the constraints.

3. Were uncertainties appropriately classified into reference (primary) or robustness (secondary) set and sufficiently explained?

Yes, uncertainties were appropriately classified into reference and robustness sets. The Review Panel acknowledged that the robustness sets were based primarily on information solicited from stakeholders during workshops, built into the MSE by the analysts, and approved by the stakeholders.

2. Evaluate the strengths and weaknesses of methods used to simulate the stock.

1. Are methods to generate operating models scientifically sound?

Yes. The Review Panel agreed that the MSE presented at the workshop was scientifically sound, particularly given the extreme limitations to both data and empirical information on dolphinfish biology. The Review Panel agreed that the primary strength of the method was that it made use of the information available and was supported by rational decisions and assumptions made by the analytical team. While there were no weaknesses inherent to the method that the analytical team presented, there were numerous suggestions for additional work to be conducted, which are documented throughout the report.

2. Did methods meet the needs of stakeholders and/or research questions (i.e., appropriate spatial resolution, time-step, ability to measure key performance statistics)?

Yes, the methods met the needs of the stakeholder. In particular, the Review Panel was impressed with the efforts made to capture spatial resolution and the within year time steps to address stakeholder management options. However, the Review Panel noted that the spatial scale may be too large to meet all stakeholder needs.

3. If data were unavailable to parameterize the model, were the assumptions used to overcome this limitation reasonable and/or multiple assumptions included as an axis of uncertainty?

Yes. The Review Panel agreed that the methods used to set up the axes of uncertainty were reasonable. However, the Review Panel returned to the subject of uncertainty in life history under this TOR. Specifically, there was some concern that coefficients of variation (CVs) were not treated consistently across M, K, and h; following discussion, the analytical team agreed to use the SD for each moving forward for consistency of comparison. Although tagging and recapture location data exists for dolphinfish, it was not available to the analyst which meant greater uncertainty in the movement model; however, the approach taken to model movement was reasonable given the refinements suggested by the Review Panel.

4. Was plausibility weighting of reference operating models appropriate and sufficiently justified?

The reference OMs were essentially unweighted because there wasn't enough information to implement an informed weighting scheme.

5. **Does the robustness of the operating model grid allow the management procedure to fail?**

In principle, yes, but the Review Panel noted that the MP seems largely unresponsive except when subjected to extreme conditions.

3. **Evaluate operating model conditioning**
    1. **Did conditioning the operation model on available data result in simulated data with reasonable statistical properties relative to what would be available to the management procedure?**

Yes, with caveats. The Review Panel noted multiple concerns with the treatment of recruitment. One suggested that annual recruitment needed to be checked to determine whether forecasted recruitment dynamics are consistent with OM-conditioned recruitment dynamics. Another reviewer pointed out that recruitment is allocated based on the proportion of biomass within a spatial area, which may be unavoidably simple but should be summarized in the documentation. The Review Panel also noted that the forecasted index was not presented and could not be commented on. The Review Panel agreed that the forecasted index will need to be examined at the next level of review and before results are shown to managers.

There was extensive discussion about the MSE's current reliance on the index of relative abundance derived using Vector Autoregressive Spatiotemporal model (VAST). The VAST index is derived from a standardization model fit to largely nontargeted dolphinfish catch rates from the US Atlantic commercial pelagic longline fleet logbook program. As such, it is fishery-dependent and corresponds to fishing activity responsible for only 4% of total removals. The analytical team also noted that the standardization model was somewhat unstable. The Review Panel agreed that the VAST index is still likely the best index of relative abundance available, but due to the many caveats, it should be reviewed carefully. Correlation analyses between the VAST index and environmental signals, e.g., the blue blob and ENSO, were conducted during the Review Workshop to determine whether the VAST index was informing on relative abundance vs. availability. The analytical team determined that the VAST index, blue blob, and ENSO were highly correlated, which suggested that the VAST index was not taking environmental factors into full consideration. The analytical team acknowledged that the reliance on a single index was an axis of uncertainty that the MSE did not confront at this stage.

4. **Evaluate MSE projections**
    1. **Did the operating models project data that would be available to the management procedure?**

Yes. Specifically, the MP relies on the VAST index for the Southern Florida and Caribbean region, which requires the US Atlantic commercial pelagic longline logbook data. The Review Panel discussed what time lag in application of the MP would be reasonable given the time required to analyze the logbook data and generate an up-to-date VAST index. Reviewers noted that the current timing assumption is nine months to a one year lag between observation and management advice. Reviewers recognized that this is typically reasonable, but that the short-lived nature of dolphinfish may mean most fish are dead by the time the MP is implemented. Therefore, the Review Panel recommended investigating whether a shorter time lag would be possible, treating the data as an early indicator of fishing opportunity that could be updated later.

    2. **Were projection assumptions reasonable and appropriate for the stock (e.g., decisions about future parameter estimates and uncertainty; resampling approaches to generate future data; future nonstationarity, productivity, etc.)?**

Yes. However, the Review Panel wanted to see some environmental effects modeled explicitly, at least in a robustness test. This could include using information on environmental drivers of availability such

as the "blue blob" or ENSO to create changes in catchability to which the MP would need to adapt (which it currently is not designed to do). Alternatively, the "blue blob"/ENSO could be modeled to impact dolphinfish production/abundance through recruitment (or some other mechanism).

5. Evaluate performance metrics

1. Do performance metrics include all legally mandated management objectives as outlined in the Magnuson-Stevens Fishery Conservation and Management Act (i.e., to include status determination criteria with suitable risk tolerance to measure probability of overfishing and overfished status; and rebuild overfished stock in accordance with rebuilding requirements)?

Yes, but there was consensus among the Review Panel that any conclusions about stock status, e.g., overfishing/overfished, are conditional on the OMs representing a range of plausible realities. The Review Panel could not comment on legality.

2. Did performance metrics sufficiently capture additional manager and/or stakeholder objectives to achieve optimum yield, if relevant (i.e., to include desired management objectives such as: total catch, catch rate, catch size, fishing opportunity/season length, etc.)?

Yes, but the Review Panel recommends some additional performance metrics to address stakeholder objectives. These included a metric for the number of large fish available to US fisheries, and a metric to quantify the opportunity to fish. There was also some discussion about how effort should be dealt with in projections, but no consensus was reached as this would require additional software development time.

6. Evaluate candidate management procedures.

The Review Panel's ability to evaluate MPs was limited. The Review Panel expressed concerns about what effect the MPs could have on the stock given that the US is responsible for less than half of total removals. One CIE reviewer recommended further analysis of controlled (US) vs. uncontrolled (International) removals and associated exploitation rates. Both the empirical MP and the constant catch harvest control rule (Amendment 3; status quo) were generally insensitive to the range of projected conditions; the exception being a state of nature in which recruitment was heavily reduced. The constant catch MP was also insensitive to management measures such as trip limits and bag limits; the Review Panel agreed that this was useful to show that managers and stakeholders will need to look at something else to manage the stock. The Review Panel suggested that there should be a no fishing scenario and a high fishing scenario to elicit a response from the MP, noting that reference points appeared sustainable due to the biology of the animal.

1. Did the candidate management procedures only utilize data available for the stock in practice?

Yes, but the Review Panel recommended investigating some additional sources of data that were not utilized in the MSE. These include dolphinfish tournament catch-per-unit-effort from Puerto Rico, which could serve as an imperfect index of (and sanity-check for) availability of dolphinfish in the southernmost region of the OM; age and growth derived K values from the Caribbean; and the tag-recapture movement data from the Dolphinfish Research Program to inform or corroborate movement in the OM .

2. Did the management procedure explore management tools and controls that are applicable to the stock (e.g., appropriate management procedure archetype)

Yes, as it pertains to the set of OMs presented during the Review Workshop.

3. Were top-performing management procedures tuned to minimally achieve all satisficing criteria?

Yes, as it pertains to the set of OMs presented during the Review Workshop. However, here and with respect to TOR 6.2, the Review Panel noted a need for an additional range of options to get the MP to have a larger effect on the stock. At this stage, it is not wholly clear to reviewers what the MP can control.

4. If empirical management procedure, does the MSE include a mechanism to periodically update stock status?

No, and the Review Panel agreed that it should not be expected to because stock status is effectively unknown in the absence of a conventional stock assessment model.

7. Provide or comment on recommendations to improve the MSE.

In addition to the feedback summarized in TORs 1-6, the Review Panel provided the following recommendations to improve the MSE:

- Improve the matching of performance metrics with manager and stakeholder objectives
- Develop diagnostics for MP behavior, e.g., check interannual variability in catch against the catch constraint built into the harvest control rule
- Develop diagnostics to ensure projected population dynamics are internally consistent with OM-conditioned population dynamics
- Use a more realistic CV for the index of relative abundance (>0.2)
- Consider shortening the lag from the current timing assumption (~ one year) if it can be done without compromising catch advice
- Consider a robustness test and/or exceptional circumstances in the case of stock range contraction
- For continuous variables, consider using a one gradient operating model instead of a grid approach that gives multiple operating models; the one gradient operating model is useful for forecasting.
- Improve estimates of international unreported harvests (they were flat since 2007 and that is likely biased)
- Research to determine if El Nino years lead to higher landings because of increased availability/catchability or increase in recruitment/biomass
- Explore utility of in-season management like is done for Peruvian anchovy with SONAR and environmental data. Justification is that most of the dolphinfish are ~6 months old.

The Review Panel also recommended investing in data collection to improve the basic understanding of the Atlantic dolphinfish population dynamics. Specific suggestions included collecting additional biological sampling data; developing a directed index of relative abundance; and collecting any other data that would support a conventional stock assessment to determine true stock status and more certain OMs in any future dolphinfish MSE..

8. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the MSE and addressing each TOR.

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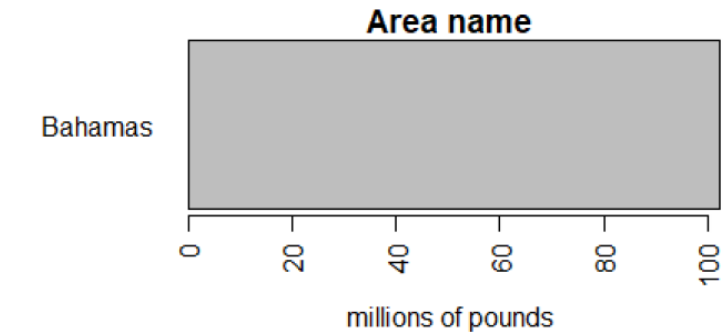
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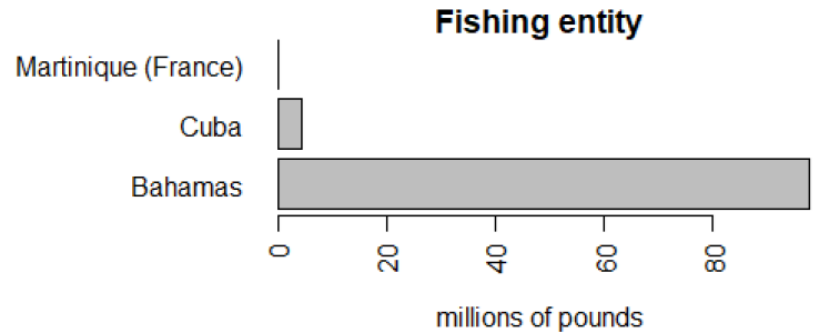
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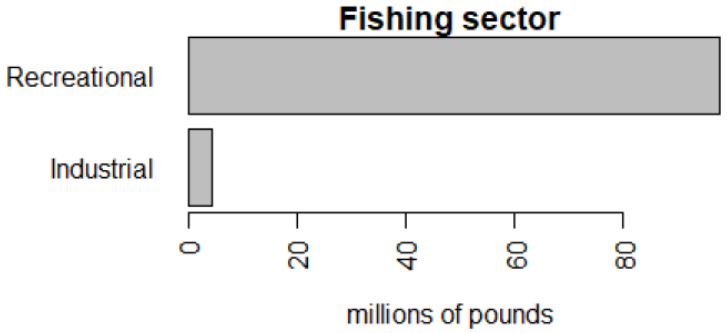
11 September 2026

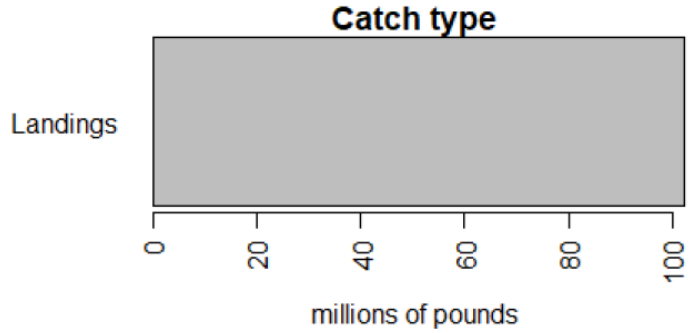
SEDAR
4055 Faber Place Drive, Suite 201 North
Charleston, SC 29405

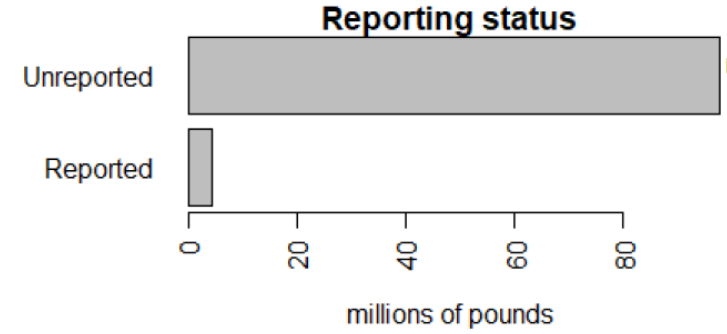
Additional Data figures

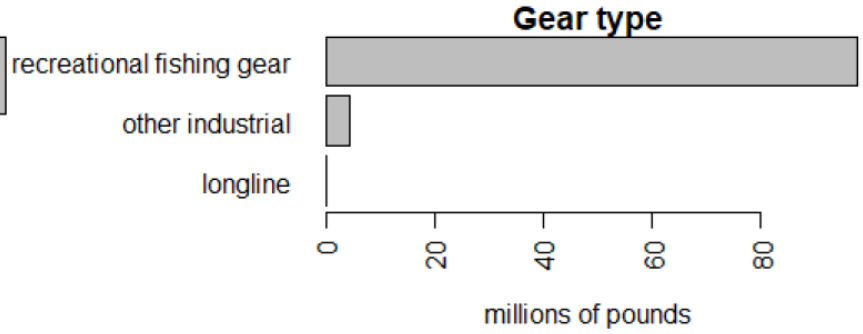

Area name
Bahamas
0
20
40
60
80
100
millions of pounds

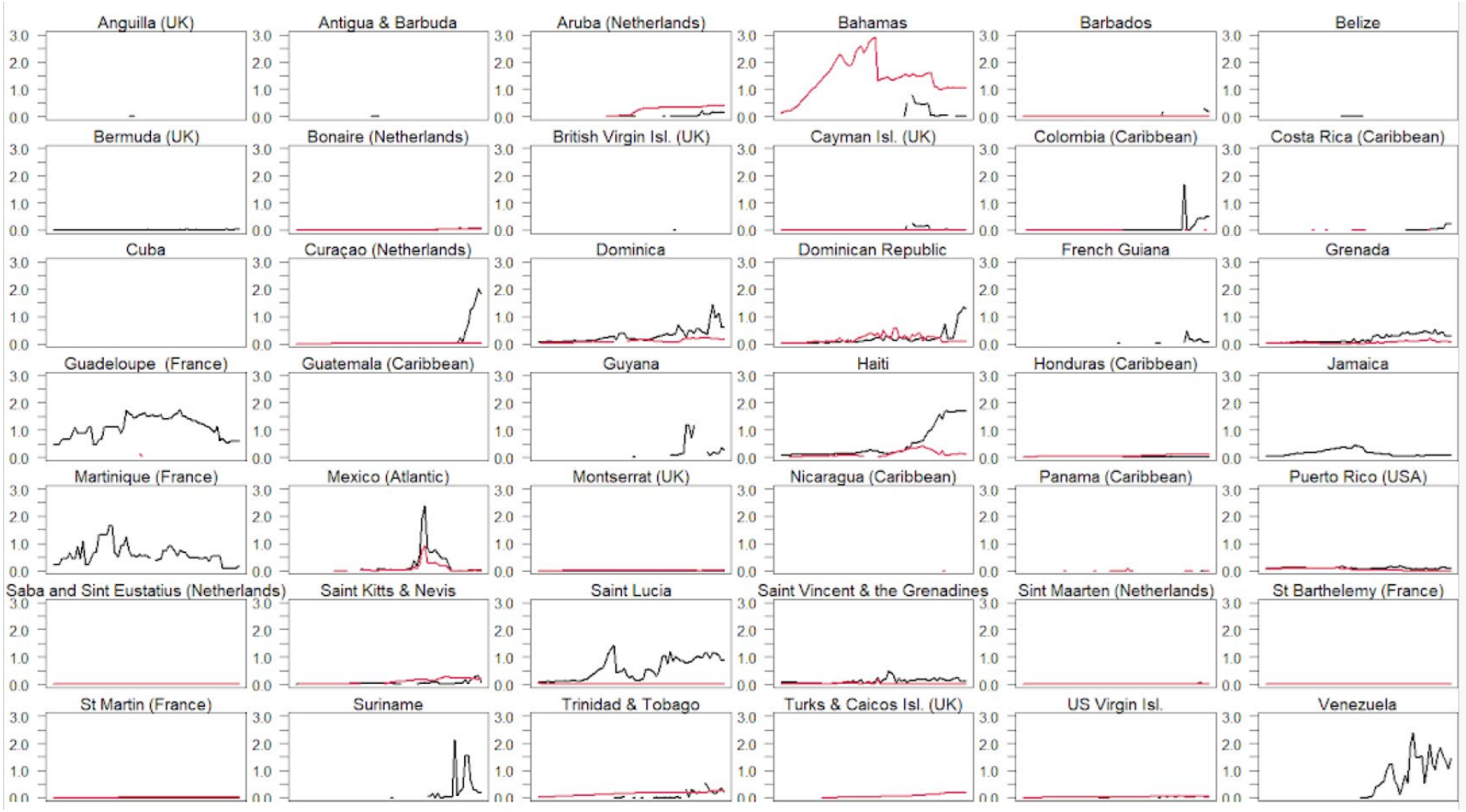

Fishing entity
Martinique (France)
Cuba
Bahamas
0
20
40
60
80
millions of pounds

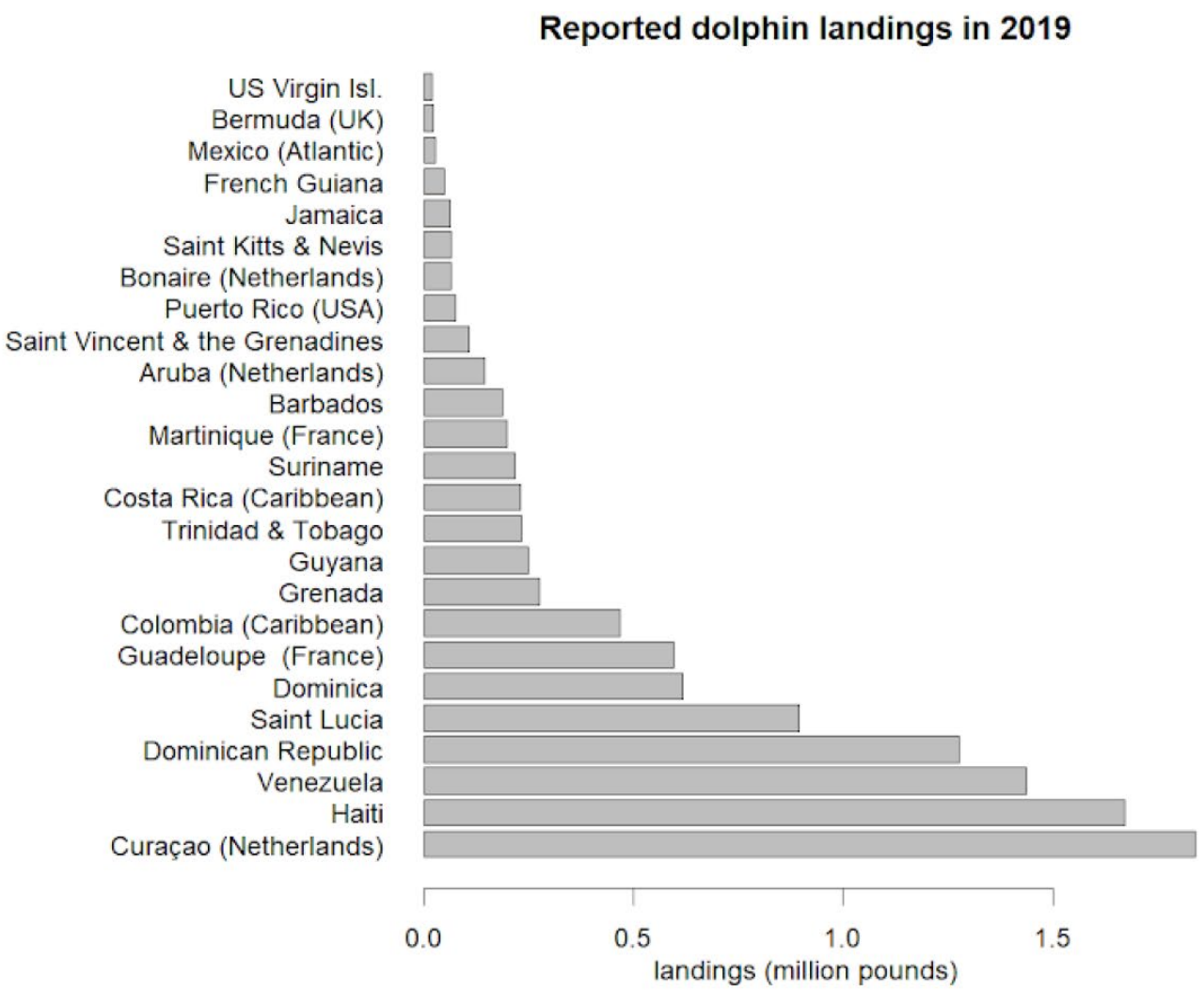

Fishing sector
Recreational
Industrial
0
20
40
60
80
millions of pounds

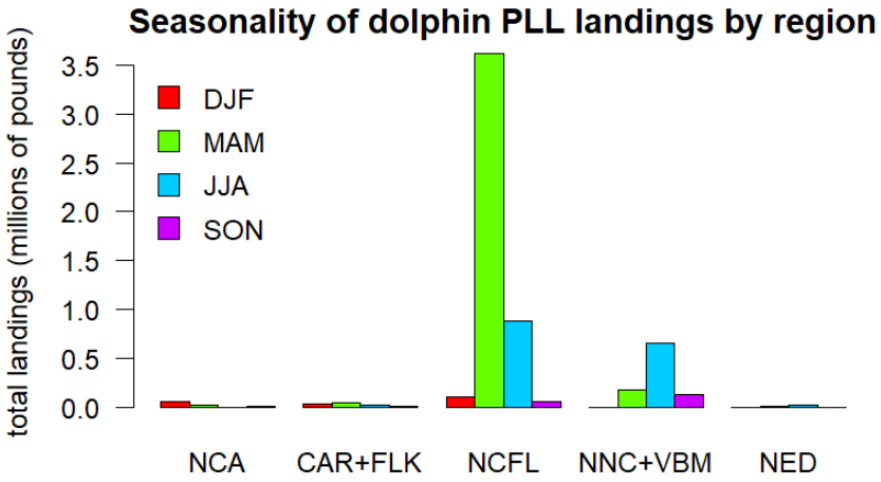

Catch type
Landings
0
20
40
60
80
100
millions of pounds

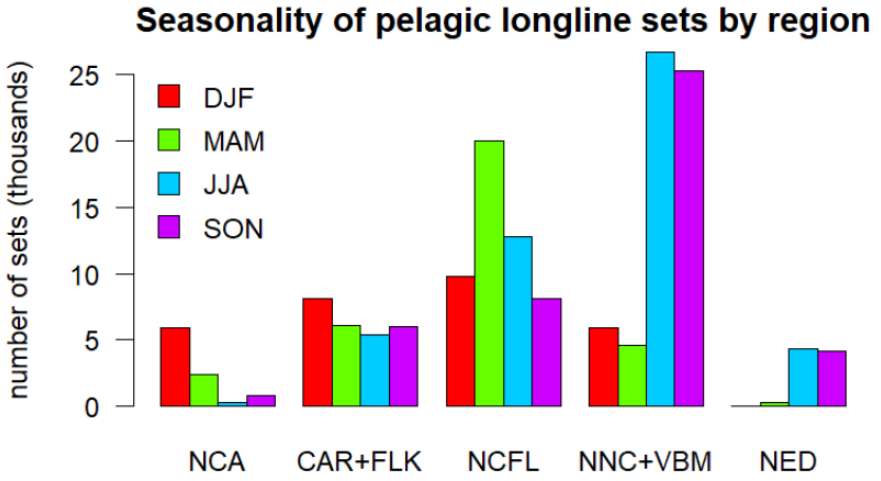

Reporting status
Unreported
Reported
0
20
40
60
80
millions of pounds

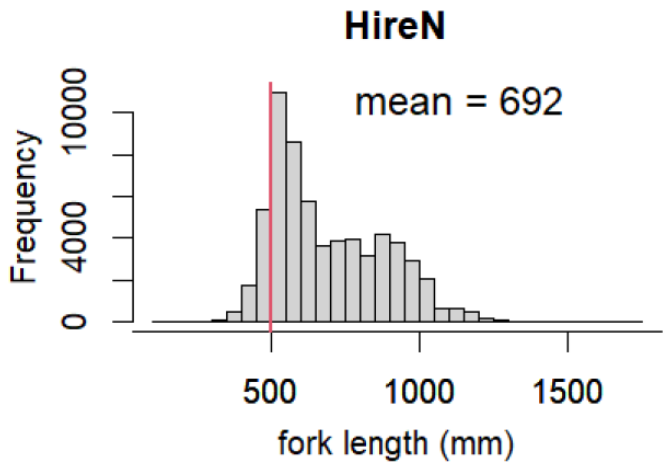

Gear type
recreational fishing gear
other industrial
longline
0
20
40
60
80
millions of pounds

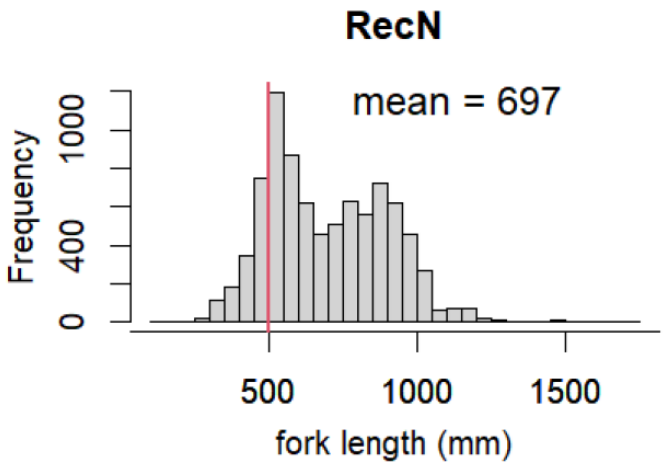

Anguilla (UK)
Antigua & Barbuda
Aruba (Netherlands)
Bahamas
Barbados
Belize
Bermuda (UK)
Bonaire (Netherlands)
British Virgin Isl. (UK)
Cayman Isl. (UK)
Colombia (Caribbean)
Costa Rica (Caribbean)
Cuba
Curaçao (Netherlands)
Dominica
Dominican Republic
French Guiana
Grenada
Guadeloupe (France)
Guatemala (Caribbean)
Guyana
Haiti
Honduras (Caribbean)
Jamaica
Martinique (France)
Mexico (Atlantic)
Montserrat (UK)
Nicaragua (Caribbean)
Panama (Caribbean)
Puerto Rico (USA)
Saba and Sint Eustatius (Netherlands)
Saint Kitts & Nevis
Saint Lucia
Saint Vincent & the Grenadines
Sint Maarten (Netherlands)
St Barthelemy (France)
St Martin (France)
Suriname
Trinidad & Tobago
Turks & Caicos Isl. (UK)
US Virgin Isl.
Venezuela
0.0
1.0
2.0
3.0

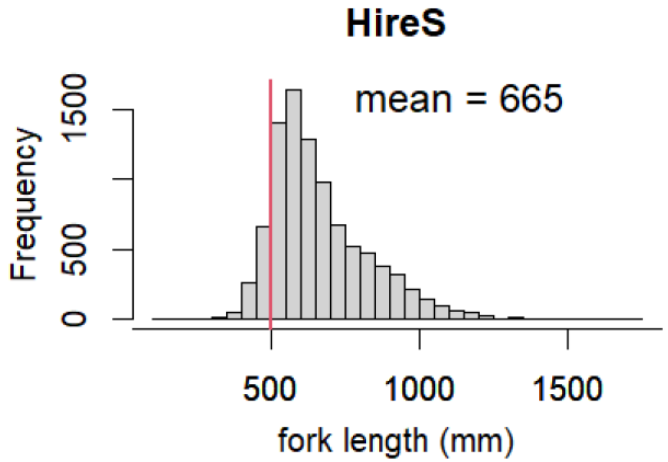

Reported dolphin landings in 2019
US Virgin Isl.
Bermuda (UK)
Mexico (Atlantic)
French Guiana
Jamaica
Saint Kitts & Nevis
Bonaire (Netherlands)
Puerto Rico (USA)
Saint Vincent & the Grenadines
Aruba (Netherlands)
Barbados
Martinique (France)
Suriname
Costa Rica (Caribbean)
Trinidad & Tobago
Guyana
Grenada
Colombia (Caribbean)
Guadeloupe (France)
Dominica
Saint Lucia
Dominican Republic
Venezuela
Haiti
Curaçao (Netherlands)
0.0
0.5
1.0
1.5
landings (million pounds)

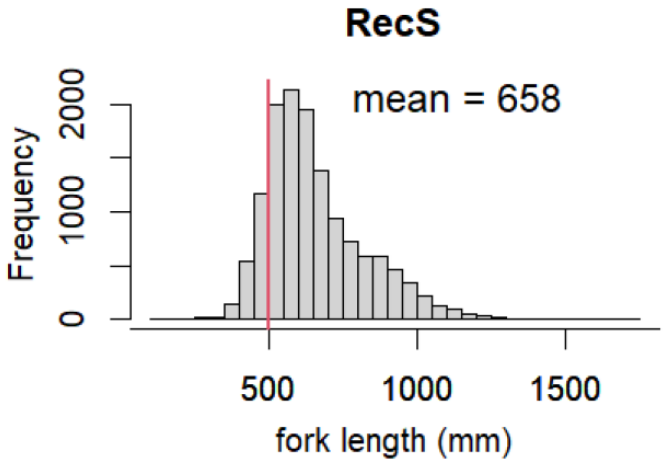

Seasonality of dolphin PLL landings by region
total landings (millions of pounds)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
DJF
MAM
JJA
SON
NCA
CAR+FLK
NCFL
NNC+VBM
NED

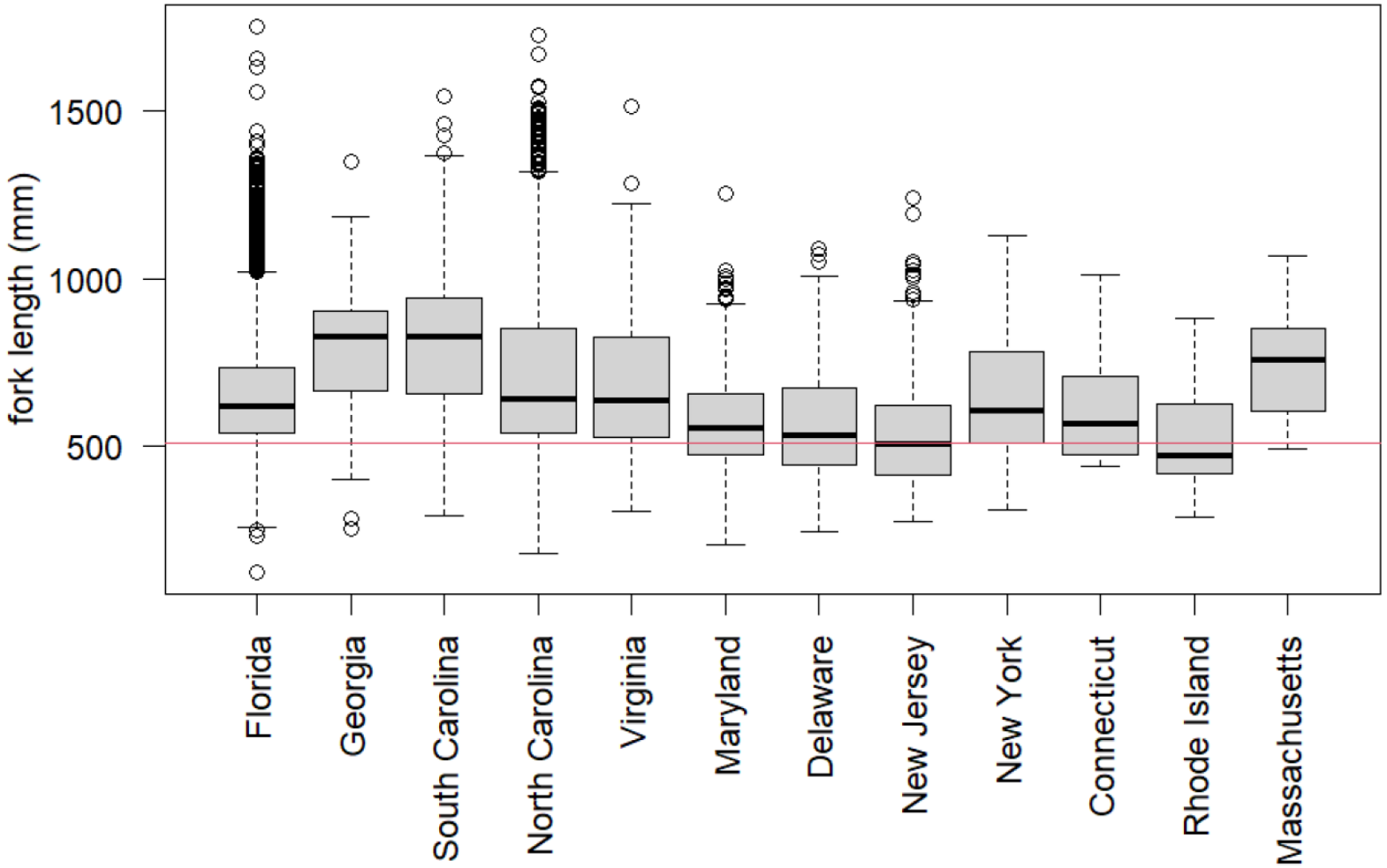

Seasonality of pelagic longline sets by region
number of sets (thousands)
25
20
15
10
5
0
DJF
MAM
JJA
SON
NCA
CAR+FLK
NCFL
NNC+VBM
NED


HireN
mean = 692
Frequency
0
4000
10000
500
1000
1500
fork length (mm)

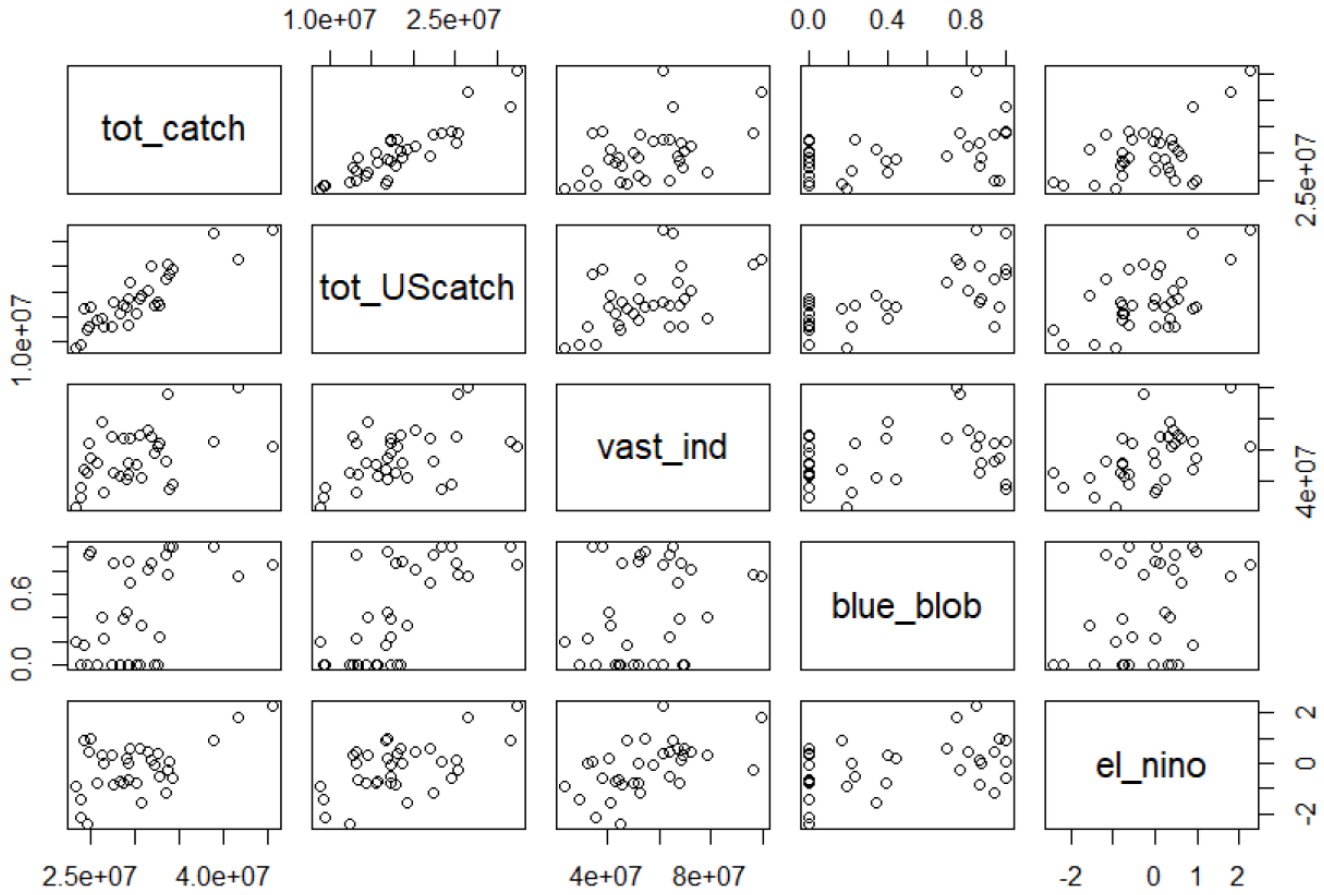

RecN
mean = 697
Frequency
0
400
1000
500
1000
1500
fork length (mm)

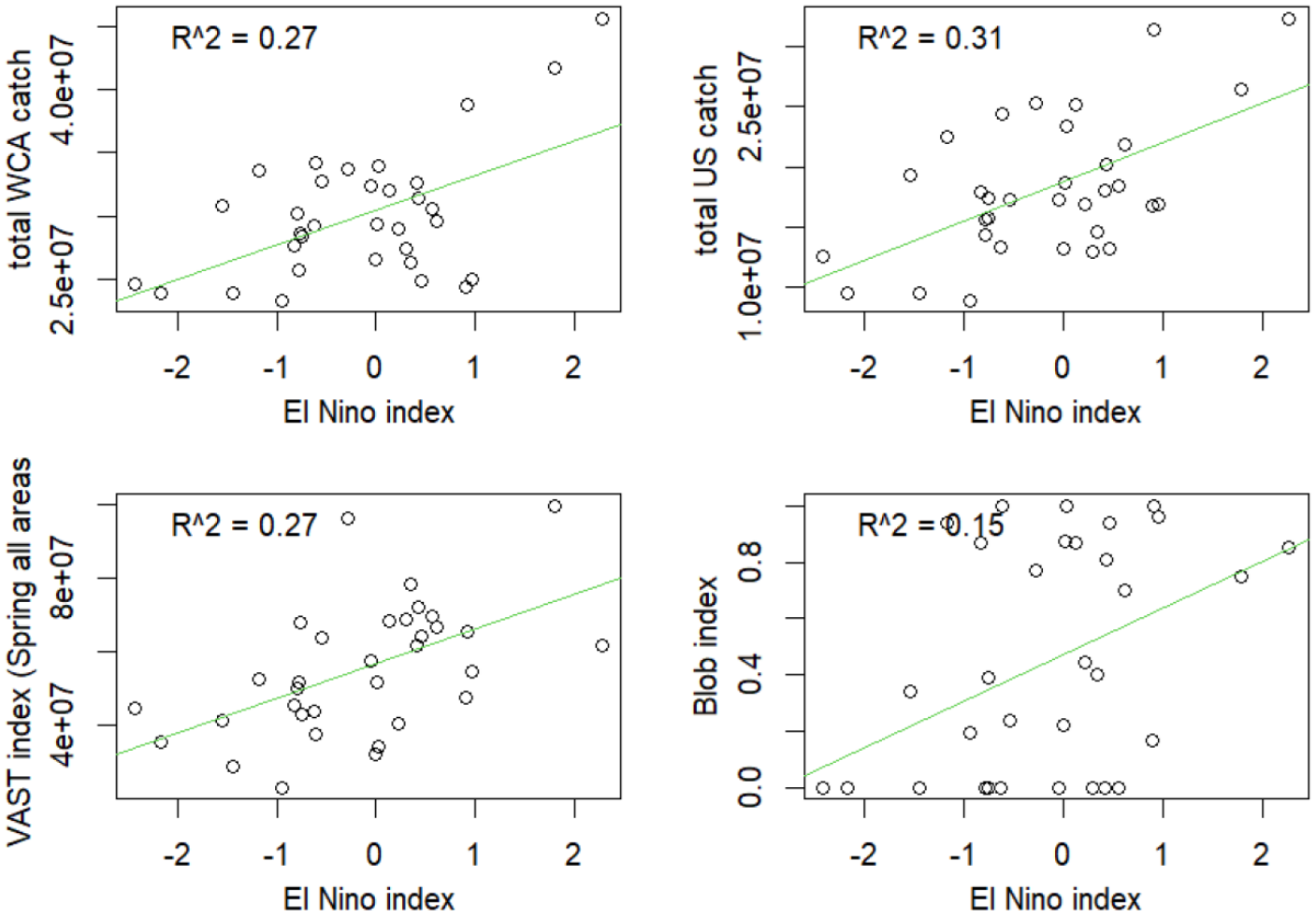

HireS
mean = 665
Frequency
0
500
1500
500
1000
1500
fork length (mm)


RecS
mean = 658
Frequency
0
1000
2000
500
1000
1500
fork length (mm)


fork length (mm)
1500
1000
500
Florida
Georgia
South Carolina
North Carolina
Virginia
Maryland
Delaware
New Jersey
New York
Connecticut
Rhode Island
Massachusetts

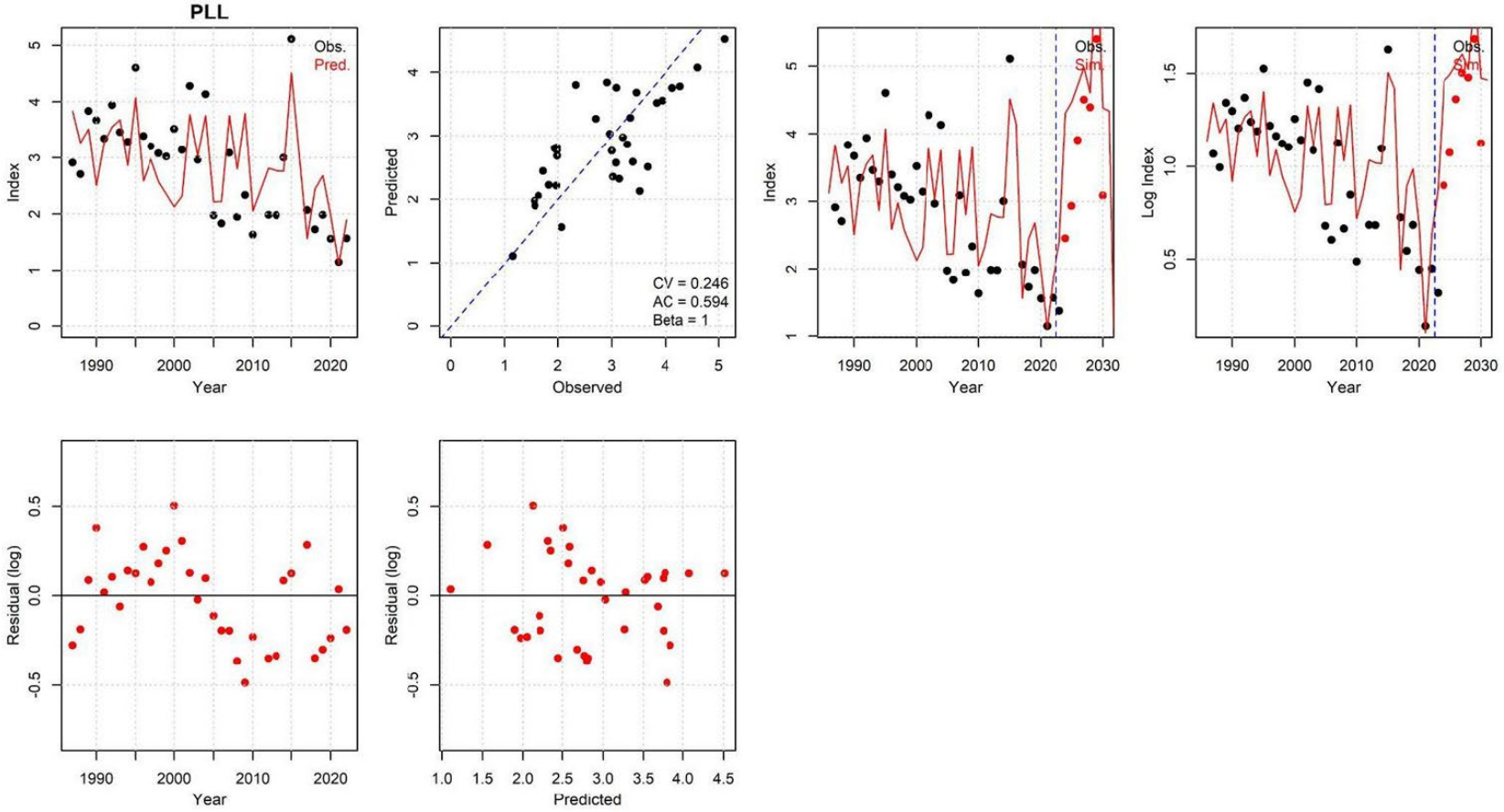
Environmental index correlations


tot_catch
tot_UScatch
vast_ind
blue_blob
el_nino
1.0e+07
2.5e+07
0.0
0.4
0.8
1.0e+07
2.5e+07
4e+07
0.0
0.6
-2
0
2
2.5e+07
4.0e+07
4e+07
8e+07
-2
0
1
2


R^2 = 0.27
total WCA catch
2.5e+07
4.0e+07
-2
-1
0
1
2
El Nino index
R^2 = 0.31
total US catch
1.0e+07
2.5e+07
-2
-1
0
1
2
El Nino index
R^2 = 0.27
VAST index (Spring all areas
4e+07
8e+07
-2
-1
0
1
2
El Nino index
R^2 = 0.15
Blob index
0.0
0.4
0.8
-2
-1
0
1
2
El Nino index

Additional presentation & Slick edits

Day 2 Request (Residual Error plots - PLL)



Slick Fixes (Day 3 Reviewer Comments)

- Slick Time Series Discontinuity
- AAVY calculation
- CER vs CER_A anomaly
- Inclusion of Landings by US / non US
- Inclusion of Indices

Slick Time Series Discontinuity

Was:

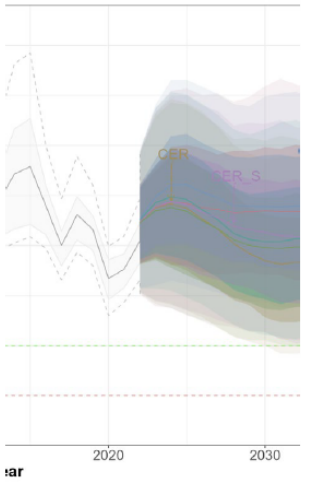
Time(timeseries) <- c(rev(seq(2022, by=-1, length.out=hyears)),
seq(**2022**, by=1, length.out=proyears))

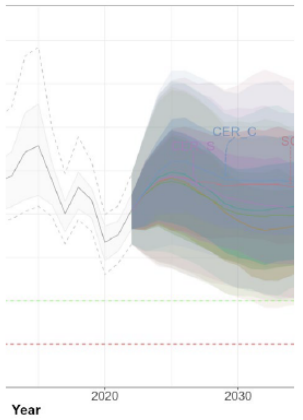
… 2021, **2022, 2022**, 2023, …

Now:

Time(timeseries) <- c(rev(seq(2022, by=-1, length.out=hyears)),
seq(**2023**, by=1, length.out=proyears))

… 2021, **2022, 2023**, 2024, …





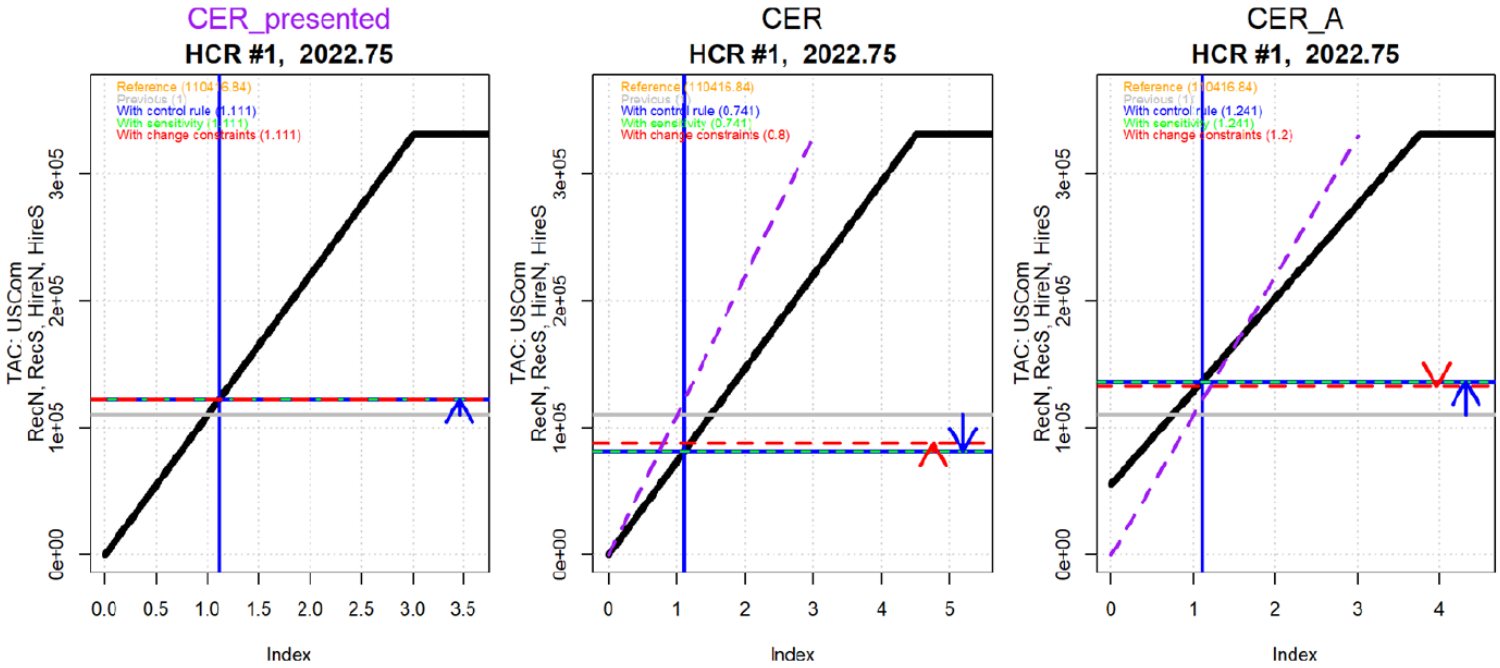
AAVY Calculation

- Correct calculation but applied across quarters not years

```
cat("Calculating Catch Diff (Cdif) \n")
# --- Catch diff ----------------------------------------------------------------
t1 = 1:(dim(Landings_byfleet)[3]-1)
t2 = 2:dim(Landings_byfleet)[3]
CDif = abs((Landings_byfleet[,,t2,,,drop=F] -
              Landings_byfleet[,,t1,,,drop=F]) /
             Landings_byfleet[,,t1,,,drop=F])
dimnames(CDif) = list(OMnames,paste("sim",1:dms$nsim),ylab[2:nylab],Fleets,names(MSElist[[1]]@MPs))
```

CER versus CER_A

In a previous version of mahiMSE, MP HCRs were phrased in terms of both Catch relative to 2022 and Index relative to 2022. Hence the default HCR control slope was essentially a 1:1 line. The results presented had that slope, not the revised slope which uses the actual index value (approx 1.5 in 2022)



```
# CER_S
CER_S = CER
formals(CER_S)$HCR_up_max = 0.1       # up to 10% increases in TAC
formals(CER_S)$HCR_down_max = 0.1     # up to 10% decreases in TAC
class(CER_S) = 'mp'

# CER_A more aggressive
CER_A = CER
formals(CER_A)$HCR_ICP = list(c(0, 3.75))          # Control points are PLL 1.5 and 2.5
formals(CER_A)$HCR_LCP = list(c(0.5, 3))       # TAC is between 50% and 150% of 2022 catches
class(CER_A) = 'mp'

# CER_B
CER_B = CER
formals(CER_B)$HCR_ICP = list(c(0.75, 2.25))     # Control points are PLL 1.5 and 2.5
formals(CER_B)$HCR_LCP = list(c(0.5, 1.5))       # TAC is between 50% and 150% of 2022 catches
class(CER_B) = 'mp'

# CER_C constrained
CER_C = CER
formals(CER_C)$HCR_ICP = list(c(1, 1.5))          # Control points are PLL 1.5 and 2.5
formals(CER_C)$HCR_LCP = list(c(0.25, 1))       # TAC is between 50% and 150% of 2022 catches
class(CER_C) = 'mp'
```

Inclusion of US / non US landings

Not quite yet

Inclusion of Indices

Trickier than I had previously thought due to these being generated within the MP. Can use the ‘Misc’ slot to do this but need Adrian to code it into the posterior predicted data output of the MSE objects.