An Accounting of Approaches to Incorporate Environmental, Climate, and Ecosystem Impacts in Fishery Stock Assessments in the U.S. from 2003–2023

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U.S. Department of Commerce
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ABSTRACT

Ecosystems are not static, and it has been well established that changes in ocean and environmental conditions affect marine species. Our ability to account for ecosystem and environmental changes, impacts, and variability in our stock assessments is important, and interest is rising among scientists, managers, and other interested/affected groups, resulting in increased scrutiny with respect to tracking and documenting the ways in which NOAA Fisheries is currently incorporating this information into stock assessments. Collecting and compiling this information is a first step toward understanding how environmental information is being included in the stock assessment and management process throughout NOAA Fisheries. This can aid in both highlighting agency successes and identifying key gaps and areas for improvement moving forward. The goal of this review is to establish a baseline understanding of how ecosystem, environmental, and climate information is incorporated in U.S. fisheries stock assessments. For this review, stock assessment staff at each science center were asked to provide their expert opinion on the appropriate environment linkage level for each of the stocks for which they are lead authors. Authors were asked follow-up questions to provide an opportunity to describe all the linkage approaches taken for a given stock. In this analysis, 364 stock assessments conducted solely or in partnership with NOAA Fisheries were reviewed, of which 232 (63.7 percent) explicitly or implicitly accounted for environmental variability or factors in at least one stage of the assessment process. Of those assessments, 26.3 percent (61/232) were level 1, meaning that environmental conditions were accounted for during processing of assessment inputs or informed the selection of an assessment parameter. Seventy percent (163/232) of them were level 2, where ecosystem variability was implicitly accounted for through the use of time-varying parameters or time-blocks/regimes. Only 3.4 percent (8/232) of them were level 3 or 4, indicating that one or more assessment parameters were directly linked to an environmental/climate factor in the final assessment model. This review highlights the efforts NOAA Fisheries is taking towards expanding the scope of single-species stock assessments in the U.S. to be more holistic and environmentally-linked and discusses limitations and future directions to continue this progress.

INTRODUCTION

Stock assessments are an essential part of sustainable fisheries management. The goal of stock assessments is to evaluate the current state of the population (e.g., how much is in the population now), what is likely to be there in the near future, and how best to harvest it without imperiling future reproductive success and yield. Stock assessments use models to represent fishing and biological processes such as recruitment, growth, natural mortality, and selectivity. Those models are integrated and fit to data using statistical methods (for more of an introduction to stock assessments, see Quinn and Deriso, 1999). Traditional stock assessments assume that these biological parameters remain unchanged over time (e.g., stationarity assumption), often with only recruitment varying temporally around a stationary mean process (Maunder and Thorson, 2019). This assumption implies a heavy focus on fishing as the primary driver of fish population dynamics and productivity, largely neglecting other potential drivers such as the environment (Nakken, 2002; Keyl and Wolff, 2008).

Growing evidence suggests that changing environmental conditions can cause variations in population processes. In a meta-analysis of 224 stocks, Szuwalski et al. (2015) found that the environment was often a stronger diver of recruitment than spawning stock biomass. Britten et al. (2017) found that 68 percent of the 276 stocks evaluated exhibited non-stationary trends in the intrinsic rate of population growth (*r*). Additionally, changes in stocks' spatial distributions resulting from changing ocean conditions can affect survey availability, thus impacting survey catchability and the resulting abundance trend estimates. Failing to account for variation in biological processes driven by climate or environmental changes could bias estimates of depletion, the biomass available for harvest, and reference points, leading to riskier and less robust management advice (Haltuch et al., 2009; Haltuch and Punt, 2011; Stawitz et al., 2019; Szuwalski et al., 2018).

Recognizing the impacts of changing climate conditions on fish stock distributions and biomass and the challenges posed to fisheries management by directional climate-driven change (Karp et al., 2019), the U.S. is moving toward more holistic, ecosystem-based, and climate-ready fisheries management. NOAA Fisheries understands the importance of incorporating ecosystem, environmental, and climate information into fish stock assessments and fisheries management. It is directly addressed by key strategic plans including the NOAA Fisheries Climate Science Strategy (NCSS; Link et al., 2015), Ecosystem-based Fisheries Management Road Map (EBFM; NMFS 2016), and Implementing a Next Generation Stock Assessment Enterprise: An Update to the NOAA Fisheries Stock Assessment Improvement Plan (NG-SAIP; Lynch et al. 2018). NOAA Fisheries released the NCSS to help increase its production, delivery, and use of climate-related information required to satisfy mandates, such as sustainably managing U.S. fish stocks. The EBFM Roadmap outlines specific actions to advance how NOAA Fisheries integrates social, economic, habitat, climate change, ecological, ocean-use, and ocean condition information into fisheries management and policy planning. The NG-SAIP builds off of the NCSS and EBFM Roadmap to emphasize the need for more holistic and ecosystem-linked stock assessments.

Various methods exist to incorporate environmental variables into assessments or to account for environmental variability. One approach is to explicitly link population processes to environmental covariates within the stock assessment model. However, only approximately 2 percent of global stock assessments employ this approach (Skern-Mauritzen et al., 2016) due to insufficient mechanistic understanding of such linkages (Myers, 1998; Haltuch et al., 2019a). Alternatively, assessments can implicitly account for unidentified ecosystem dynamics by including time regimes/blocks, random variation in biological processes, empirical weight at age, time/spatially varying biological parameters, or other such approaches. These approaches typically receive less attention than the more explicit approaches (Trenkel et al., 2023). However, for data-rich stocks with quality age-composition data, these implicit/empirical approaches provide useful accounting for the impacts of past environmental variability and trends on stock dynamics (Lee et al., 2018; Hollowed et al., 2023).

Environmental information can also improve processing of assessment inputs or inform selection of fixed parameters (parameters are set at predetermined values) in assessment models. For instance, including an environmental covariate when standardizing an index of abundance can help to account for environmentally driven changes in species distributions (Forrestal et al., 2019; Hoyle et al., 2024). Additionally, environmental and ecosystem information can inform the selection of the value of fixed demographic properties (growth, natural mortality, and stock–recruitment relationship), which can impact the management advice a stock assessment model provides. For example, outputs from multispecies or ecosystem models can inform the selection of a fixed natural mortality parameter in the single species assessment of a stock to better account for predation (Adams et al., 2022).

Before 2019, NOAA Fisheries only tracked the inclusion of ecosystem, environmental, spatial, and seasonal factors for stock assessments utilizing advanced age-structured or length-structured assessment models. That tracking focused primarily on explicit linkages and failed to account for the implicit approaches to the inclusion of environmental variability and change, resulting in an inconsistent and incomplete accounting of agency efforts and activities. NOAA Fisheries must adequately track and document which of its stock assessments have included environmental factors or variability if it is to understand the state of its operational science products and the progress being made toward its strategic priorities.

The agency has taken steps to improve its tracking and understanding of ecosystem linkages in stock assessments through revisions to the assessment classification system and collection of detailed information on whether and how stock assessments consider or incorporate ecosystem linkages. Collecting and compiling this information is a first step toward improving NOAA Fisheries’ understanding of how environmental information is being included in its stock assessment and management processes. It will aid the agency in highlighting successes and in identifying key gaps and areas for improvement moving forward. The goal of this review is to establish a baseline record of how the impacts of ecosystem, environmental, and climate variability are accounted for or incorporated in U.S. fisheries stock assessments.

METHODS

Each stock assessment reviewed was categorized based on the following six ecosystem-linkage levels from the NG-SAIP (Lynch et al., 2018; Table 1): (0) none; (1) informative or used to process input data; (2) random variation, not mechanistic; (3) direct linkage(s); (4) direct linkages informed by process studies; and (5) fully coupled (Table 1). Each stock assessment was also categorized by an assessment model category described in the NG-SAIP as follows: (1) data-limited; (2) index-based; (3) aggregate biomass dynamics; (4) virtual population analysis; (5) statistical catch-at-length; and (6) statistical catch-at-age.

The current study differs from previous studies that included reviews of the incorporation of ecosystem information in U.S. stock assessments (Skern-Mauritzen et al., 2016; Marshall et al., 2019; Pepin et al., 2020) in two notable ways. First, the current study uses the ecosystem-linkage level categories as defined in the NG-SAIP to score each assessment. Second, the scoring in the current study is based on whether the information was included in the final assessment model accepted for use in management. This differs from Marshall et al. (2019), which states that the scores reflected the level of consideration given to ecosystem information in the assessment report but not whether the final model used for decision-making included that ecosystem information. Therefore, direct comparison of numbers or percentage of assessments incorporating ecosystem, climate, or environmental information, between studies without consideration of these differences, is not recommended. The results presented in this study should be used to track progress moving forward.

The Ecosystem-Linkages Questionnaire

In the U.S., stock assessments for federally managed stocks are primarily carried out by scientists in the six regional fisheries science centers: Northeast Fisheries Science Center (NEFSC), Southeast Fisheries Science Center (SEFSC), Northwest Fisheries Science Center (NWFSC), Southwest Fisheries Science Center (SWFSC), Alaska Fisheries Science Center (AFSC), and Pacific Islands Fisheries Science Center (PIFSC). For this review, stock assessment staff at each science center were asked to select the most appropriate environment linkage level (Table 1) for each of the assessments for which they are lead authors based on their expert opinion. They were instructed to set the level at the highest linkage score for stocks utilizing multiple approaches at varying levels. For example, if an assessment used an environmental covariate in the standardization of abundance indices (level 1) and estimated random recruitment deviations (level 2), the overall environmental linkage score selected for the assessment would be a level 2.

Table 1: Ecosystem-linkage level definitions from Implementing a Next Generation Stock Assessment Enterprise (Lynch et al., 2018).

Level	Short Name	Description
0	None	No linkage to ecosystem dynamic or consideration of ecosystem properties (environment, climate, habitat, predator–prey, etc.) in configuring the assessment (i.e., equilibrium conditions assumed for ecosystem).
1	Informative or used to process data inputs	Ecosystem-based hypotheses inform the assessment model structure (e.g., defining the stock boundaries and/or spatial or temporal features) and/or are used for processing assessment inputs (e.g., abundance index, informing selection of parameter value) but no explicit linkage to any ecosystem drivers in the assessment model (environment, climate, habitat, predator–prey, etc.).
2	Random variation, not mechanistic	The assessment includes some form of variability or effect to explicitly account for unidentified ecosystem dynamic(s) (e.g., time/space “regimes”, random variation, or other approaches to changing features without direct inclusion of ecosystem data).
3	Direct linkage(s)	One or more assessment feature is linked to a dynamic (i.e., data) from at least one of the following categories: environment, climate, habitat, predator–prey data (e.g., covariate).
4	Direct linkage(s) informed by process studies	The assessment model is linked to at least one ecosystem dynamic, and one or more process studies directly support the manner in which environmental, climate, habitat, and/or predator–prey dynamics are incorporated (e.g., consumption rates measured and covariate informed by results).
5	Fully coupled	The assessment approach is configured to be coupled or linked with an ecosystem process (e.g., multispecies, coupled biophysical, and climate-linked models).

The questionnaire included a set of follow-up questions that prompted authors to describe all the linkage approaches taken for a given stock. Specifically, for each key assessment attribute the assessment author was asked to select from a dropdown menu of potential linkage approaches and then select the environmental process or variable linked in the assessment using the selected approach (see Appendix I). We instructed authors to select one of the time-varying options only when there was an underlying environmental hypothesis or rationale supporting the choice to make a parameter time-varying. Therefore, we did not consider parameters that were time-varying to account for changes in fishing behavior or regulations. Authors provided this information for the most recent benchmark or full update assessment for a stock. Our protocol did not allow for an evaluation of historical trends in the inclusion of environmental factors in stock assessments going back in time. Additional follow-ups clarified any inconsistencies or incomplete data entries. All information was collected within a new module in the NOAA Fisheries Species Information System (SIS).

While collecting this information directly from assessment authors helped ensure that we were provided with the most accurate and up-to-date information for an assessment, we acknowledge that it may have introduced some error or heterogeneity into the responses, as individual stock assessment authors may have occasionally interpreted the specific questions differently.

Selected Stocks

We reviewed 364 stock assessments conducted solely or in partnership with NOAA Fisheries. An initial list of 498 assessments was obtained through a query of the SIS database. That list included all stocks for which an assessment record was created within the SIS database. The list was trimmed based on the following criteria: (1) assessment completed since 2003; (2) removed rejected assessments and only kept assessments which were either "full acceptance," "partial acceptance," or "accept previous approach;" (3) not a salmon stock; (4) assessment unit is "self;" and (5) remove the old records for stocks that are now split or joined and assessed at different spatial resolutions. We chose 2003 because it aligned with the establishment of the requirement to set Annual Catch Limits for all stocks by the Magnuson–Stevens Fishery Conservation and Management Act reauthorization (16 U.S.C. §§1801-1891(d)). Salmon were not considered in this analysis as their assessments are generally conducted by tribal or state agencies, making it challenging to obtain the detailed information we are looking for in this analysis. The first criterion resulted in removing 23 records, the second resulted in a further removal of 24 stocks, the third resulted in an additional 67 stocks being excluded from the analysis, and the fourth removed 3 assessment records. Lastly, 17 additional records were removed for stocks that either split or combined assessments in later years (only their current, either split or combined, assessment was evaluated).

RESULTS

Overview of Environmental Linkage Levels

Of the 364 assessments we reviewed, 232 (63.7 percent) explicitly or implicitly accounted for environmental variability or factors in at least one stage of the assessment process (Figure 1). Of those assessments, 26.3 percent (61/232) were level 1, meaning that they accounted for environmental conditions during processing of assessment inputs or to inform selection of an assessment parameter. Seventy percent (163/232) of them were considered level 2, where ecosystem variability was implicitly accounted for through the use of time-varying parameters or time-blocks/regimes. Only 3.4 percent (8/232) of them were considered level 3 or 4, indicating that one or more assessment parameters were directly linked to an environmental/climate factor in the final assessment model. There were no level 5 (fully coupled) assessments.

Stock assessments that utilized models in higher categories incorporated more environmental considerations. Most of the assessments that did not incorporate ecosystem considerations (113/132, 85.6 percent) were data-limited or index-based methods (i.e., model category 1 or 2;

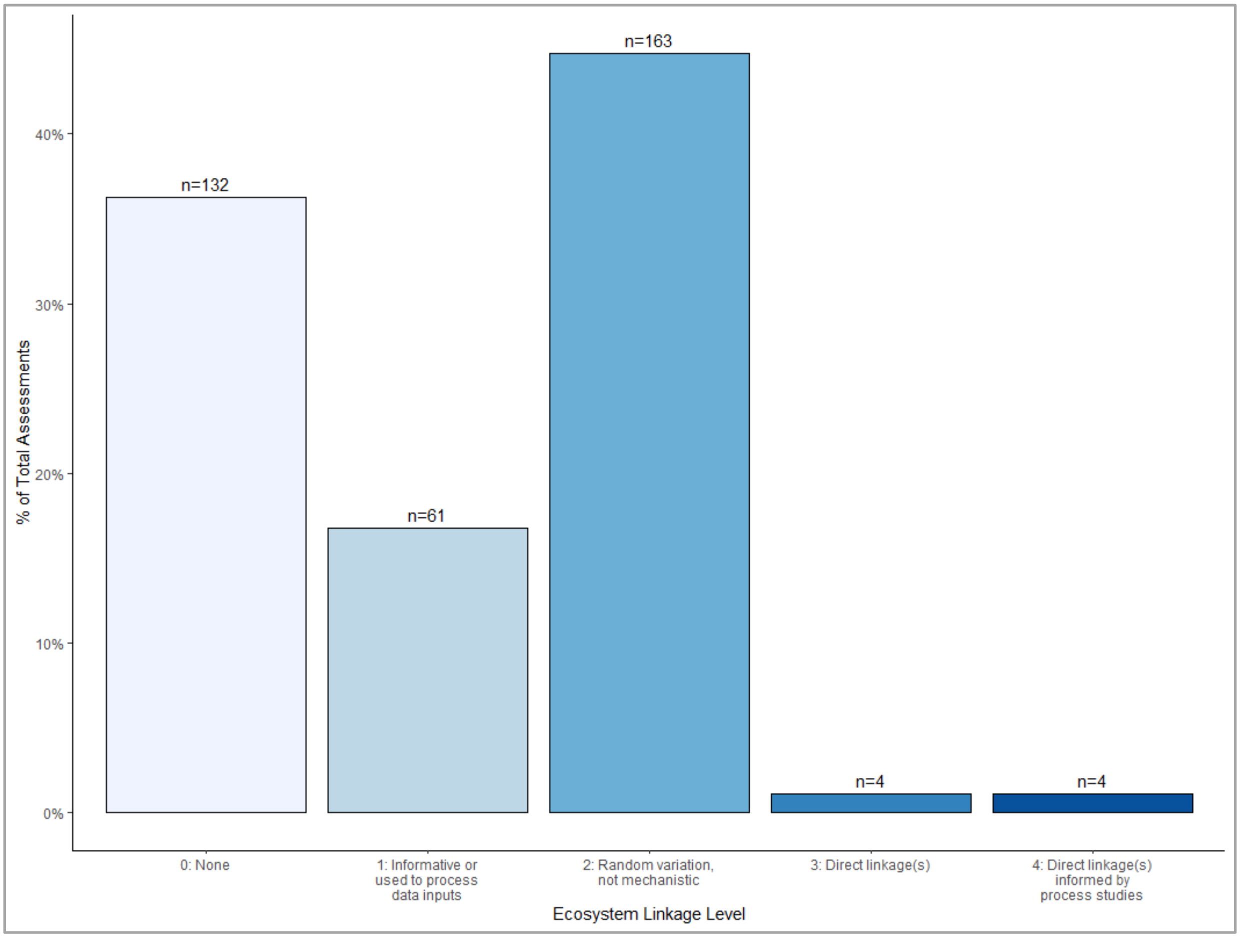

Figure 1: Counts of ecosystem-linkage levels (see Table 1 for more detailed definitions).

Figure 2). On the other hand, almost all of the assessments with an ecosystem-linkage of 2 or greater (165/171, 96.5 percent) were statistical-catch-at-length or statistical-catch-at-age models (i.e., model category 5 or 6; Figure 2).

Integration of Environmental Considerations by Stage and Linkage Approach

Informative or used to process assessment data inputs

Approximately 20 percent of the stock assessments examined (71/364) included environmental/climate or habitat information as covariates when standardizing their abundance indices (Figure 3). In those assessments, temperature was the most common climate/environmental factor used (30 assessments), followed by salinity (13), current direction (4), and the cold-pool index (3) (Table 2). Depth was the most commonly used habitat covariate (34 assessments), followed by reef as a categorical variable (9) (Table 2). One assessment (Alaska sablefish) accounted for the impact of whale depredation (whales removing or damaging fish on fishing gear) in the longline survey and commercial fishery (Goethel et al., 2023) by simultaneously estimating a depredation coefficient used to inflate catches at survey stations with

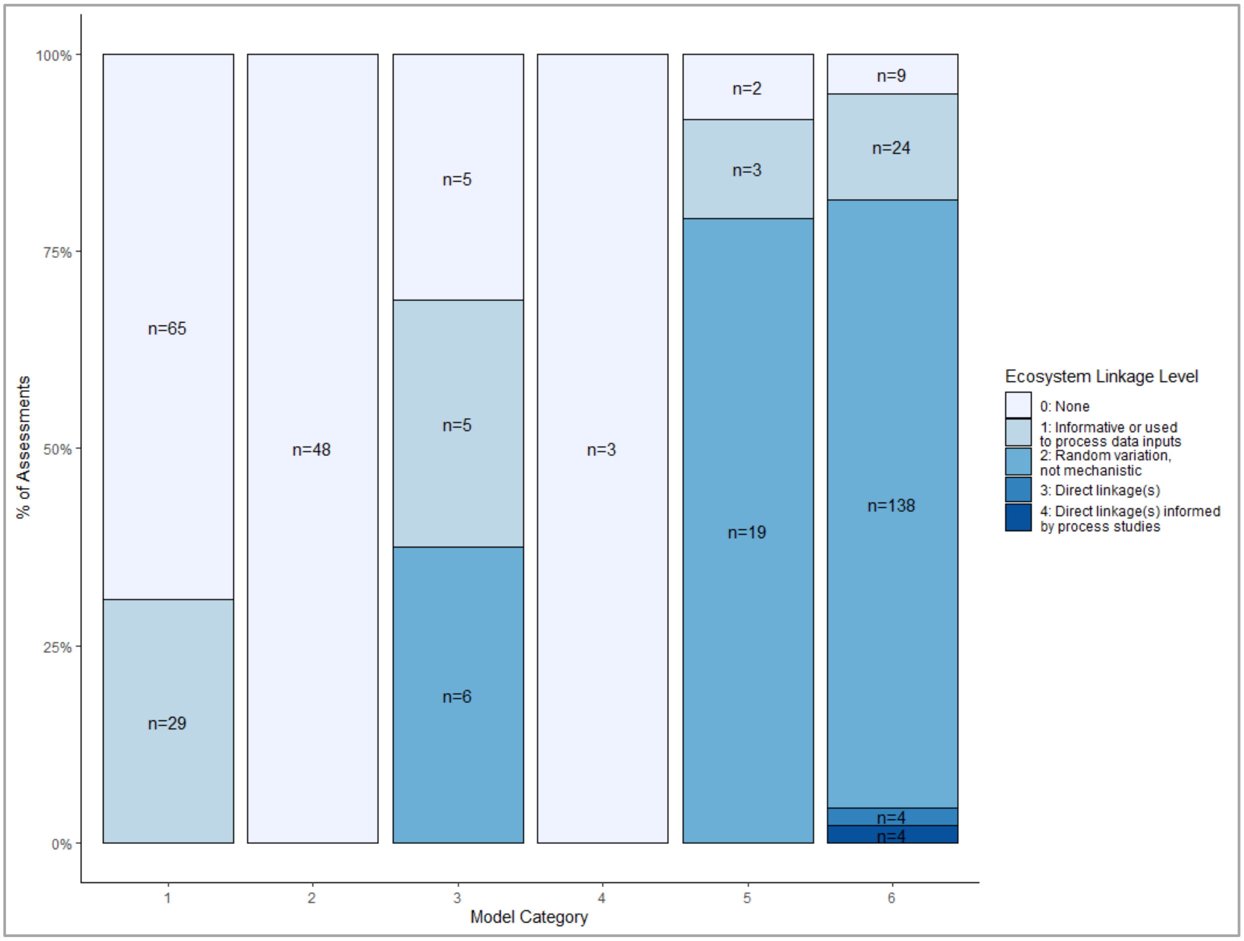

Figure 2: Ecosystem-linkage levels by assessment model category. Assessment model category is described in the NG-SAIP as: (1) data-limited, (2) index-based, (3) aggregate biomass dynamics, (4) virtual population analysis, (5) statistical catch-at-length, and (6) statistical catch-at-age.

evidence of sperm whale depredation (Peterson and Hanselman, 2017; Goethel et al., 2023). The majority of the 71 assessments that incorporated a climate/environmental or habitat covariate in the index of abundance standardization was carried out by the SEFSC (31 assessments) and the NWFSC/SWFSC (27 assessments). Climate/environmental factors were more common covariates in stock assessments conducted by the SEFSC (27 assessments), whereas habitat variables were more often included in stock assessment index standardization conducted by the NWFSC/SWFSC (26 assessments).

While not directly used as a covariate in the index of abundance standardization, the walleye pollock (Western/Central/West Yakutat Gulf of Alaska) assessment used observations of temperature and age structure contextually to predict variations in spawning timing and used them to inform bias estimates in the survey-based abundance index (Monnahan et al., 2023). This is based on studies which have shown that variation in spawn timing is not random but is linked to thermal conditions in March and the age structure of the spawning stock (Rogers and

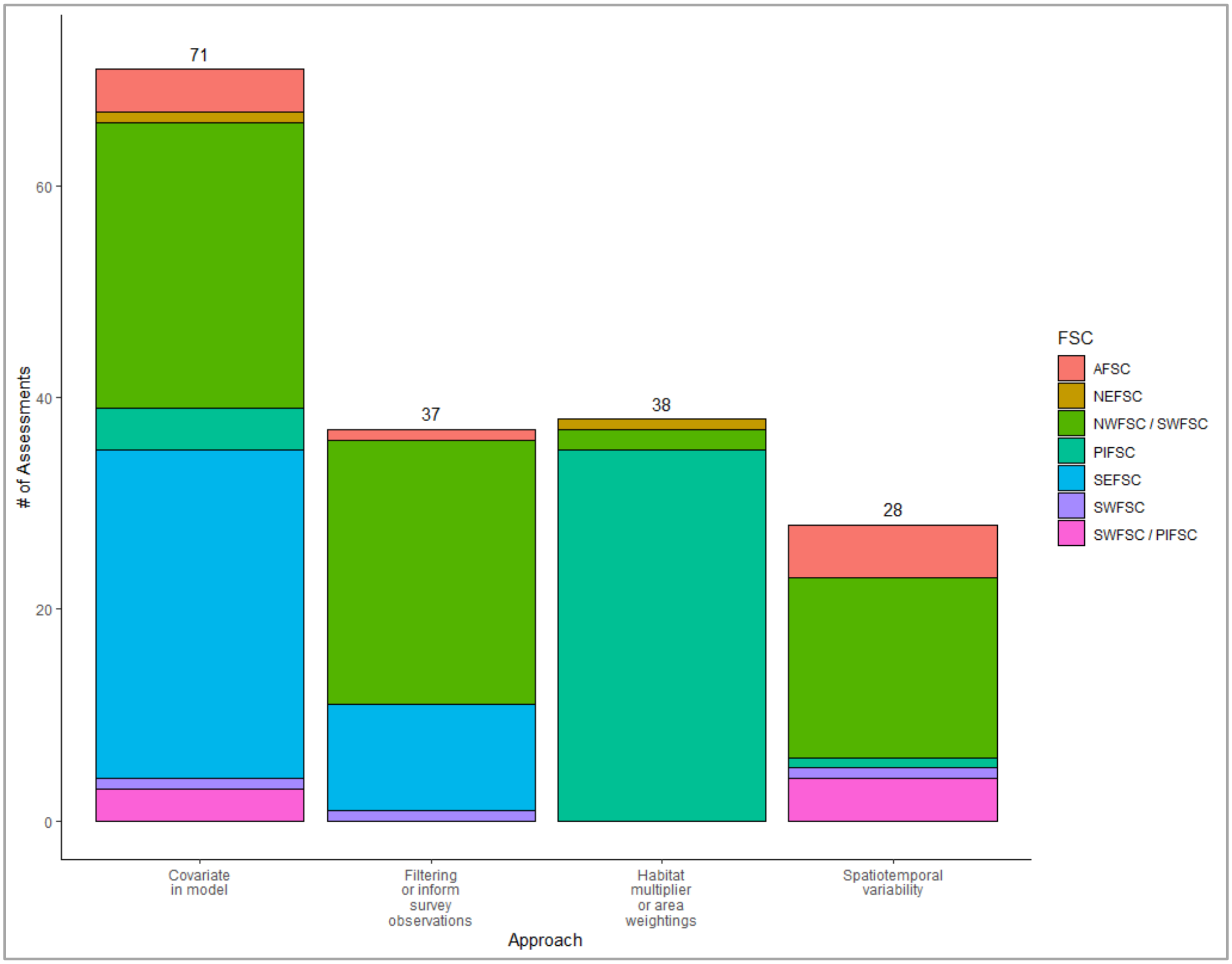

Figure 3: Counts of approach taken to process data inputs.

Dougherty, 2019). Spatiotemporal variability was accounted for in 28 assessments through using geostatistical models for the index of abundance standardization.

Twenty-one percent of the stock assessments examined (75/364) used habitat or climate/environmental information to filter out or correct observations of the assessed species in fishery-dependent or -independent surveys to account for survey–habitat mismatches (Figure 3). Habitat, characterized as bottom depth, distance to reef habitat, or the presence of co-occurring species (Stephens and McCall, 2004), was used to filter or remove catch observations used for fishery-dependent indices of abundance in 37 assessments, most frequently for the NWFSC/SWFSC (25 assessments) but rarely for other regions. The method was developed on the West Coast, and the lack of cross-region discussions on stock assessment tools is a potential reason for the lack of application elsewhere.[1] Scientists at the SWFSC developed a habitat model that uses sea surface temperature and chlorophyll to separate Pacific sardine fishery-dependent catch data into northern and southern subpopulations to inform their stock assessment of the

[1] Haltuch, M. 2024. Personal commun. Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

Table 2: Counts of environmental, climate, and ecosystem drivers used in different stock assessment features or processes. PDO = Pacific Decadal Oscillation, AMO = Atlantic Multidecadal Oscillation.

Category	Count of variable use by Assessment Process						
	Abundance Index	Catchability	Growth	Mortality	Maturity	Recruitment	Recruitment (Projections)
Habitat Variables							
Depth	42	1	0	0	0	0	0
Presence of co-occuring species in catch	23	0	0	0	0	0	0
Reef (categorical)	9	0	0	0	0	0	0
Distance to reef	8	0	0	0	0	0	0
Reef habitat area	6	0	0	0	0	0	0
Climate/Environmental Variables							
Temperature (simple)	29	3	0	1	0	0	0
Salinity	13	0	0	0	0	0	0
Predation/Consumption	1	0	0	3	0	1	0
Marine heatwaves	0	2	0	3	0	0	0
Climate oscillations (e.g., PDO, AMO, ENSO)	1	3	1	0	0	0	0
Current direction	4	0	0	0	0	0	0
Cold pool	3	0	0	0	0	0	0
Tide	3	0	0	0	0	0	0
Mixed layer depth	2	0	0	0	0	0	0
Chlorophyll-a	2	0	0	0	0	0	0
Wind speed	2	0	0	0	0	0	0
Harmful algal blooms	0	0	0	2	0	0	0
Moon fullness	1	0	0	0	0	0	0
Turbidity	1	0	0	0	0	0	0
Sea surface height	0	0	0	0	0	1	0

northern subpopulation (Demer and Zwolinski, 2014; Kuriyama et al., 2024; Zwolinski and Demer, 2024).

Thirty-eight stock assessments (10.4 percent) used habitat area as either a multiplier for densities observed in the survey or to weight the densities to adjust the final biomass estimates (Figure 3). Thirty-five of those assessments (95 percent) were conducted by the PIFSC for stocks managed by the Western Pacific Fishery Management Council. Twenty-six of them were stocks managed as part of the coral reef fishes of Hawaii complex, where the surveyed fish biomass density per sector was multiplied by the amount of hard-bottom habitat area within each sector to obtain the final abundance index (Nadon, 2017). Nine were stocks assessed as part of the American Samoa bottomfish assessment, where the annual catch per unit effort (CPUE) was estimated as an area weighted average where the weightings assigned to each area were based on their relative proportion of the available bottomfish habitat (Nadon et al., 2023).

In a few instances (7 of the 364 assessments), habitat or climate/environmental information informed the selection of a fixed parameter in the model (Figure 4). Information on predation informed the selection of the natural mortality parameter in four assessments (Atlantic herring, Northwestern Atlantic coast; giant octopus, Bering Sea/Aleutian Islands; walleye pollock, Eastern Bering Sea; and walleye pollock, Western/Central/West Yakutat Gulf of Alaska) (NEFSC, 2024a; Cronin-Fine et al., 2023; Ianelli et al., 2023; Monnahan et al., 2023). The Bluespine unicornfish (Guam) assessment selected an estimate for longevity from a study in Guam, rather than for the same species in Hawaii, based on a study that confirmed a strong relationship between temperature and longevity in the species (Nadon, 2017; Nadon, 2019). The Pacific coast longnose skate assessment used habitat information to inform a prior on catchability. Specifically, latitudinal, depth, and vertical availability of longnose skate to the bottom trawl survey as well as the probability of catch in survey net path were considered (Gertseva et al., 2019). Sex-specific priors for natural mortality for Pacific sanddab were calculated using Hoenig's maximum ages, von Bertalanffy's growth coefficients (K), asymptotic lengths, and mean temperature (He et al., 2013).

Random variation, not mechanistic

Forty-five percent of the stock assessments evaluated (164/364) included some form of variability on a parameter in the population model to implicitly account for changing ocean conditions (Figure 4). The most frequent approach was to estimate random deviations, primarily around mean recruitment (157/364, 43.1 percent); however, random deviations were also estimated for catchability in four assessments (Pacific cod, Eastern Bering Sea; Pacific hake, Pacific coast; walleye pollock, West/Central/Western Yakutat Gulf of Alaska; Northern anchovy, Southern Pacific coast), for growth in two (Pacific cod, Eastern Bering Sea, Gulf of Maine haddock), and natural mortality in one (sea scallops, Northwest Atlantic) (Barbeaux et al., 2023;

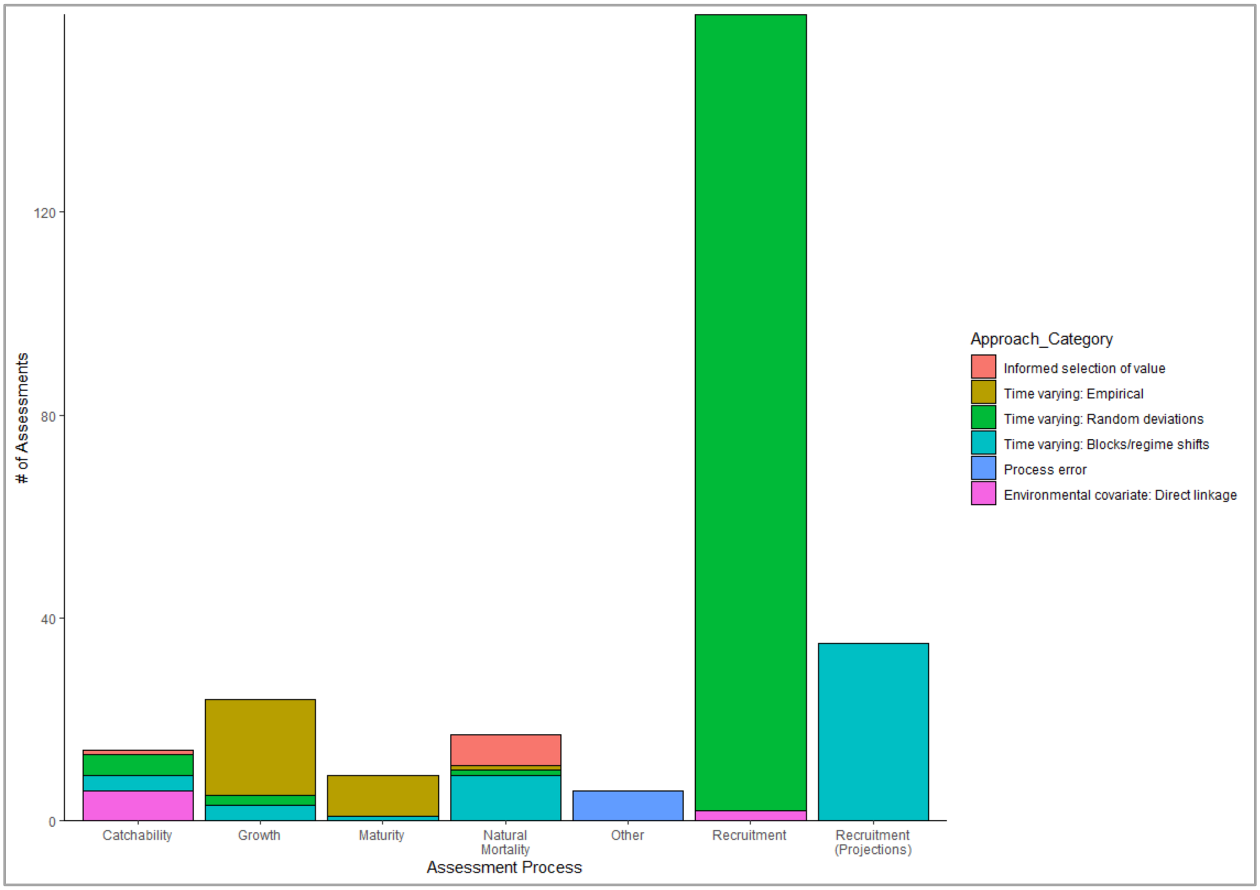

Figure 4: Ecosystem-linkage approach taken within the stock assessment model.

Grandin et al., 2024; Monnahan et al., 2023; Kuriyama et al., 2022; Kuriyama et al., 2023; NEFSC, 2022a; NEFSC, 2020).

Thirteen assessments (3.6 percent) implemented time-blocks specifically to account for an environmental event or regime change for at least one parameter in the assessment model. Natural mortality was the parameter most often time-blocked (*n* = 9), followed by catchability (*n* = 3), growth (*n* = 3), and maturity (*n* = 1). Six assessments implemented time-blocks on mortality to account for episodic or extreme environmental events. In the Gulf of Mexico, both the gag and the red grouper assessments accounted for increased mortality during severe red-tide events through modeling red-tide as a pseudo-fishing fleet operating only in identified severe red-tide years with 100 percent discard mortality (SEDAR, 2022; SEDAR, 2019). Gulf of Alaska Dover sole and Pacific cod, as well as Bering Sea snow and red king crab, assessments implemented time-blocks on mortality to account for the increased mortality during recent marine heatwave events (McGilliard and Ferriss, 2023; Hulson et al., 2023; Szuwalski, 2023; Palof, 2023; Hamazaki, 2023). Of the three assessments that implemented time-blocks on growth, only one (Chilipepper) explicitly identified an environmental driver (Field et al., 2015). In that assessment, time-varying growth was estimated internally in the model, implemented with time-block offsets for the growth coefficient (K) informed by major shifts in the signal for the Pacific Decadal Oscillation.

Thirty-five assessments (9.6 percent) used recruitment estimates from the most recent time period or regime in the projections, which implicitly integrates the environment, allowing for the impact of recent environmental conditions on recruitment to be reflected in reference points and harvest control rules (Figure 4). This approach was most commonly applied for stocks in the Alaska region (28 assessments) as the AFSC has recognized that an environmental "regime shift" affecting the long-term productive capacity of many groundfish stocks, with some exceptions, in the Bering Sea and Aleutian Islands (BSAI) occurred during the period 1976–1977. Thus, many groundfish stocks in the BSAI make projections and calculate reference points using average recruitment values for year classes spawned after 1976 (the 1977-year class). Five stock assessments conducted by the NEFSC (Atlantic mackerel, butterfish, white hake, Southern New England/Mid-Atlantic winter flounder, and Southern New England/Mid-Atlantic yellowtail flounder) implemented a recruitment regime shift in their projections as well (NEFSC, 2023b; NEFSC, 2024b; NEFSC, 2022d; NEFSC, 2022b; NEFSC, 2022c). However, unlike stocks in Alaska, each of these stocks uses a different time period of recent recruitment informed by different hypotheses and lines of evidence.

Nineteen assessments (5.2 percent) enabled time-varying parameters in the model through empirical estimates of growth, maturity, and natural mortality (Figure 4). In all 19 assessments, time-varying growth was estimated through the use of empirical-weight-at-age. In eight assessments (all conducted by the NEFSC), both growth and maturity were empirically estimated, and in one AFSC assessment (Southern tanner crab, Eastern Bering Sea), growth, maturity, and natural mortality were all empirically estimated.

Six assessments conducted at the PIFSC using Bayesian methods added process error to the deterministic process dynamics. The process error model related the dynamics of exploitable biomass to natural variability in demographic and environmental processes affecting populations of bottomfish management unit species such as trophic interactions, environmental conditions, and other factors not directly accounted for in the model.

Environmental covariates: Direct linkages

Only eight assessments (2.2 percent of the 364 evaluated) directly linked an environmental driver to a parameter in the stock assessment model (Figure 4). Six of them linked temperature or thermal regimes to catchability: arrowtooth flounder (Bering Sea/Aleutian Islands), Pacific cod (Gulf of Alaska), yellowfin sole (Bering Sea/Aleutian Islands), silky shark (Western and Central Pacific), bluefin tuna (Western Atlantic), and swordfish (North Atlantic) (Clark et al. 2018; Shotwell et al., 2022; Hulson et al., 2023; Spies et al., 2023; Anonymous, 2022). Pacific cod have been observed to change distribution with varying ocean temperatures, making them more or less available to the AFSC longline survey, which has a limited depth range (Yang et al., 2019). Therefore, in the assessment model, the AFSC longline survey catchability included a parameter to additively adjust annual catchability values based on an annual temperature index. Similarly, the catchability of yellowfin sole (Nichol et al., 2019) and arrowtooth flounder (Shotwell et al., 2022) are thought to positively co-vary with bottom temperature. The assessment models use the survey-estimated bottom temperature anomaly as a covariate in the catchability equation estimated inside the operational model. The Atlantic Multidecadal Oscillation (AMO) influences the distribution of swordfish in the Northwest Atlantic affecting catchability by east and west fleets. Based on regressions between CPUE residuals and the AMO, the Canadian (west), Japan (west), EU-Portugal (east), Morocco (east), and EU-Spanish Age_1, Age_2, Age_4, and Age_5+ (all east) catchability (q) were made a function of the AMO. Similarly, the catchability values for three indices in the Western Atlantic bluefin tuna assessment were also linked to the AMO (Tsukahara et al., 2021). The 2018 assessment for silky shark included an ENSO index as an environmental covariate in the catchability model to account for the influence of oceanographic conditions on catch rates (Clark et al. 2018).

Two assessments used a time-series of an environmental indicator as an index of recruitment. The Pacific coast sablefish assessment used a time-series of sea surface height as a survey index of recruitment based on studies indicating that variation around the stock–recruitment curve was negatively correlated with sea level north of Cape Mendocino. This index serves as a proxy for large-scale climate forcing that impacts relevant ocean transport dynamics (Tolimieri et al., 2018; Johnson et al., 2023). The Pacific coast shortbelly rockfish assessment used a sea bird predation index as an indicator of recruitment strength (Field et al., 2007).

DISCUSSION

There is growing recognition of the need for a more holistic and ecosystem-linked approach to fisheries management that can account for environmentally driven changes in stock distribution and productivity (e.g., NCSS, EBFM policy and roadmap, and NG-SAIP; Karp et al., 2019). Changes in stock productivity and distribution affect the assessment and management processes. Failing to account for them could lead to errors in estimates of stock biomass and biological reference points and an increased risk of overly permissive or restrictive management advice. Incorporating habitat, ecological, and environmental/climate information in the stock assessment and management processes is an important step in the movement toward EBFM and climate-ready fisheries in the U.S.

Our analysis highlights both the implicit and explicit approaches that are used to account for and incorporate habitat, ecological, and environmental/climate variability into the stock assessment process. In the following sections, we discuss the pros and cons of implicit and explicit approaches, limitations to more explicit environment–stock linkages in assessments, and future directions and recommendations to move toward more direct climate- and environment-informed stock assessments.

Implicit vs. Explicit Incorporation

When considering implicit and explicit approaches to account for habitat, ecosystem, and environmental/climate conditions, over half of the U.S. marine fish and invertebrate stock assessments account for past environmental variability to some extent. This is a greater proportion of assessments than Skern-Mauritzen et al.'s 2016 global review and Marshall et al.'s 2019 review of U.S stock assessments. However, neither considered implicit approaches to account for environmental trends and variability impacts on stock dynamics, such as estimating recruitment deviations or using empirical weight-at-age, in their evaluations. Therefore, when taking a more inclusive view on what "counts," the U.S. is already implementing an ecosystem approach to fisheries management for many stocks.

Implicit approaches accounting for environmental change and variability outnumber explicit consideration within U.S. Federal stock assessment models. Consistent with past studies and meta-analyses, we found that recruitment was the most common parameter to be time-varying (43.1 percent of assessments). While we documented several stock assessments in which mortality was modeled as time-varying, it comprised a notably smaller percentage of assessments in the U.S. (3 percent) compared with Canadian (Pepin et al., 2020) and ICES (Trenkel et al., 2023) stocks, where 33 percent and 20 percent, respectively, included time-varying natural mortality.

Implicit approaches are appealing as they do not require detailed knowledge of the mechanistic relationship between the environment and stock productivity or distribution. Thus, they are generally less costly and more straightforward. Their simplicity does not come without risks, and it is important that ecological and biological understanding informs decisions related to the inclusion of time-varying parameters or regime shifts. For example, it is possible to fit the wrong process as time-varying if relying solely on statistical model fitting. Szuwalski et al. (2018) found that retrospective biases could be reduced by allowing the wrong process to vary through time. Fisch et al. (2023) showed that modeling time-variation on the wrong process can result in biased estimates of depletion and spawning stock biomass. Similar issues can arise when truncating the recruitment time-period to focus on recent conditions to account for regime shift. Such an approach runs the risk of incorrectly identifying the existence of an environmentally induced change in productivity (e.g., Type I error) and can lead to a model misspecifying reference points (Haltuch and Punt, 2011). Implicit approaches also lack the capacity to project future impacts on stock dynamics, such as those due to climate change. As such, they cannot improve future projections of stock population dynamics or harvest guidance.

Our review found that explicit inclusion of environmental variables in a stock assessment more often accounted for stock distribution or availability changes as opposed to productivity changes, which aligns with Skern-Mauritzen et al.'s 2016 and Marshall et al.'s 2019 findings. Six assessments accounted for changing distributions through including an environmental covariate in the catchability equation, and an additional 40 stock assessments included an environmental or climate covariate in the standardization of abundance indices outside of the stock assessment model. Only two stock assessments (Pacific sablefish, shortbelly rockfish) directly linked a population parameter to an environmental driver to account for changing productivity (Johnson et al., 2023; Field et al., 2007). While these linkages can enable projections of future climate and ecosystem impacts on fish stocks, it is only possible if forecasts are available for the included environmental drivers. Additionally, actually doing these projections is not always straightforward because it depends on the capabilities of the specific stock assessment modeling package being used.

Limitations and Barriers

While many assessments account for changing conditions, at least implicitly, few are able to explicitly incorporate environmental linkages, limiting their ability to project what future environmental trends might do to stocks. There are several limitations and barriers that hinder the more frequent direct incorporation of or accounting for the impacts of environmental/climate variability into stock assessment models. These barriers fall under four main categories: mechanistic understanding, data and model limitations, agency capacity, and institutional inertia.

Our understanding of the functional relationships between environmental indicators and stock dynamics is often limited. This hinders the incorporation of the environmental effects in stock assessment models and projections, which requires some understanding of causal links or mechanisms. There is a general need for more process-based laboratory and field studies that use survey data to validate relationships between species and the environment (Saba et al., 2023). Additionally, more basic population demographic information, especially maturity data, and trophic dynamics (e.g., diet and consumption data), is needed to enable the identification of time variation and its incorporation into stock assessment models.

Even in instances when a well-known mechanistic linkage is identified, it is possible that its inclusion may not meaningfully improve the performance of the resulting model or the resulting management advice. This is especially true when standard data (e.g., age-comp) and environmental data show similar patterns, except when the age data are missing (Haltuch et al., 2019a, b; Hollowed et al., 2023). Therefore, it is perhaps best to focus on two core advantages offered by the inclusion of environmental linkages. One is their capacity to improve the estimation of parameters before and after the years for which the standard data already informs these parameters (e.g., sea surface height index in Pacific sablefish assessment; Haltuch et al., 2019b). The other is their utility in calibrating the relationship such that it can be used in projections, which is a key aspect of moving toward climate-ready fisheries.

Not all assessment model approaches are amenable to the integration of environmental considerations. With some exceptions, only more advanced assessment models (e.g., statistical catch-at-length and catch-at-age) account for environmental variability in some manner (i.e., level 2 ecosystem-linkage level or higher). While index-based assessments could theoretically include a level 1 ecosystem-linkage, none did in this analysis. Some of the data-limited assessments were identified as level 1, typically because they used a habitat multiplier for the biomass density estimate.

Even the more advanced modeling approaches commonly used today have their limitations, particularly when it comes to their ability to allow multiple population parameters to be time-varying within the models (Stock and Miller, 2021). For example, traditional statistical catch-at-age models typically only allow recruitment estimates to vary annually via deviations (although as noted in this study, temporal variation in weight- and maturity-at-age is also done). They then assume other parameters are constant mainly due to the fact that there are not enough degrees of freedom to estimate many time-varying parameters (Stock and Miller, 2021). Therefore, within traditional single species stock assessment frameworks, it may be difficult to be more holistic even if there is a solid understanding of process-environmental linkages. NOAA Fisheries is using state-space modeling to address some of these issues, as it has capacity to accommodate multiple time-varying parameters.

Human capacity limitations also hinder more operational integration of environmental and ecosystem information into stock assessment models. The process of identifying and incorporating ecosystem factors into stock assessments through explicit connections is time- and resource-intensive. However, many fisheries science centers have faced level funding in their permanent budgets for the past decade. As operational costs rise over time, this funding plateau forces NOAA Fisheries to decrease its mission scope and prioritize staff time for critical operations. This situation places NOAA Fisheries in a precarious position, as it grapples with growing instability across multiple eco-regions that challenges the assumptions of stationarity in its stock assessments.

Institutional inertia is another key barrier that must be overcome. There is a high bar to demonstrate improvements of including the environmental relationship in the model and general reluctance to increase complexity (Trenkel et al., 2023; Pepin et al., 2020). Often, assessment authors face long lead times for changes during which they need to communicate the changes multiple times before managers are comfortable with and understanding of the changes. A contributing factor to this hesitancy is the concern over correlations weakening or failing over time (Myers, 1998) and the number of times spurious correlations have been identified and subsequently removed after being included in an assessment model (e.g., Pacific sardine) (Zwolinski and Demer, 2024). This issue is exacerbated by the lack of clear systematic guidance on how and where it is appropriate or recommended to incorporate ecosystem information, trends, and variability into stock assessment models. In addition, many stocks listed in fishery management plans have current levels of catch that are well below biological limits; therefore, there is low priority to fine-tune a limit that is not constraining.

Future Directions and Recommendations

New initiatives within NOAA Fisheries seek to improve our ability to address the challenge of a dynamic, non-stationary environment moving forward. In 2023, NOAA launched a new crossline office, Climate, Ecosystems, and Fisheries Initiative (CEFI), which aims to build an operational modeling and decision support system to enable living marine resources managers and partners to make more climate-informed decisions. CEFI plans to provide high-resolution regional ocean model hindcasts, forecasts, and projections of physical and biogeochemical variables for all U.S. large marine ecosystems. These regional ocean model hindcasts can help fill the data gaps in key environmental data time-series and thus help inform the mechanistic understanding of the impacts of ocean change on living marine resources (Saba et al., 2023). Additionally, the ocean model forecasts and projections developed by CEFI can be used to develop climate-informed stock projections.

Recent advances in analytical methods being explored and implemented in stock assessment models may aid in the identification of key environmental drivers and provide a rigorous statistical framework for incorporating environmental influences. State-space assessment models like the Woods Hole Assessment Model (WHAM; Stock and Miller, 2021), developed by scientists at the NEFSC, enable estimation of both process and observation error and multiple time-varying parameters, and link environmental indicators to specific life-history parameters in the assessment model. In fact, at the time of the writing of this document, the NEFSC had recently completed a Research Track assessment for black sea bass, which uses a WHAM-based multi-region state-space assessment model with expected log recruitment modeled as a linear function of winter bottom temperature (Tabandera et al., 2023).

The Fisheries Integrated Modeling System (FIMS; Stawitz et al., in prep.) is a next-generation framework of stock assessment models, which when operational, will offer NOAA Fisheries an advanced set of stock assessment models that can incorporate ecosystem and socioeconomic data and models, as well as climate effects and other drivers. Dynamic Structural Equation Modeling is a statistical approach to "causal modeling" that can better estimate and understand the relationship between covariates and their impact on species of interest and may be able to help control for some types of non-stationarity (Thorson et al., 2024). Along with these analytical advancements, additional research on best practices for testing and incorporating environmental covariates is needed as climate-linked stock assessments are increasingly evaluated as tactical tools for providing management advice. The results of such efforts can be used to inform the development of best practices guidance.

Recent movement toward Open Science principles in stock assessment work could help to address institutional inertia related to ecosystem considerations. Such an approach could also provide scientific benefits through building efficiencies in data workflows and reproducibility, improving the quality of research outputs, and fostering collaboration among practitioners across multiple disciplines, all of which will be crucial elements in addressing climate change impacts (Lowndes et al., 2024).

The results of this study also highlight a key institutional strategic decision point. When examining the complete portfolio of NOAA Fisheries current stock assessments (Figure 2), two clear stories emerge. Nearly all of the stock assessments completed using advanced catch-at-age or catch-at-length models account for ecosystem dynamics through implicit and explicit means. Notably fewer, if any, of the stock assessments completed using simpler models account for ecosystem dynamics, all of which did so through implicit approaches. This suggests that when information is available and the methods allow for it, ecosystem dynamics are mostly being considered and incorporated in some fashion. Thus, if NOAA Fisheries' goal is to maintain sustainable fisheries in changing environments, its strategy of pursuing ecosystem-linked stock assessments should focus on individualized stock risks and data needs. The agency should take steps to identify which of its stocks are most at risk, considering factors such as harvest attainment, current condition, and estimated vulnerability. It should then address the data collection, model development, and process research needs to elevate priority stocks' assessments to be more holistic.

This study focused on understanding how environmental information is brought into the stock assessment model. There are other avenues through which climate and environmental information influences the fisheries management and harvest setting process. Some stocks incorporate environment–species relationships into their harvest control rules. As an example, Pacific sardine's harvest control rule has linked to the average sea surface temperature since 2014, allowing catch limits to adjust as temperature changes (PFMC, 2021). Another example stock, Atlantic menhaden, is a key forage fish in the Mid-Atlantic region. Its annual catch limit is developed using both its single-species stock assessment and the output from a multispecies model that includes four key menhaden predators (SEDAR, 2020). Ecosystem Status Reports provide trends for a variety of physical, chemical, biological, and socio-economic indicators at the large marine ecosystem scale. These reports are provided to councils along with the stock assessments and provide contextual information on environmental conditions and changes that can be used to inform Annual Biological Catch (ABC) determinations. However, it remains challenging to assimilate information from these broader ecosystem products into assessments focused on the status and trends of individual key stocks, which are used to make management decisions. In response to this challenge, a more stock-specific product, called Ecosystem and Socioeconomic Profiles (ESPs; Shotwell et al., 2023) has been developed. ESP is a standardized framework that facilitates the integration of ecosystem and socioeconomic factors within the stock assessment process and acts as a proving ground for use in management advice. The information in ESPs can be used contextually to inform uncertainty and broader strategic decisions in a region or quantitatively to inform stock assessment model assumptions, choices, and covariates. Risk tables were integrated into the fishery management process in Alaska in 2018 and now have expanded to other regions to provide a way to more explicitly consider and document ecosystem concerns within the ABC setting process that are not addressed within the stock assessment model (Dorn and Zador, 2020).

CONCLUSION

This analysis highlights the current state of stock assessments to account for broader ecosystem, climate, and environmental change either implicitly or explicitly, and establishes a baseline that can inform NOAA Fisheries' strategic planning moving forward. This information should continue to be routinely tracked and reported on beyond this study and the visibility and access to this information increased. Potential pathways to achieve this include continued tracking within the NOAA Fisheries Species Information System, adding visualizations of these results to the Stock SMART[2] web portal and stock assessment report website[3], and presentations and discussions with managers and scientists.

NOAA Fisheries has consistently emphasized the importance of integrating environmental and ecosystem approaches into stock assessments, as outlined in key strategic planning documents, including the NCSS, EBFM, and the NG-SAIP (Link et al., 2015; NMFS, 2016; Lynch et al., 2018). One significant outcome of the NG-SAIP was the NOAA Fisheries' "Setting Targets and Analyzing Data Gaps for U.S. Fish Assessments" (also known as Gap Analysis; Blackhart and Oleynik, 2023), which set targets for ecosystem considerations and other data inputs for all U.S. fish stocks and compared them against current levels. That analysis revealed ecosystem targets were the least frequently met, with 33 percent of NOAA Fisheries' stock assessments achieving the desired benchmarks.

While we work toward expanding stock assessments to include more consideration of fishery and ecosystem interactions, we must also recognize that for many stocks there will be no ability to account for environmental changes on stock dynamics within the assessment model, and thus, alternative management approaches that are robust to changing and uncertain conditions will need to be explored and adopted. Additionally, incorporating environmental indices may not be necessary or result in improved advice for some stocks. Therefore, moving forward NOAA Fisheries should capitalize on the various exercises completed to date, such as climate vulnerability assessments and Gap Analysis, as part of a transparent process to determine and prioritize stocks that we have the ability and need to account for changes due to the environment.

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APPENDIX I: ECOSYSTEM-LINKAGES AND CONSIDERATIONS IN NMFS SPECIES INFORMATION SYSTEM QUESTIONNAIRE

What: The Species Information System (SIS) has added a new tab focused on collecting more in-depth information related to how ecosystem/environmental variability and impacts are considered and taken into account in NMFS stock assessments.

Why: Ecosystems are not static, and it has been well established that changes in ocean and environmental conditions affect marine species. Our ability to account for ecosystem and environmental change, impacts, and variability in our stock assessments is important and is drawing increased interest at the national level. This has resulted in some increased scrutiny with respect to tracking and documenting the ways in which NMFS is currently incorporating it into stock assessments. Tracking this information was identified in the strategic documents including the following:

1. The 2019–2022 NOAA Fisheries Strategic Plan
2. The 2018 Stock Assessment Improvement Plan
3. The 2020 Fisheries Priorities and Annual Guidance

Several external publications released in recent years have also classified NMFS's use of ecosystem information in stock assessments, all coming to different conclusions.

The current tracking field on the "Assessment Summary" tab is not collecting sufficiently detailed information for the Office of Science and Technology (OST) to adequately respond to questions pertaining to ecosystem factors in stock assessments. This new tab will allow us to compile a more comprehensive record of where, why, and how ecosystem factors are being considered, explored, and used in stock assessments. It will:

- Collect information on what biological process is incorporating ecosystem information, what the driver is, and how its influence is incorporated into the assessment model.
- Enable OST to better independently respond to internally and externally driven questions concerning how ecosystem information is being used in stock assessments.
- Enable cross-center and cross-taxa analyses investigating common approaches to incorporating ecosystem information into stock assessments.
- Identify barriers to and gaps in our ability to incorporate ecosystem information into stock assessments, so we can better communicate needs and priorities to stakeholders (e.g., Congress).

How: Each lead assessment author was asked to provide the following information directly in SIS. Below is a detailed description of the new information they were asked to provide.

- **Ecosystem Linkage (required)** - Categorical classification describing the use of ecosystem linkage data in the stock assessment. This level should be based on the highest level of data that was actually used in the final version of the assessment model. The classification system is described in Implementing a Next Generation Stock Assessment Enterprise (see Appendix A; NOAA, 2018[4]). Note that this field is duplicated from the Assessment Summary record; a pop-up

[4] https://spo.nmfs.noaa.gov/sites/default/files/TMSPO183.pdf

message will appear alerting users if there is a conflict between the two fields as a cross-check. Select from the following dropdown list options:

0. No linkage to ecosystem dynamic or consideration of ecosystem properties (environment, climate, habitat, predator-prey, etc.) in configuring the assessment (i.e., equilibrium conditions assumed for ecosystem).
1. Ecosystem-based hypotheses inform the assessment model structure (e.g., defining the stock boundaries and/or spatial or temporal features) and/or are used for processing assessment inputs (e.g., abundance index, informing selection of parameter value) but no explicit linkage to any ecosystem drivers (environment, climate, habitat, predator–prey, etc.).
2. The assessment includes some form of variability or effect to explicitly account for unidentified ecosystem dynamic(s) (e.g., time/space "regimes", random variation, or other approaches to changing features without direct inclusion of ecosystem data).
3. One or more assessment feature is linked to a dynamic (i.e., data) from at least one of the following categories: environment, climate, habitat, and predator–prey data (e.g., covariate).
4. The assessment model is linked to at least one ecosystem dynamic, and one or more process studies directly support the manner in which environmental, climate, habitat, and/or predator–prey dynamics are incorporated (e.g., consumption rates measured and covariate informed by results).
5. The assessment approach is configured to be coupled or linked with an ecosystem process (e.g., multispecies, coupled biophysical, climate-linked models).

- *For Level 0 Assessments Only*:
    - **Ecosystem Info Considered (required)** - Although the final stock assessment model configuration may not have included ecosystem considerations, ecosystem information may have been considered sometime during the development of assessment and left out for various reasons. Select from the dropdown model:
        - Yes - Environmental information was considered during the assessment process but not included in the final assessment model.
        - No - Environmental information was not considered at any point during the assessment process.
    - **Reason Not Included (required)** - This field tracks why ecosystem information was not considered in the assessment or considered during the assessment process but not included in the final assessment. This field has a dropdown list of common options; users may type a new entry into the field if the appropriate option is not available from the list.
- *For Level 1–5 Assessments*: Common assessment features (i.e., Assessment Structure, Data Inputs, Growth, Maturity/Fecundity, Recruitment, Natural Mortality, Catchability, and Model Configuration) are listed along with the **Linkage Approach(es)** and **Environmental Process(es)** used to inform them. Each field has a dropdown list of common options; a new entry may be typed into the field if necessary. Note that each dropdown menu includes "None" as an option; all fields must have an entry. Further details on selecting options for the Linkage Approach and Environmental Process fields are provided below.
    - **Linkage Approach(es)** - Ecosystem and environmental information can inform or be linked to assessment features using a range of approaches. The details below will help

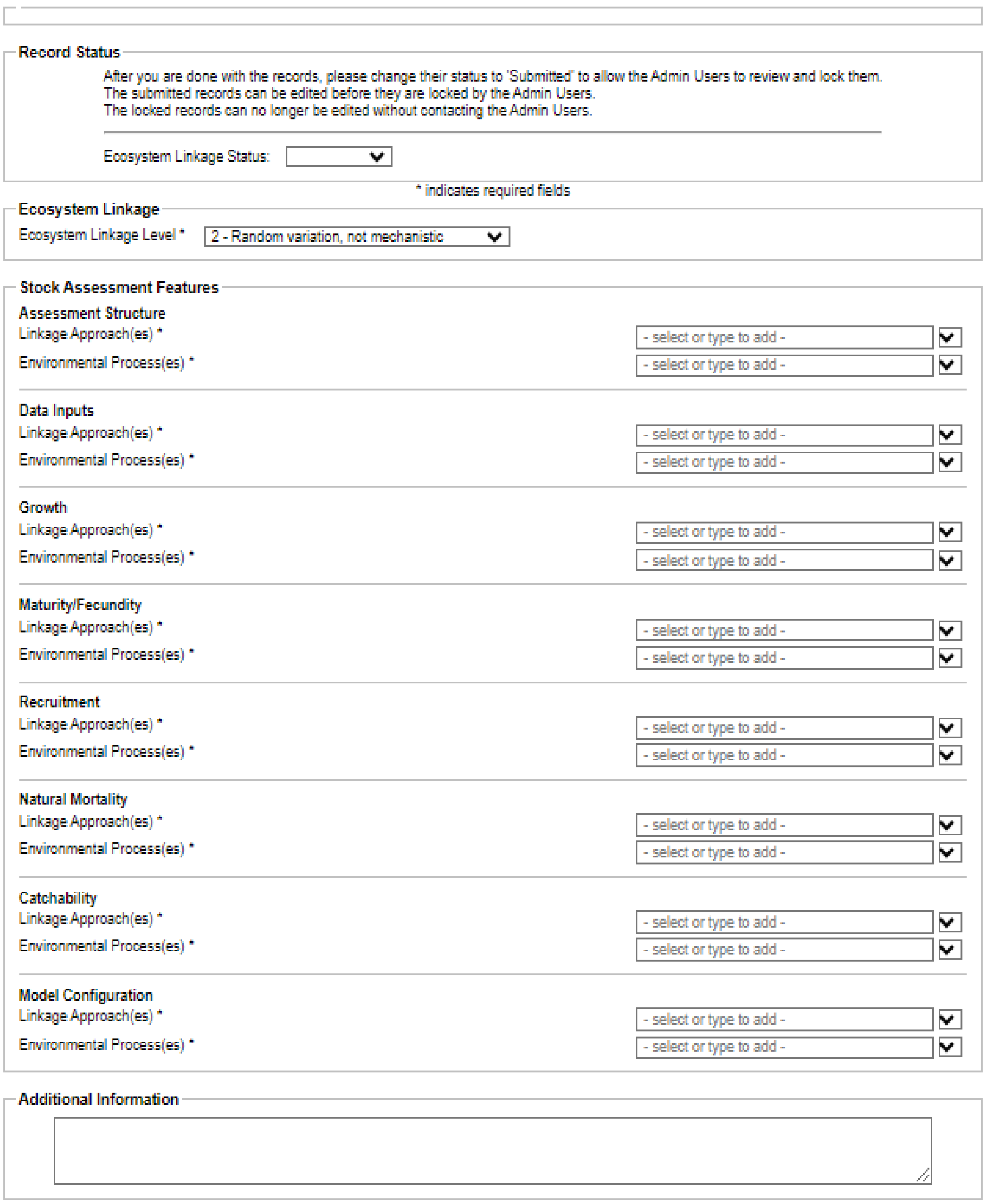
users select the appropriate option from the dropdown list. Note that dropdown menus are customized to assessment features, so not all options are available for each assessment feature.

- *Index of Abundance:* Ecosystem-based hypothesis or information informed the manner in which data from fishery-independent or -dependent surveys were processed. [Examples: Environmental information (e.g., sea surface temperature) was incorporated in the CPUE standardization process; index of abundance was adjusted for whale depredation.]
- *Informed Selection of Value:* The selection of a fixed value of a stock assessment parameter was informed by a hypothesis about the impact of an environmental process on that parameter. [Example: Sea surface temperature is taken into consideration when selecting an appropriate natural mortality value.]
- *Time-Varying: Empirical:* Allows for the impacts of climate change and environmental variability and ecosystem shifts by imposing trends in values of some key parameters to mimic plausible trends based on the time-series data. [Example: Cycles of linear increases and decreases in recruitment over time.]
- *Time-Varying: Random Deviations:* Environmental variability is accounted for by estimating annual deviations in the assessment feature of interest. [Example: Estimating annual deviations about the stock–recruitment relationship that reflect environmental influences on reproductive success.]
- *Time-Varying: Blocks/Regime Shifts:* Changes or shifts in an ecosystem state are accounted for through either abrupt changes in a parameter between two or more time periods (i.e., blocks) that are associated with the different ecosystem states or a switch to only using data from a certain time period that is thought to represent "prevailing environmental conditions." [Example: R_{MSY} for groundfish in Bering Sea Alaska is based on data from post-1977 when an ecosystem shift occurred and groundfish productivity increased. Example: growth time-blocks informed by a major shift in the PDO to capture changes in productivity of California current.]
- *Environmental Covariate: Direct Linkage:* Ecosystem data is included as a covariate in the modeling of an assessment feature or directly modifies the feature.
- *Environment Linked to Recruitment Variability:* An environmental covariate or data is used as an index of recruitment variability (proxy for survey-based age-0 time-series) and used to tune the time-series of annual recruitment deviations.
- *Climate Linked:* The stock assessment model is linked to climate models enabling analysis of climate change scenarios.
- *Coupled Biophysical:* A modeling approach that integrates information about ocean dynamics (e.g., physical processes such as nutrient fluxes, ocean circulation eddies/fronts, phytoplankton, zooplankton) with fish dynamics (e.g., fish life history, food habits, and fisheries catch) into a modeling framework designed to provide fisheries management advice.
- *Multispecies:* Modeling approach that explicitly considers biological interactions between species within an ecosystem (e.g., predator–prey or competition) and/or

technical interactions between species (e.g., bycatch) in the development of management advice.

- **Environmental Process(es)** - Many environmental or ecological factors/processes can impact a stock. Select the environmental factor(s) corresponding to the Linkage Approach selected for each assessment feature.

Additional Information - For all assessments regardless of level, please provide any relevant information to describe in further detail the answers provided for the fields above. For example, users may include further details on why ecosystem information was not considered in the assessment, or on how the environmental process was linked to the assessment feature.



Record Status

After you are done with the records, please change their status to 'Submitted' to allow the Admin Users to review and lock them.
The submitted records can be edited before they are locked by the Admin Users.
The locked records can no longer be edited without contacting the Admin Users.

Ecosystem Linkage Status:

* indicates required fields

Ecosystem Linkage

Ecosystem Linkage Level * 2 - Random variation, not mechanistic

Stock Assessment Features

Assessment Structure
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Data Inputs
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Growth
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Maturity/Fecundity
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Recruitment
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Natural Mortality
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Catchability
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Model Configuration
Linkage Approach(es) * - select or type to add -
Environmental Process(es) * - select or type to add -

Additional Information

APPENDIX II: ECOSYSTEM LINKAGE LEVELS AND APPROACHES BY SPECIES

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Arrowtooth flounder - Bering Sea/Aleutian Islands	NPFMC	2022	6	4	Catchability	Environmental covariate: Direct linkage	Climate/Environment
	NPFMC	2022	6	4	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	4	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Pacific cod - Gulf of Alaska	NPFMC	2022	6	4	Catchability	Environmental covariate: Direct linkage	Climate/Environment
	NPFMC	2022	6	4	Natural Mortality	Time varying: Blocks/regime shifts	Climate/Environment
	NPFMC	2022	6	4	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	4	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Yellowfin sole - Bering Sea/Aleutian Islands	NPFMC	2022	6	4	Abundance index standardization	Covariate in model; spatiotemporal variability	Climate/Environment; Spatiotemporal variability
	NPFMC	2022	6	4	Catchability	Environmental covariate: Direct linkage	Climate/Environment
	NPFMC	2022	6	4	Growth	Time varying: Empirical	None
	NPFMC	2022	6	4	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NPFMC	2022	6	4	Recruitment	Time varying: Random deviations	None
Sablefish - Pacific Coast	PFMC	2020	6	4	Recruitment	Environmental covariate: Direct linkage	Climate/Environment
	PFMC	2020	6	4	Recruitment	Time varying: Random deviations	Climate/Environment

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC	2023	6	4	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Bluefin tuna - Western Atlantic	Atlantic HMS	2020	6	3	Recruitment	Time varying: Random deviations	None
	Atlantic HMS	2021	6	3	Catchability	Environmental covariate: Direct linkage	Climate/Environment
Swordfish - North Atlantic	Atlantic HMS	2022	6	3	Abundance index standardization	Covariate in model	Climate/Environment
	Atlantic HMS	2022	6	3	Catchability	Environmental covariate: Direct linkage	Climate/Environment
	Atlantic HMS	2022	6	3	Recruitment	Time varying: Random deviations	None
Silky shark - Western and Central Pacific	WPFMC	2018	6	3	Catchability	Environmental covariate: Direct linkage	Climate/Environment
Shortbelly rockfish - Pacific Coast	PFMC	2006	6	3	Recruitment	Environmental covariate: Direct linkage	Predation
	PFMC	2006	6	3	Recruitment	Time varying: Random deviations	Predation
Atlantic menhaden - Atlantic Coast	ASMFC	2022	6	2	Recruitment	Time varying: Random deviations	None
Bigeye tuna - Atlantic	Atlantic HMS	2021	5	2	Recruitment	Time varying: Random deviations	None
Blue shark - North Atlantic	Atlantic HMS	2023	6	2	Recruitment	Time varying: Random deviations	None
Skipjack tuna - Western Atlantic	Atlantic HMS	2022	5	2	Recruitment	Time varying: Random deviations	None
White marlin - Atlantic	Atlantic HMS	2019	5	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Yellowfin tuna - Atlantic	Atlantic HMS	2019	6	2	Recruitment	Time varying: Random deviations	None
Queen triggerfish - Puerto Rico	CFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Gag - Gulf of Mexico	GMFMC	2021	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat, Climate/Environment
	GMFMC	2021	6	2	Natural Mortality	Time varying: Blocks/regime shifts	Climate/Environment
	GMFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Gray snapper - Gulf of Mexico	GMFMC	2022	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat, Climate/Environment; Habitat
	GMFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Gray triggerfish - Gulf of Mexico	GMFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Greater amberjack - Gulf of Mexico	GMFMC	2021	6	2	Abundance index standardization	Filtering survey observations	Climate/Environment; Habitat
	GMFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Hogfish - Eastern Gulf of Mexico	GMFMC	2018	6	2	Abundance index standardization	Filtering survey observations	Climate/Environment; Habitat
	GMFMC	2018	6	2	Recruitment	Time varying: Random deviations	None
Red grouper - Gulf of Mexico	GMFMC	2022	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	GMFMC	2022	6	2	Natural Mortality	Time varying: Blocks/regime shifts	Climate/Environment
	GMFMC	2022	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Red snapper - Gulf of Mexico	GMFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment; Habitat
	GMFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	GMFMC	2021	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Scamp - Gulf of Mexico	GMFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Tilefish - Gulf of Mexico	GMFMC	2011	6	2	Abundance index standardization	Filtering survey observations	Habitat
	GMFMC	2012	6	2	Recruitment	Time varying: Random deviations	None
Vermilion snapper - Gulf of Mexico	GMFMC	2020	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	GMFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Yellowedge grouper - Gulf of Mexico	GMFMC	2010	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	GMFMC	2010	6	2	Recruitment	Time varying: Random deviations	None
Pacific halibut - Pacific Coast/Alaska	IPHC	2022	6	2	Recruitment	Time varying: Random deviations	None
Atlantic mackerel - Gulf of Maine/Cape Hatteras	MAFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	MAFMC	2023	6	2	Growth	Time varying: Empirical	None
	MAFMC	2023	6	2	Maturity	Time varying: Empirical	None
	MAFMC	2023	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Atlantic surfclam - Mid-Atlantic Coast	MAFMC	2020	6	2	Growth	Time varying: Empirical	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Black sea bass - Mid-Atlantic Coast	MAFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment; Habitat
	MAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	MAFMC	2021	6	2	Growth	Time varying: Empirical	None
	MAFMC	2021	6	2	Maturity	Time varying: Empirical	None
Bluefish - Atlantic Coast	MAFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Butterfish - Gulf of Maine/Cape Hatteras	MAFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	MAFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Ocean quahog - Atlantic Coast	MAFMC	2020	6	2	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Scup - Atlantic Coast	MAFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	MAFMC	2023	6	2	Growth	Time varying: Empirical	None
	MAFMC	2023	6	2	Maturity	Time varying: Empirical	None
Summer flounder - Mid-Atlantic Coast	MAFMC	2023	6	2	Growth	Time varying: Empirical	None
	MAFMC	2023	6	2	Maturity	Time varying: Empirical	None
	MAFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Tilefish - Mid-Atlantic Coast	MAFMC	2021	6	2	Growth	Time varying: Empirical	None
	MAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Acadian redfish - Gulf of	NEFMC	2023	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Maine/Georges Bank	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2022	6	2	Growth	Time varying: Empirical	None
Atlantic cod - Gulf of Maine	NEFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2021	6	2	Natural Mortality	Time varying: Blocks/regime shifts	None
Atlantic herring - Northwestern Atlantic Coast	NEFMC	2022	6	2	Natural Mortality	Informed selection of value	Predation
	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2022	6	2	Growth	Time varying: Empirical	None
	NEFMC	2022	6	2	Maturity	Time varying: Empirical	None
Atlantic wolffish - Gulf of Maine/Georges Bank	NEFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
Haddock - Eastern Georges Bank	NEFMC	2023	6	2	Natural Mortality	Time varying: Blocks/regime shifts	None
	NEFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2023	6	2	Growth	Time varying: Empirical	None
	NEFMC	2023	6	2	Maturity	Time varying: Empirical	None
Haddock - Georges Bank	NEFMC	2022	6	2	Natural Mortality	Time varying: Blocks/regime shifts	None
	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2022	6	2	Growth	Time varying: Empirical	None
	NEFMC	2022	6	2	Maturity	Time varying: Empirical	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Haddock - Gulf of Maine	NEFMC	2022	6	2	Growth	Time varying: Random deviations	None
Pollock - Gulf of Maine/Georges Bank	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NEFMC	2022	6	2	Growth	Time varying: Empirical	None
Sea scallop - Northwestern Atlantic Coast	NEFMC	2020	5	2	Natural Mortality	Time varying: Random deviations	None
White hake - Gulf of Maine/Georges Bank	NEFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Winter flounder - Southern New England/Mid-Atlantic	NEFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Yellowtail flounder - Southern New England/Mid-Atlantic	NEFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NEFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Spiny dogfish - Atlantic Coast	NEFMC / MAFMC	2023	5	2	Growth	Time varying: Blocks/regime shifts	None
	NEFMC / MAFMC	2023	5	2	Maturity	Time varying: Blocks/regime shifts	None
	NEFMC / MAFMC	2023	5	2	Recruitment	Time varying: Random deviations	None
Alaska plaice - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Alaska skate - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Aleutian Islands Blackspotted and Rougheye	NPFMC	2023	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
rockfish Complex	NPFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Arrowtooth flounder - Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Atka mackerel - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Blue king crab - Saint Matthew Island	NPFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
Dover sole - Gulf of Alaska	NPFMC	2021	6	2	Catchability	Time varying: Blocks/regime shifts	Climate/Enviro nment
	NPFMC	2021	6	2	Natural Mortality	Time varying: Blocks/regime shifts	Climate/Enviro nment
	NPFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Dusky rockfish - Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2023	6	2	Abundance index standardizati on	Spatiotemporal variability	Spatiotemporal variability
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Flathead sole - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Flathead sole - Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Golden king crab - Eastern Aleutian Islands	NPFMC	2023	5	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	NPFMC	2023	5	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Golden king crab - Western Aleutian Islands	NPFMC	2023	5	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2023	5	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Greenland halibut - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Gulf of Alaska Blackspotted and Rougheye rockfish Complex	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Kamchatka flounder - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Northern rock sole - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Growth	Time varying: Empirical	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Northern rock sole - Central Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Northern rock sole - Western Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Northern rockfish - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Northern rockfish - Western/Central Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2023	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Pacific cod - Bering Sea	NPFMC	2022	6	2	Abundance index standardization	Covariate in model; spatiotemporal variability	Climate/Environment; Spatiotemporal variability
	NPFMC	2022	6	2	Catchability	Time varying: Random deviations	None
	NPFMC	2022	6	2	Growth	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Pacific Ocean perch - Bering Sea/Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Pacific Ocean perch - Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Red king crab - Bristol Bay	NPFMC	2022	5	2	Natural Mortality	Time varying: Blocks/regime shifts	None
	NPFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
	NPFMC	2022	5	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Red king crab - Norton Sound	NPFMC	2023	5	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Red king crab - Pribilof Islands	NPFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
Rex sole - Eastern Gulf of Alaska	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Rex sole - Western/Central Gulf of Alaska	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Rock sole - Central Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Rock sole - Western Gulf of Alaska	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Sablefish - Eastern Bering Sea/Aleutian Islands/Gulf of Alaska	NPFMC	2022	6	2	Abundance index standardization	Covariate in model	Predation
	NPFMC	2022	6	2	Growth	Time varying: Blocks/regime shifts	Climate/Environment
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Snow crab - Bering Sea	NPFMC	2022	5	2	Catchability	Time varying: Blocks/regime shifts	Climate/Environment
	NPFMC	2022	5	2	Natural Mortality	Time varying: Blocks/regime shifts	Climate/Environment
	NPFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
Southern Tanner crab - Bering Sea	NPFMC	2022	5	2	Growth	Time varying: Empirical	None
	NPFMC	2022	5	2	Maturity	Time varying: Empirical	None
	NPFMC	2022	5	2	Natural Mortality	Time varying: Empirical	None
	NPFMC	2022	5	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NPFMC	2022	5	2	Recruitment	Time varying: Random deviations	None
Walleye pollock - Aleutian Islands	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Walleye pollock - Eastern Bering Sea	NPFMC	2022	6	2	Natural Mortality	Informed selection of value	Predation
	NPFMC	2022	6	2	Abundance index standardization	Covariate in model; spatiotemporal variability	Climate/Environment; Spatiotemporal variability
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Walleye pollock - Western/Central /West Yakutat Gulf of Alaska	NPFMC	2022	6	2	Natural Mortality	Informed selection of value	Predation
	NPFMC	2022	6	2	Abundance index standardization	Informed/background	Temperature (simple)
	NPFMC	2022	6	2	Growth	Time varying: Empirical	None
	NPFMC	2022	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
	NPFMC	2022	6	2	Catchability	Time varying: Random deviations	None
	NPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Arrowtooth flounder - Pacific Coast	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2021	6	2	Abundance index standardization	Spatiotemporal variability	spatiotemporal variability
Aurora rockfish - Pacific Coast	PFMC	2013	6	2	Recruitment	Time varying: Random deviations	None
Black rockfish - California	PFMC	2019	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Black rockfish - Washington	PFMC	2019	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Bocaccio - Southern Pacific Coast	PFMC	2017	6	2	Abundance index standardization	Filtering survey observations, Covariate in model, Spatiotemporal variability	Habitat, Spatiotemporal variability
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Cabezon - Northern California	PFMC	2019	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Cabezon - Oregon	PFMC	2019	6	2	Abundance index standardization	Covariate in model, Filtering survey observations	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Cabezon - Southern California	PFMC	2019	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
California Blue and Deacon Rockfish Complex	PFMC	2019	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
California scorpionfish - Southern California	PFMC	2017	6	2	Abundance index standardization	Covariate in model, Filtering survey observations	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Canary rockfish - Pacific Coast	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2021	6	2	Abundance index standardizati on	Spatiotemporal variability	Spatiotemporal variability
Chilipepper - Southern Pacific Coast	PFMC	2017	6	2	Abundance index standardizati on	Covariate in model	Habitat
	PFMC	2017	6	2	Growth	Time varying: Blocks/regime shifts	Climate/Enviro nment
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Copper rockfish - Northern California	PFMC	2022	6	2	Abundance index standardizati on	Covariate in model	Habitat
	PFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Copper rockfish - Southern California	PFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2023	6	2	Abundance index standardizati on	Habitat multiplier or area weightings, Covariate in model	Habitat, Climate/Enviro nment
Darkblotched rockfish - Pacific Coast	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2021	6	2	Abundance index standardizati on	Spatiotemporal variability	Spatiotemporal variability
Dover sole - Pacific Coast	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2021	6	2	Abundance index standardizati on	Spatiotemporal variability	Spatiotemporal variability
Greenstriped rockfish - Pacific Coast	PFMC	2009	6	2	Abundance index standardizati on	Covariate in model	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC	2009	6	2	Recruitment	Time varying: Random deviations	None
Kelp greenling - Oregon	PFMC	2015	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2015	6	2	Recruitment	Time varying: Random deviations	None
Lingcod - Northern Pacific Coast	PFMC	2021	6	2	Abundance index standardization	Filtering survey observations, Covariate in model, Spatiotemporal variability	Habitat, Spatiotemporal variability
	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Lingcod - Southern Pacific Coast	PFMC	2021	6	2	Abundance index standardization	Filtering survey observations, Spatiotemporal variability, Covariate in model	Habitat, Spatiotemporal variability
	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Longspine thornyhead - Pacific Coast	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2019	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Northern anchovy - Southern Pacific Coast	PFMC	2022	6	2	Catchability	Time varying: Random deviations	None
	PFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2022	6	2	Growth	Time varying: Empirical	None
Northern California Gopher/Black-and-Yellow Rockfish Complex	PFMC	2019	6	2	Abundance index standardization	Covariate in model, Filtering survey observations	Habitat
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Oregon Blue and Deacon Rockfish Complex	PFMC	2017	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Pacific chub mackerel - Pacific Coast	PFMC	2022	6	2	Catchability	Time varying: Blocks/regime shifts	Spatiotemporal variability
	PFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2023	6	2	Growth	Time varying: Empirical	None
Pacific Coast Blackspotted and Rougheye rockfish Complex	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Pacific hake - Pacific Coast	PFMC	2023	6	2	Catchability	Time varying: Random deviations	None
	PFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2023	6	2	Growth	Time varying: Empirical	None
Pacific Ocean perch - Pacific Coast	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2017	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Pacific sanddab - Pacific Coast	PFMC	2011	6	2	Natural Mortality	Informed selection of value	None
	PFMC	2012	6	2	Abundance index standardization	Filtering survey observations	Habitat
	PFMC	2013	6	2	Recruitment	Time varying: Random deviations	None
Pacific sardine - Northern Subpopulation	PFMC	2022	6	2	Abundance index standardization	Filtering survey observations	Climate/Environment

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2022	6	2	Growth	Time varying: Empirical	None
Petrale sole - Pacific Coast	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2021	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Quillback rockfish - California	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Quillback rockfish - Oregon	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Rex sole - Pacific Coast	PFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2023	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Shortspine thornyhead - Pacific Coast	PFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
	PFMC	2024	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Splitnose rockfish - Pacific Coast	PFMC	2009	6	2	Recruitment	Time varying: Random deviations	None
Vermilion and Sunset rockfish Complex - Northern California	PFMC	2021	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Vermilion and Sunset rockfish Complex - Southern California	PFMC	2021	6	2	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Vermilion rockfish - Oregon	PFMC	2021	6	2	Abundance index standardization	Filtering survey observations	Habitat
	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Vermilion rockfish - Washington	PFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Widow rockfish - Pacific Coast	PFMC	2019	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
	PFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Yelloweye rockfish - Pacific Coast	PFMC	2017	6	2	Abundance index standardization	Filtering survey observations, Covariate in model, Spatiotemporal variability	Habitat, Spatiotemporal variability
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Yellowtail rockfish - Northern Pacific Coast	PFMC	2017	6	2	Abundance index standardization	Spatiotemporal variability, Filtering survey observations	Spatiotemporal variability, Habitat
	PFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Albacore - North Pacific	PFMC / WPFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Bigeye tuna - Eastern Pacific	PFMC / WPFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
	PFMC / WPFMC	2020	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
	PFMC / WPFMC	2020	6	2	Recruitment (Projections)	Time varying: Blocks/regime shifts	None
Bigeye tuna - Western and Central Pacific	PFMC / WPFMC	2020	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	PFMC / WPFMC	2020	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Blue shark - North Pacific	PFMC / WPFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Pacific bluefin tuna - Pacific	PFMC / WPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
	PFMC / WPFMC	2022	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Shortfin mako - North Pacific	PFMC / WPFMC	2018	6	2	Recruitment	Time varying: Random deviations	None
Skipjack tuna - Eastern Pacific	PFMC / WPFMC	2022	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	PFMC / WPFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Skipjack tuna - Western and Central Pacific	PFMC / WPFMC	2019	5	2	Abundance index standardization	Covariate in model	Climate/Environment; Spatiotemporal variability
	PFMC / WPFMC	2019	5	2	Recruitment	Time varying: Random deviations	None
Striped marlin - Western and Central North Pacific	PFMC / WPFMC	2023	5	2	Abundance index standardization	Covariate in model	Climate/Environment
	PFMC / WPFMC	2019	5	2	Recruitment	Time varying: Random deviations	None
Swordfish - Eastern Pacific	PFMC / WPFMC	2014	3	2	Other	Process error	None
Swordfish - Western and Central North Pacific	PFMC / WPFMC	2018	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	PFMC / WPFMC	2018	6	2	Recruitment	Time varying: Random deviations	None
Thresher shark - North Pacific	PFMC / WPFMC	2018	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Yellowfin tuna - Eastern Pacific	PFMC / WPFMC	2020	6	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
	PFMC / WPFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Yellowfin tuna - Western and Central Pacific	PFMC / WPFMC	2020	5	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
	PFMC / WPFMC	2020	5	2	Recruitment	Time varying: Random deviations	None
Black sea bass - Southern Atlantic Coast	SAFMC	2018	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2018	6	2	Recruitment	Time varying: Random deviations	None
Gag - Southern Atlantic Coast	SAFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Greater amberjack - Southern Atlantic Coast	SAFMC	2020	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Hogfish - Florida Keys/East Florida	SAFMC	2014	6	2	Abundance index standardization	Covariate in model; Filtering survey observations	Climate/Environment, Habitat
	SAFMC	2014	6	2	Recruitment	Time varying: Random deviations	None
Red grouper - Southern Atlantic Coast	SAFMC	2017	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2017	6	2	Recruitment	Time varying: Random deviations	None
Red porgy - Southern Atlantic Coast	SAFMC	2020	6	2	Abundance index standardization	Covariate in model	Climate/Environment

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
	SAFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Red snapper - Southern Atlantic Coast	SAFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Scamp - Southern Atlantic Coast	SAFMC	2023	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Snowy grouper - Southern Atlantic Coast	SAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Tilefish - Southern Atlantic Coast	SAFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Vermilion snapper - Southern Atlantic Coast	SAFMC	2018	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	SAFMC	2018	6	2	Recruitment	Time varying: Random deviations	None
Black grouper - Southern Atlantic Coast/Gulf of Mexico	SAFMC / GMFMC	2010	6	2	Recruitment	Time varying: Random deviations	None
Cobia - Gulf of Mexico	SAFMC / GMFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
King mackerel - Gulf of Mexico	SAFMC / GMFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
King mackerel - Southern Atlantic Coast	SAFMC / GMFMC	2020	6	2	Recruitment	Time varying: Random deviations	None
Mutton snapper - Southern Atlantic Coast/Gulf of Mexico	SAFMC / GMFMC	2015	6	2	Recruitment	Time varying: Random deviations	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Spanish mackerel - Gulf of Mexico	SAFMC / GMFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Spanish mackerel - Southern Atlantic Coast	SAFMC / GMFMC	2023	6	2	Recruitment	Time varying: Random deviations	None
Yellowtail snapper - Southern Atlantic Coast/Gulf of Mexico	SAFMC / GMFMC	2022	6	2	Abundance index standardization	Filtering survey observations	Habitat
	SAFMC / GMFMC	2022	6	2	Recruitment	Time varying: Random deviations	None
Albacore - South Pacific	WPFMC	2020	5	2	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
	WPFMC	2021	5	2	Recruitment	Time varying: Random deviations	None
American Samoa Bottomfish Multispecies Complex	WPFMC	2018	3	2	Other	Process error	None
Blue marlin - Pacific	WPFMC	2021	6	2	Abundance index standardization	Covariate in model	Climate/Environment
	WPFMC	2021	6	2	Recruitment	Time varying: Random deviations	None
Green jobfish - Main Hawaiian Islands	WPFMC	2020	5	2	Recruitment	Time varying: Random deviations	None
Green jobfish - Main Hawaiian Islands	WPFMC	2020	5	2	Abundance index standardization	Covariate in model	Climate/Environment
Guam Bottomfish Multispecies Complex	WPFMC	2019	3	2	Other	Process error	None
Main Hawaiian Islands Deep 7 Bottomfish Multispecies Complex	WPFMC	2021	3	2	Other	Process error	None
	WPFMC	2021	3	2	Abundance index standardization	Covariate in model	Climate/Environment

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Northern Mariana Islands Bottomfish Multispecies Complex	WPFMC	2019	3	2	Other	Process error	None
Oceanic whitetip shark - Western and Central Pacific	WPFMC	2019	6	2	Recruitment	Time varying: Random deviations	None
Spanner crab - Main Hawaiian Islands	WPFMC	2019	3	2	Other	Process error	None
Albacore - North Atlantic	Atlantic HMS	2020	3	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment
Atlantic sharpnose shark - Atlantic	Atlantic HMS	2013	6	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment
Atlantic sharpnose shark - Gulf of Mexico	Atlantic HMS	2013	6	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment
Blacknose shark - Atlantic	Atlantic HMS	2011	6	1	Abundance index standardizati on	Covariate in model, Filtering survey observations	Climate/Enviro nment, Habitat
Blacktip shark - Atlantic	Atlantic HMS	2021	6	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment
Blacktip shark - Gulf of Mexico	Atlantic HMS	2018	6	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment
Blue marlin - Atlantic	Atlantic HMS	2018	5	1	Abundance index standardizati on	Covariate in model	Habitat
Dusky shark - Atlantic and Gulf of Mexico	Atlantic HMS	2016	3	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment; Habitat
Gulf Smoothhound Complex	Atlantic HMS	2015	3	1	Abundance index standardizati on	Covariate in model	Climate/Enviro nment

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Porbeagle - Northwestern Atlantic	Atlantic HMS	2021	1	1	Abundance index standardization	Covariate in model	Climate/Environment
Sandbar shark - Atlantic and Gulf of Mexico	Atlantic HMS	2018	5	1	Abundance index standardization	Covariate in model	Climate/Environment
Scalloped hammerhead - Atlantic and Gulf of Mexico	Atlantic HMS	2009	3	1	Abundance index standardization	Covariate in model	Climate/Environment
Shortfin mako - North Atlantic	Atlantic HMS	2017	6	1	Abundance index standardization	Covariate in model	Habitat
Smooth dogfish - Atlantic	Atlantic HMS	2015	6	1	Abundance index standardization	Covariate in model	Climate/Environment
Giant octopus - Bering Sea/Aleutian Islands	NPFMC	2022	1	1	Natural Mortality	Informed selection of value	Predation
Black rockfish - Oregon	PFMC	2021	6	1	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
Brown rockfish - Pacific Coast	PFMC	2013	3	1	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
China rockfish - Central Pacific Coast	PFMC	2019	6	1	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
China rockfish - Northern Pacific Coast	PFMC	2019	6	1	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
China rockfish - Southern Pacific Coast	PFMC	2019	6	1	Abundance index standardization	Filtering survey observations, Covariate in model	Habitat
Cowcod - Southern California	PFMC	2019	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Greenspotted rockfish - Pacific Coast	PFMC	2011	6	1	Abundance index standardization	Covariate in model, Filtering survey observations	Habitat
Longnose skate - Pacific Coast	PFMC	2019	6	1	Catchability	Informed selection of value	Habitat
Longnose skate - Pacific Coast	PFMC	2019	6	1	Abundance index standardization	Spatiotemporal variability	Spatiotemporal variability
Squarespot rockfish - Pacific Coast	PFMC	2021	5	1	Abundance index standardization	Covariate in model	Climate/Environment
Striped marlin - Eastern Pacific	PFMC / WPFMC	2010	6	1	Abundance index standardization	Covariate in model	Climate/Environment
Bigeye bream - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Bigscale soldierfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Black jack - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Blacktail snapper - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Blue goatfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Bluefin trevally - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Bluespine unicornfish - Guam	WPFMC	2019	1	1	Natural Mortality	Informed selection of value	Climate/Environment
Bluespine unicornfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Bullethead parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Common bluestripe snapper - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Common bluestripe snapper - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Eyestripe surgeonfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Flame snapper - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Giant trevally - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Goatfish (*Parupeneus porphyreus*) - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Golden eye jobfish - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Green jobfish - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Island jack - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Naso tang - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Oblique-banded snapper - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat

Stock	**Managing Body**	**Asmt Year**	**Model Cat**	**Eco Level**	**Asmt Process**	**Approach Cat**	**Interaction Type**
Orange goatfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Palenose parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Peacock hind - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Redlip parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Regal parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Ringtail surgeonfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Rusty jobfish - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Shortnosed unicornfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Sleek unicornfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Spectacled parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Spotcheek emperor - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Stareye parrotfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Twosaddle goatfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Yellow-edged lyretail - American Samoa	WPFMC	2023	6	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Yellowfin goatfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Yellowstripe goatfish - Main Hawaiian Islands	WPFMC	2017	1	1	Abundance index standardization	Habitat multiplier or area weightings	Habitat
Atlantic Small Coastal shark Complex	Atlantic HMS	2007	4	0	Not Considered	None	None
Finetooth shark - Atlantic and Gulf of Mexico	Atlantic HMS	2007	3	0	Not Considered	None	None
Sailfish - Western Atlantic	Atlantic HMS	2023	3	0	Not Considered	None	None
Caribbean Parrotfishes Complex	CFMC	2009	1	0	Not Considered	None	None
Caribbean spiny lobster - Puerto Rico	CFMC	2020	6	0	Not Considered	None	None
Caribbean spiny lobster - St. Croix	CFMC	2020	6	0	Not Considered	None	None
Caribbean spiny lobster - St. Thomas/St. John	CFMC	2020	6	0	Not Considered	None	None
Red hind - Caribbean	CFMC	2014	1	0	Not Considered	None	None
Redtail parrotfish - Caribbean	CFMC	2012	1	0	Not Considered	None	None
Silk snapper - Caribbean	CFMC	2012	1	0	Not Considered	None	None
Lane snapper - Gulf of Mexico	GMFMC	2020	1	0	Not Considered	None	None
Royal red shrimp - Gulf of Mexico	GMFMC	2020	2	0	Not Considered	None	None
Blueline tilefish - Mid-Atlantic Coast	MAFMC	2018	1	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Longfin inshore squid - Georges Bank/Cape Hatteras	MAFMC	2023	2	0	Not Considered	None	None
Atlantic cod - Eastern Georges Bank	NEFMC	2023	1	0	Not Considered	None	None
Atlantic cod - Georges Bank	NEFMC	2021	2	0	Not Considered	None	None
Atlantic halibut - Northwestern Atlantic Coast	NEFMC	2022	1	0	Not Considered	None	None
Barndoor skate - Georges Bank/Southern New England	NEFMC	2023	2	0	Not Considered	None	None
Clearnose skate - Southern New England/Mid-Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Little skate - Georges Bank/Southern New England	NEFMC	2023	2	0	Not Considered	None	None
Ocean pout - Northwestern Atlantic Coast	NEFMC	2022	2	0	Not Considered	None	None
Red deepsea crab - Northwestern Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Red hake - Gulf of Maine/Northern Georges Bank	NEFMC	2023	2	0	Not Considered	None	None
Red hake - Southern Georges Bank/Mid-Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Rosette skate - Southern New England/Mid-Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Silver hake - Gulf of Maine/Northern Georges Bank	NEFMC	2023	2	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Silver hake - Southern Georges Bank/Mid-Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Smooth skate - Gulf of Maine	NEFMC	2023	2	0	Not Considered	None	None
Thorny skate - Gulf of Maine	NEFMC	2023	2	0	Not Considered	None	None
Windowpane - Gulf of Maine/Georges Bank	NEFMC	2023	2	0	Not Considered	None	None
Windowpane - Southern New England/Mid-Atlantic	NEFMC	2023	2	0	Not Considered	None	None
Winter flounder - Georges Bank	NEFMC	2022	4	0	Not Considered	None	None
Winter flounder - Gulf of Maine	NEFMC	2022	2	0	Not Considered	None	None
Winter skate - Georges Bank/Southern New England	NEFMC	2023	2	0	Not Considered	None	None
Witch flounder - Northwestern Atlantic Coast	NEFMC	2022	2	0	Not Considered	None	None
Yellowtail flounder - Cape Cod/Gulf of Maine	NEFMC	2022	4	0	Not Considered	None	None
Yellowtail flounder - Georges Bank	NEFMC	2023	2	0	Not Considered	None	None
Goosefish - Gulf of Maine/Northern Georges Bank	NEFMC/MAFMC	2022	2	0	Not Considered	None	None
Goosefish - Southern Georges Bank/Mid-Atlantic	NEFMC/MAFMC	2022	2	0	Not Considered	None	None
Atka mackerel - Gulf of Alaska	NPFMC	2016	1	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Bering Sea/Aleutian Islands Other Flatfish Complex	NPFMC	2020	2	0	Not Considered	None	None
Bering Sea/Aleutian Islands Other Rockfish Complex	NPFMC	2022	2	0	Not Considered	None	None
Bering Sea/Aleutian Islands Other Skates Complex	NPFMC	2022	2	0	Not Considered	None	None
Bering Sea/Aleutian Islands Sculpin Complex	NPFMC	2019	2	0	Not Considered	None	None
Bering Sea/Aleutian Islands Shark Complex	NPFMC	2016	1	0	Not Considered	None	None
Bering Sea/Aleutian Islands Skate Complex	NPFMC	2007	1	0	Not Considered	None	None
Bering Sea/Aleutian Islands Squid Complex	NPFMC	2016	1	0	Not Considered	None	None
Big skate - Gulf of Alaska	NPFMC	2021	2	0	Not Considered	None	None
Blue king crab - Pribilof Islands	NPFMC	2021	2	0	Not Considered	None	None
Eastern Bering Sea Blackspotted and Rougheye Rockfish Complex	NPFMC	2022	2	0	Not Considered	None	None
Golden king crab - Pribilof Islands	NPFMC	2017	1	0	Not Considered	None	None
Gulf of Alaska Other Deepwater Flatfish Complex	NPFMC	2016	1	0	Not Considered	None	None
Gulf of Alaska Other Rockfish Complex	NPFMC	2021	2	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Gulf of Alaska Other Shallow Water Flatfish Complex	NPFMC	2021	2	0	Not Considered	None	None
Gulf of Alaska Sculpin Complex	NPFMC	2019	2	0	Not Considered	None	None
Gulf of Alaska Shallow Water Flatfish Complex	NPFMC	2018	6	0	Not Considered	None	None
Gulf of Alaska Shark Complex	NPFMC	2020	2	0	Not Considered	None	None
Gulf of Alaska Skate Complex	NPFMC	2021	2	0	Not Considered	None	None
Gulf of Alaska Squid Complex	NPFMC	2016	1	0	Not Considered	None	None
Longnose skate - Gulf of Alaska	NPFMC	2021	2	0	Not Considered	None	None
North Pacific spiny dogfish - Gulf of Alaska	NPFMC	2022	1	0	Not Considered	None	None
Pacific cod - Aleutian Islands	NPFMC	2022	2	0	Not Considered	None	None
Pacific sleeper shark - Bering Sea/Aleutian Islands	NPFMC	2022	1	0	Not Considered	None	None
Red king crab - Western Aleutian Islands	NPFMC	2017	1	0	Not Considered	None	None
Shortraker rockfish - Bering Sea/Aleutian Islands	NPFMC	2022	2	0	Not Considered	None	None
Shortraker rockfish - Gulf of Alaska	NPFMC	2021	2	0	Not Considered	None	None
Shortspine thornyhead - Gulf of Alaska	NPFMC	2022	2	0	Not Considered	None	None
Walleye pollock - Bogoslof	NPFMC	2022	2	0	Not Considered	None	None
Walleye pollock - Southeast Gulf of Alaska	NPFMC	2022	2	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Weathervane scallop - Alaska	NPFMC	2023	2	0	Not Considered	None	None
Yelloweye rockfish - Gulf of Alaska	NPFMC	2022	2	0	Not Considered	None	None
Bank rockfish - California	PFMC	2010	1	0	Not Considered	None	None
Big skate - Pacific Coast	PFMC	2019	6	0	Not Considered	None	None
Blackgill rockfish - Northern Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Blackgill rockfish - Southern California	PFMC	2019	6	0	Not Considered	None	None
Bocaccio - Northern Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Bronzespotted rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Cabezon - Washington	PFMC	2019	1	0	Not Considered	None	None
Copper rockfish - Oregon	PFMC	2021	5	0	Not Considered	None	None
Copper rockfish - Washington	PFMC	2021	5	0	Not Considered	None	None
Cowcod - Northern Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
English sole - Pacific Coast	PFMC	2013	3	0	Not Considered	None	None
Flag rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Grass rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Greenblotched rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Honeycomb rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Kelp greenling - California	PFMC	2010	1	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Kelp rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Leopard shark - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Mexican rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Olive rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Opalescent inshore squid - Pacific Coast	PFMC	2006	1	0	Not Considered	None	None
Pacific grenadier - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Pink rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Quillback rockfish - Washington	PFMC	2021	6	0	Not Considered	None	None
Redbanded rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Redstripe rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Rock sole - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Rosethorn rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Rosy rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Sand sole - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Sharpchin rockfish - Pacific Coast	PFMC	2013	3	0	Not Considered	None	None
Shortraker rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Silvergray rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Speckled rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Spiny dogfish - Pacific Coast	PFMC	2021	6	0	Not Considered	None	None

Stock	Managing Body	Asmt Year	Model Cat	Eco Level	Asmt Process	Approach Cat	Interaction Type
Starry flounder - Northern Pacific Coast	PFMC	2017	1	0	Not Considered	None	None
Starry flounder - Southern Pacific Coast	PFMC	2017	1	0	Not Considered	None	None
Starry rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Stripetail rockfish - Pacific Coast	PFMC	2013	1	0	Not Considered	None	None
Swordspine rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Tiger rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Tope - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Treefish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Yellowmouth rockfish - Pacific Coast	PFMC	2010	1	0	Not Considered	None	None
Blueline tilefish - Southern Atlantic Coast	SAFMC	2017	3	0	Not Considered	None	None
Brown rock shrimp - Southern Atlantic Coast	SAFMC	2018	2	0	Not Considered	None	None
Brown shrimp - Southern Atlantic Coast	SAFMC	2018	2	0	Not Considered	None	None
Pink shrimp - Southern Atlantic Coast	SAFMC	2018	2	0	Not Considered	None	None
White shrimp - Southern Atlantic Coast	SAFMC	2018	2	0	Not Considered	None	None
Wreckfish - Southern Atlantic Coast	SAFMC	2014	6	0	Not Considered	None	None
Bigeye bream - Guam	WPFMC	2019	1	0	Not Considered	None	None
Blacktail snapper - Guam	WPFMC	2019	1	0	Not Considered	None	None
Bluefin trevally - Guam	WPFMC	2019	1	0	Not Considered	None	None
Filament-finned parrotfish - Guam	WPFMC	2019	1	0	Not Considered	None	None

Stock	**Managing Body**	**Asmt Year**	**Model Cat**	**Eco Level**	**Asmt Process**	**Approach Cat**	**Interaction Type**
Humpback red snapper - Guam	WPFMC	2019	1	0	Not Considered	None	None
Island jack - Guam	WPFMC	2019	1	0	Not Considered	None	None
Longnose emperor - Guam	WPFMC	2019	1	0	Not Considered	None	None
Pacific longnose parrotfish - Guam	WPFMC	2019	1	0	Not Considered	None	None
Redlip parrotfish - Guam	WPFMC	2019	1	0	Not Considered	None	None
Steephead parrotfish - Guam	WPFMC	2019	1	0	Not Considered	None	None
Yellowlip emperor - Guam	WPFMC	2019	1	0	Not Considered	None	None