Proposed framework for stock-specific ecosystem considerations (SEC) in Alaskan groundfish fishery management plans

S. Kalei Shotwell, Dana H. Hanselman, Stephani Zador, and Kerim Aydin
September 2014

Executive Summary

The integration of ecosystem information into the stock assessment process is receiving substantial attention for effective marine conservation and management. Current ecosystem projects and initiatives stress the need for communication and coordination with stock assessment authors as well as development of ecosystem integration directly within an assessment. The recent revision of the SAFE guidelines did not provide recommendations for improving the stock-specific ecosystem considerations (SEC) section. This section is one of the clear avenues for providing ecological context for the assessment and has the goal of ultimately including relevant ecosystem data directly into the assessment model. Previously assessment authors were encouraged to use information contained in the Ecosystem Considerations chapter to assist them in developing stock-specific analyses. This chapter has since moved to an ecosystem synthesis approach and does not readily link to stock-specific issues.

This report develops a framework for revamping the SEC section to include 1) an assessment input-based categorization to identify the stock or stock complex priorities with reference to spatial, temporal, ecosystem, habitat, and climate (E/H/C) linkages, 2) a draft conceptual model template that organizes the trending spatial and temporal assessment inputs by potential E/H/C mechanisms, and 3) an updateable report card that identifies relevant proxy indicators to explain assessment trends. Taken together, the stock priorities, conceptual linkages, and report card provide the necessary building blocks for moving toward the next generation of integrated ecosystem stock assessments.

We anticipate that the stock assessment authors would use the templates and tables provided in this document to accomplish the first objective and part of the second objective. A panel of ecosystem experts could then convene and provide context and background for developed proxy indicators that would inform the draft conceptual model built by the assessment authors and complete the report card which would follow the region-based format of the Ecosystem Considerations chapter. Given that E/H/C linkages were a priority for a particular assessment, the report card could be updated annually using an existing stock assessment data portal (e.g. AKFIN) by maintaining a stock-specific indicators database.

Introduction

During recent years a number of established ecosystem initiatives have highlighted and enhanced the National Marine Fisheries Service (NMFS) mandate to sustain marine fish and associated habitats by moving toward an ecosystem-based management. Several funding entities now include in their Request for Proposals (RFP) that applicants make clear objectives to consult and coordinate with stock assessment scientists to ensure that ecosystem related projects will contribute toward informing fisheries assessments and management decisions (e.g. FATE, HAIP, ISA). The newly proposed prioritization approach for managing fisheries stocks across the nation includes an ecosystem importance component. Following this, the update to the current Stock Assessment Improvement Plan (SAIP 2015) focuses on guidelines for incorporating ecosystem information into single-species stock assessment and discussion of new analytical tools to accomplish this effort. The result of these initiatives is to move toward Next Generation Stock Assessment (NGSA) by utilizing ecosystem properties to inform stock parameters.

Along with these broader scope initiatives, there are regional collaborative integrated ecosystem research projects (IERPs) that seek to gain understanding of population fluctuations in relation to their surrounding environment. The Bering Sea IERP and the Gulf of Alaska IERP are two such examples of these efforts for the Alaska Fisheries Science Center (AFSC). The products of these programs include high resolution physical, plankton, and fish models (e.g. ROMS, NPZ, FEAST) that generate estimates of ecosystem and fish population trajectories. These models along with many other integrated products can support a variety of assessments by providing relevant indicators for extended stock assessment models (ESAMs) to developing projections of future climate change for management strategy evaluations (MSEs). Given a proper feedback system and continued support and timeliness to the assessment community, these research efforts may contribute substantially to our Integrated Ecosystem Assessment (IEA) activities and take the first steps toward the ultimate goal of ecosystem-based fisheries management.

AFSC guidelines for producing the stock assessment and fishery evaluation (SAFE) reports are provided to stock assessment authors to allow for a consistent format for distribution and presentation of information regarding stock status and harvest specifications. In May 2012, a working group was formed to review and revise these guidelines where appropriate. One particular item the group discussed was the organization and length of the stock-specific ecosystem considerations (SEC) section. This section is included in all the single species chapters and provides ecological context for stock assessment. The ultimate goal of including this auxiliary information is to incorporate relevant ecosystem data directly into the assessment model (Townsend et al. 2008). Current guidelines on this section encourage authors to use information in the Ecosystem Considerations chapter to assist in developing stock-specific analyses; however, these guidelines were produced prior to the updated Ecosystem Considerations chapter which has since moved toward an ecosystem synthesis approach. This approach attempts to assess the status of the four large marine ecosystems in Alaska (Bering Sea, Aleutian Islands, Gulf of Alaska, and Arctic). The region-based approach limits direct reference to indicators for use in the single-species stock assessments. Additionally, many of the SECs are rarely updated in the SAFE reports given time constraints surrounding the assessment process. Given the potentially substantive changes required to improve the SEC, no revisions or improvements to this section were included in the updated guidelines provided to stock assessment authors in October 2012.

In an effort to address revamping the SEC, a stock-specific ecosystem framework was proposed at the November 2012 Groundfish Plan Team meetings. The Teams discussion indicated that the approach had potential, but there was concern over requiring authors to produce stock-specific ecosystem conceptual models and report cards on their own. Rather, the Teams recommended the establishment of an ecosystem/assessment committee to produce an example that authors could fill-in and to have an in-house discussion on the topic before further review. The potential for this framework was later reported to the Science and Statistical Committee (SSC) during the December 2012 meeting. The SSC encouraged authors to develop the capability to project future year-class strength by evaluating the forecast skill of proposed ecosystem linkages (such as in Shotwell et al. 2012) and awaits receiving updates on the progress of this effort. Improving the ecosystem information framework and accessibility to this information for stock assessment authors will benefit the SEC sections.

Objectives

We propose a new framework for the SEC section that establishes a feedback loop to coordinate the efforts between the individual stock assessment authors, the ecosystem considerations chapter authors, and PIs from projects funded under RFPs such as the IERPs and FATE that are designed and in some cases, require coordination with stock assessment scientists. The primary goal of this framework will be to first identify trends in the population assessment and then define potential ecosystem, habitat, and/or climate (E/H/C) linkages that could lead to the development of a mechanistic conceptual model. Our specific objectives are to 1) establish priorities within the current categorization of stock or stock complex with reference to spatial, temporal, and/or E/H/C linkages 2) reorganize and simplify the current ecosystem considerations sections using a conceptual model template and 3) create a stock-specific updatable report card following the format presented in the Ecosystem Considerations chapter. When considered together, the categorization, conceptual model, and report card provide the necessary information for establishing the role of the stock in the ecosystem while identifying relevant indicators and areas for potential future research and prioritization.

Guidelines for Interpretation of Ecosystem, Habitat, and Climate (E/H/C) Data

Ecosystem-based management (EBM) and the associated IEAs have become the forefront of effective marine conservation and resource management (Levin et al., 2009). In general, this approach consists of two main components: 1) a comprehensive ecosystem assessment and 2) an assessment of a changing environment on species in the fishery (Hollowed et al., 2014). The Ecosystem Considerations chapter attempts to tackle the first component and represents a concentrated effort from a multidisciplinary team of experts to synthesize numerous data contributions that together describe the status of the four Alaska large marine ecosystems. The SEC section within individual stock SAFE reports is an attempt at the second component. Currently, the SEC section is organized into two parts, 1) ecosystem effects on the stock and 2) fishery effects on the ecosystem. The Ecosystem Considerations chapter primarily concerns ecosystem assessment and information on fishery effects on the ecosystem (#2 above) such as bycatch and discards is already included in many cases. This chapter also has an ecosystem indicators section which provides detailed information and updates on the status and trends of ecosystem components (Zador et al. 2012). However, it is unclear which indicators would be most relevant to understanding ecosystem effects that are stock-specific (#1 above). Even though the information in the Ecosystem Consideration chapter is presented each year, few assessments are able to compile the indicators for a particular stock (or stock complex) and integrate this information into the SEC for potential use in models or informing harvest advice (Townsend et al., 2008).

The organization of the indicators section in the Ecosystem Considerations chapter along with the associated data access links and summary reports from the Alaska Marine Ecosystem Considerations web site (http://access.afsc.noaa.gov/reem/ecoweb/index.php) provide a contextual link to the SEC sections and a valuable resource for developing this new framework. Additionally, a collection of ecosystem guidelines from efforts such as the SAIP and National Ecosystem Modeling Workshops (NEMoWs) are also available and can assist with linking this data to stock assessment. In this section, we use the general categories of ecosystem, habitat, and climate (E/C/H) to review data organization and model integration.

E/H/C Data Types

Much of the E/H/C information is currently available through data portals such as on the Ecosystem Considerations web site (e.g. http://access.afsc.noaa.gov/reem/ecoweb/DataAccess.php); however, the organization is geared more toward ecosystem assessment rather than stock-specific assessment. We attempt to put the data into the above E/H/C categories so that assessment scientists will know what is available for use in their stock assessments. Table 1 (*in progress*) summarizes the known indicators by data type and collates mechanistic inferences based on previous indicator summaries and collections (e.g. Boldt et al. 2005, Zador et al. 2012).

Ecosystem data for use in the SEC sections would typically refer to estimates of the population status (e.g. recruitment, total biomass), consumption (e.g. diet, stomach fullness), condition (e.g. mass, energy density), and diversity (e.g. evenness, spatial distribution). Habitat data includes the indices of the physical environment (e.g. bottom temperature) or biological environment (e.g. chlorophyll *a*) as well as what is typically considered essential fish habitat data (e.g. rocky substrate). Climate data refers to the large scale indicators (e.g. El Nino Southern Oscillation, Pacific Decadal Oscillation) and any climate/ecosystem model results (e.g. ROMS indices, IBM trajectories). A variety of studies have considered these data types in developing hypothesized mechanisms for understanding the fluctuations of fish stocks and are included in Table 1 to the extent known.

E/H/C Link to Assessment

There are potentially several avenues for including E/H/C information into stock assessment and we present the following three options: 1) qualitative evaluation, 2) conceptual model, and 3) integrated into assessment. The first is a type of inclusion that recognizes a change has occurred and provides context for interpretation of assessment results. An example of this would be the current SEC sections where an ecosystem indicator and observation were provided along with the interpretation and evaluation of the events in relation to the stock. The second category is the formulation of a conceptual model through evaluation of temporal and spatial trends in the assessment data and model results. This may be thought of in a similar fashion to filling out the stock structure template where a stepwise procedure identifies the evidence for stock structure (Spencer et al. 2010) following the evaluation of a variety of data sources. The conceptual model template is part of our second objective for this document and will be elaborated upon in the following proposed framework section. Finally, E/H/C information may be directly incorporated into the stock assessment analysis which is the substance of the minimally realistic models (ESAMs, MSMs, etc.). For the purposes of this document we focus on the extended stock assessment model (ESAM), which is the variety of model that incorporates E/H/C information directly into single-species stock assessment (SSA).

Table 2 (*in progress*) provides guidelines for how to link E/H/C factors and SSA with the goal of generating an ESAM. It is a modified version from the most recent NEMoW (2014) that lists the variety of inputs that are part of SSA and the appropriate E/H/C factor(s) to address known weaknesses in the traditional SSA approach (J. Link pers. comm.). We include examples where an E/H/C factor has been investigated for each of the assessment inputs where applicable. Table 2 also includes advice on how SSA output may inform ecosystem assessment (EA). This is an important consideration for coordinating the efforts between the Ecosystem Considerations chapter and the stock-specific chapters. An established feedback loop is one of the main goals for improving the SEC sections and we elaborate further on this aspect in the following section.

Proposed Framework for the Stock-specific Ecosystem Considerations Section

A consistent and comparable template for incorporating E/H/C data into the assessment process is needed. It is clear that E/H/C factors and modeling avenues for including these factors exist (Tables 1 and 2). The breakdown occurs in the communication of these efforts. In order to make progress, we need a framework for creating a feedback system between our ecosystem and stock assessment communities. We propose to do this via three steps: 1) determine stock or stock complex priorities by developing an assessment input-based categorization with reference to spatial, temporal, and E/H/C linkages, 2) perform a stepwise evaluation of the spatial and temporal trends of the assessment inputs to generate a draft conceptual model, and 3) identify relevant proxy indicators using a report card format to explain the assessment trends. The first step provides a metric for identifying which stocks can benefit the most from inclusion of E/H/C linkages in reference to the assessment capabilities and stock limitations. The second step provides a feedback forum for ecosystem and stock assessment scientists to collaborate on the details of their respective disciplines. Stock assessment scientists develop the draft conceptual model based on their knowledge of the stock life history and stock assessment inputs. Following this, ecosystem scientists close the loop by providing background on developed proxy indicators that represent the mechanisms identified in the assessment-based draft conceptual model. The third step utilizes an already established output for viewing top indicators of system change with the modification of being stock-specific. This final step would be enhanced if a central locale for E/H/C indicator data can be maintained and updated annually using a pre-existing stock assessment data portal (e.g. AKFIN). The proposed methodology for each step is provided below.

Categorization

The recent draft protocol for prioritization of stock assessments provides a standardization scheme for basing decisions about updating or conducting a particular assessment. Essentially, the suggested prioritization approach for a current assessment is determined relative to a target level and target frequency and a variety of factors contribute to scoring the particular stock (Methot et al., *In Review*). One of the factors for determining a stock target level is the importance of the stock to the ecosystem and considers both bottom-up and top-down roles in predator/prey dynamics (e.g. a stock such as krill that is a major diet item for a broad range of stocks would receive a high score). The flip-side of this role is the importance of the ecosystem, habitat, or climate to the productivity of the stock. Although these E/H/C effects on the stock do not explicitly contribute to the current draft prioritization score, the update to the SAIP does address expanding assessments to include this information and future draft prioritization protocols will likely include this in the scoring process (Methot et al., *In Review*).

In parallel, the Habitat Assessment Improvement Plan (HAIP) has identified the need to use habitat assessments to reduce uncertainty in stock assessment by including habitat information (NMFS, 2010). A similar effort of prioritization has ensued to provide scoring criteria for determining which stocks would likely benefit the most from habitat assessment (NMFS, 2011). In 2012, the Southwest region provided a pilot study for habitat assessment prioritization on both the support of stock assessment and advancement of essential fish habitat science (NMFS, 2012). This first pass at designating high, medium, and low priority stocks for habitat assessment provides a useful guideline for determining metrics of ecosystem importance and effects. We incorporate elements of this habitat prioritization scheme along with the ecosystem metric mentioned above to establish categorization of a stock with respect to E/H/C linkages. This score will assist researchers in understanding the utility of E/H/C data for informing a particular stock assessment and will assist future prioritization efforts that might ultimately require this information.

To begin the stock categorization we start with the general list of inputs for an assessment that are detailed in Table 2. This provides direct reference to previously identified E/H/C linkages from a national workshop (NEMoW 2014) and connects with information likely to be in the next SAIP update. An example of how to generate a stock categorization is presented in Table 3 for Alaska sablefish. A current and target score are determined for each assessment input concerning whether the input is spatially explicit, time varying, and/or contains E/H/C linkages (see table below). The current score is the level to which these inputs are known presently and should be based on the assessment results and expert advice (e.g. assessment/ecosystem authors). The target score is the goal for a given input and should consider the same factors that are used to generate the target assessment level from the draft prioritization protocol. These are fishery importance, ecosystem importance, and stock biology. A stock with high fishery/ecosystem importance and/or biological factors that undergo or contribute to high levels of natural fluctuations would have a high target assessment level and subsequently more likely to have higher ecosystem target scores (Methot et al. *In Review*). Conversely, a low commercial value, non-target stock might have a low target score, despite potentially having strong ecosystem linkages. We propose the following scoring rubric for setting the current and target values:

Score	***Guideline***
0	Index or parameter is not spatially explicit, time-varying, or has E/H/C linkages that are important to estimation
1	Spatial, temporal, or E/H/C linkage thought to be important, but insufficient data to support exploration of properties
2	Spatial, temporal, E/H/C linkage thought to be important, sufficient data exists to support exploration but has not been explored or implemented
3	Spatial, temporal, E/H/C linkage explored and used to inform assessment, but no process study to support (e.g. defining spatial or temporal domain but lack biological basis, environmental

	indices correlated but no mechanistic underpinning)
4	Spatial, temporal, E/H/C linkage informs assessment with supporting process study
5	Spatial, temporal, E/H/C linkage informs assessment with supporting process study and harvest policies directly take into account this information (e.g. mechanistically-driven environmental index included in assessment model that determines quota recommendations)

Summary metrics are calculated to provide information on the integration of the linkages into a given assessment input and the importance of the linkages over the whole assessment (e.g., Table 3). The Goal summary metric concerns the current versus target scores for a given assessment input over all linkages. The Priority summary metric is similar but concerns a specific linkage over all assessment inputs. Both summaries are presented as a percent. A high goal implies that the assessment of the stock or stock complex for that input is heading toward complete ecosystem integration. A high priority for a given linkage implies that the linkage is an important aspect of this population and is accounted for in one to many of the assessment inputs. A zero suggests that the inputs and/or linkages are not important to the assessment of the stock or stock complex. The final goal/priority metric (*to be determined*) could be viewed as an overall measure of the assessment ecosynthesis and might be a way to compare priorities and goals between stocks.

In general, the presence of a spatial or temporal trend in an assessment input implies that either a natural or anthropogenic effect exists that is exerting change on the population. Clear causal relationships for some assessment inputs (e.g. catch data) exist while for others (e.g. recruitment estimates) the mechanisms behind these spatial/temporal shifts are unclear. The inclusion of the spatial and temporal linkage in this categorization allows for the initial identification of trends that may subsequently lead to an E/H/C linkage given fishery influences were already taken into account (e.g. shift to IFQ, gear restrictions, economics). It seems reasonable that an evaluation of the spatial and temporal patterns should be considered first before proceeding to E/H/C linkages within an assessment. If no pattern exists for a given assessment input, then the E/H/C linkages scoring will likely also be low. In its entirety, Table 3 functions as a first pass for determining which assessments have the highest potential for being informed by incorporating E/H/C information.

Conceptual Model Template

When attempting to understand the interconnections between a variety of physical and biological elements, a holistic approach is often employed to realize the broader scope of system functioning (e.g. Spencer et al. 2010). Generally as more linkages are simultaneously evaluated a conceptual model is useful to organize the relationship between entities. Pictographs or diagrams can also be valuable to visualize the synthetic product (e.g. Mundy et al., 2005, Figure 1). As previously stated, it is useful to know the collection of E/H/C indicators that are available (Table 1) as well as the guidelines for how to incorporate this information into an assessment (Table 2). However, determining the most appropriate indicators for a given stock and if, or when to use them is not as straight-forward and may require the expertise of a multi-disciplinary team. We provide a template for stock assessment authors to evaluate the stock trends and data, develop a qualitative conceptual model, and establish E/H/C linkages in Table 4. An example of how to fill-in this table is provided for Alaska sablefish in Table 5.

The identification of spatial and/or temporal trends is a logical first step in this process. If the categorization of the previous section leads to little to no evidence of spatial or temporal trends in the assessment inputs and the fishery/ecosystem importance is low then the pursuit of E/H/C linkages is also likely a low priority. However, if the converse is true then the assessment inputs with spatial and/or temporal trends should be described and subsequent steps in the template should be evaluated.

Following the identification of trending assessment inputs, the data specific to the stock should be summarized. If the spatial or temporal trends are due to anthropogenic events such as fishing activities, it is helpful to first briefly identify and described the accounting for these influences and the methods for integration into the assessment indicated. The anthropogenic events can be gleaned from previous sections in the SAFE reports such as the Fishery Background or Management Measures sections and the methods for integration can be a simple reference to the type of assessment (e.g. age-structured model). Trends may also appear that are in fact time-varying because of human-induced action of changes in fishery-independent data (e.g. shifts in sampling timing or number of stations due to budgetary reasons). The anthropogenic section allows for description of activities or events that are currently being explored but not yet explicitly included in the assessment model. Once anthropogenic events are described, then remaining trends in the assessment inputs can be linked to E/H/C indicators and a conceptual model can be developed. One way of discovering potential unaccounted for E/H/C trends is to investigate unexplained residual patterns.

A description of the available E/H/C data for a given stock or stock complex is particularly valuable for developing a draft conceptual model. Also an associated life history table and static life history pictograph are useful for organizing the information. Examples of these items are presented for Alaska sablefish in Table 6 and Figure 1. For ecosystem data this would include diet, competitors, and predators of the stock by life stage which is often located in the SAFE reports under the Life History section or through online databases such as the Resource Ecology and Ecosystem Modeling (REEM) Life History Database. Habitat data may consist of information describing the physical or biological indicators thought to influence the stock (e.g. thermal tolerances, consumption requirements) and/or information on essential fish habitat. Some of this information may be present in the SAFE reports under the Life History section or in the EFH 5-year Review for a given stock. Climate data may consist of large-scale indices that represent dominant atmospheric and/or oceanographic patterns (e.g. Aleutian Low Pressure Index) that manifest in extreme localized downstream events. Often it will be a phase of the particular large-scale feature that sets up conditions for the fluctuations of more regional measures (e.g. increases in current velocity or nearshore upwelling). These large-scale features are also useful for generating hypotheses about mechanisms that act to influence a particular stock (e.g. Shotwell et al. 2012). If any previous investigations exist that explored developing these mechanisms for a given stock or stock complex, then this information should be included following the data descriptions.

Once the stock-specific E/H/C data and previous study results are collected, this information can be used to generate a simple draft conceptual model. We provide a fill-able form (Figure 3, *in progress*) for building this model based on life history stage, trending assessment inputs, known E/H/C data based on life history of the stock (e.g. Table 6), and associated E/H/C factors for the input trends (Table 2). A list of potential mechanisms can be linked to the form and available for selection depending on the life history stage and trending assessment inputs. For example, if a temporal trend in recruitment was thought to be connected to the pelagic early life history stage, then changes in physical transport (e.g. cross-shelf advection) might be a potential mechanism. The final completed form will be ordered by life history stage so that a sequential visualization of the trending assessment inputs may lead to developing hypotheses regarding the selected mechanisms. The example form contains some information for Alaska sablefish (Figure 3). The completed forms can be submitted online, and responses can be collated and prepared for a group of experts to convene and determine the most relevant indicators for each of the trending life history stages. The list of indicators in Table 1 could serve as a starting point for this process. Following this meeting, a list of proxy indicators can then be presented to the assessment authors and the most appropriate model input to the assessment can be chosen utilizing the information presented in Table 2.

We suggest that a feedback loop also be established between the ecosystem and assessment communities so that as indicators are developed, they are used appropriately. Avenues for this type of feedback system are available through the variety of RFP initiatives and fully integrative programs like the IERPs.

However, products from these projects often do not reach the general assessment community and stock-specific indices are somewhat lost during the production of whole ecosystem indicators. An alternative might be to provide a forum for communication that is associated with the list of available indicators and associated best practices for the indicators guideline. One model for this is the CAPAM technical workshops that are designed to understand how best to model particular elements of population assessments. A corollary would be to pick a specific assessment input such as recruitment, and setup a workshop to provide examples and guidance on E/H/C indicators particular to that input. Another forum might be to setup an E/H/C indicators database on a data portal such as AKFIN where most of our stock assessment data currently resides. Contributors would also provide a short detail of the indicator that would be useful background for the assessment scientists. To some extent, contributors to the Ecosystem Considerations chapter already do this and the current descriptions could be tailored to include a section on implications for single species assessment rather than the ecosystem wide implications.

Regardless of implementation of the feedback loop, the conceptual model template starts the conversation of whether a stock or complex should include E/H/C linkages and takes the first steps toward integrating that information into stock assessment. The template, life history table/graph, and completed form set the stage for future collaboration and research projects that can be tailored to fit the stock needs. Additionally, since the template and forms would be consistent between stocks or complexes, similar linkages may be identified amongst stocks and allow for more efficient allocation of resources to fund process studies that support the proposed extended E/H/C aspects of the assessment.

Report Card

The region-wide report cards from the Ecosystem Considerations chapter identify the top ten indicators for understanding change in those large marine ecosystems (Zador et al., 2012). Along with the indices, overall mean and variance are shown with successive high and low periods highlighted by color code. The most recent five year mean and trend are provided using symbol indicators. Finally the regime shifts and current year are also delineated (Zador et al., 2012). If a series of E/H/C indicators can be identified for a given stock or complex, then a stock-specific report card should be developed following the same format as the Ecosystem Considerations. We provide an example of this for Alaska sablefish (Figure 4). The stock specific cards utilize currently available code resources and create a consistent format for viewing in the SEC. We also suggest that the trending assessment indices be included where applicable (e.g. recruitment estimates) for comparison with the E/H/C indicators. A description of the indicators could also accompany the report card.

The conceptual model could also be utilized here to organize the indicators by life history stage so that hypothesized mechanism may be easier to track through the proxy indicators. One example of this is the Ocean Domain Dynamic Synergy or ODDS conceptual model put forward by Shotwell et al. (2012) for sablefish. They propose that a strong year class of sablefish relies on the compounding effects of three separate mechanisms operating from the offshore to the nearshore domains. This type of sequential development could be used to organize the relevant indicators generated for many species and the associated ODDS indicator card may serve as a useful tracking system for top proxies.

Example Application to Alaskan Stocks

Throughout this document we provide examples of how to develop an SEC for Alaska sablefish in Tables 3, 5, 6 and Figures 1-4. These provide drafts of the three main elements suggested for an SEC, namely the categorization, the conceptual model, and the report card. Supportive information such as the life history table, the pictograph, and habitat suitability models are also very useful. The sablefish example is in draft form and should be considered solely for soliciting feedback on this proposed SEC process rather than a peer-reviewed investigation for sablefish. A complete example for sablefish will be produced for future applications following review of this document and agreement on the best SEC process. We do provide some background for the E/H/C linkages information in the conceptual model template. Text descriptions such as this would be useful to accompany the three main elements for clarity.

E/H/C Linkages – Alaska Sablefish
Until recently E/H/C data was not specifically explored to be integrated into the stock assessment model. Rather the information has been contextual and useful for explaining recent trends in recruitment and growth. Previous reports on temporal changes in growth (Echave et al. 2011) and factors affecting sablefish recruitment in Alaska (MESA 2010) were submitted to various Plan Teams for discussing topical issues such as a sablefish EFH amendment. Recently, several projects have been completed and initiated exploring temporal trends in sablefish recruitment. A mechanistic ODDS model was proposed by Shotwell et al. (2012) that included indicators for three stages of early life history to potentially influence recruitment. Colder than average wintertime sea surface temperatures in the central north pacific associated with the path of the North Pacific polar front were suggested to create positive recruitment events for sablefish. Covariates were integrated into the recruitment deviations of the assessment model and a multistage hypothesis testing procedure combined with cross-validation and retrospective analysis were used for model selection. The impact on future projections in terms of recruitment precision and changes in female spawning biomass was also explored. Large-scale climate indices, regional upwelling, and freshwater discharge were investigated by Coffin et al. (2014), which suggested that July upwelling and eastern GOA discharge are potentially important to sablefish recruitment. Yasumiishi et al. (*In Review*) considered biophysical nearshore influences on recruitment and found that warmer sea surface temperatures, higher chlorophyll *a*, and higher pink salmon productivity were all positively associated with sablefish recruitment estimates.

Summary and Conclusions

As the goal of EBM becomes increasingly highlighted in our mandate for sustaining marine resources and IEA activities are valued in our assessment prioritization, the integration of E/H/C information into the assessments becomes priority. The SEC is a mechanism for beginning this process. The categorization status tracks the progress of an individual assessment toward including E/H/C data. The draft conceptual model template allows for the organization of current information on the stock or complex life history and provides a forum for determining the best indicators of identified trends. Finally, the ODDS style report card initiates for further development of mechanisms that are backed by stock data and establishes a connection to the Ecosystem Considerations chapter. These three elements of the SEC provide stock-specific guidance for the avenues of integrating E/H/C data into the assessment and which assessments can most benefit from including this information. It is an efficient method that allows for prioritizing research funds for process studies and takes a giant leap toward next generation stock assessment.

Although this work may help contribute to AFSCs mission to move toward next generation stock assessments, it also is useful to contribute to stakeholder interest/trust/buy-in. Most stakeholders are very unlikely to peruse the ecosystem chapter or be able to synthesize that information into how that affects their stock of interest. Much of the time, stock assessments blame low quotas on "recruitment failure" or some other unknown environmental driver. The SEC puts into one place some of the potential explanations for why quotas are variable and potential ways to think about their future investments into their stock of interest.

Acknowledgements

We would like to thank our reviewers for their careful edits and suggestions on this draft SEC report. This is the first attempt to revamp this section for the SAFEs and we welcome continued discussion to make this a useful section for both the assessment and ecosystem communities.

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Table 1: E/H/C indicators table based on information available on Ecosystem Considerations website (Zador et al. 2012)

Type	Category	Title	Region	Year St/Sp	Access	Mechanism, Reference
Ecosystem	Abundance	ADF&G Gulf of Alaska Trawl Survey	GOA	1987-2010	Worton, C.	
Anthropogenic	Disturbance	Area Disturbed by Trawl Fishing Gear in the Eastern Bering Sea	EBS	1990-2010	Greig, A.	
Ecosystem	Diversity	Average Local Species Richness and Diversity of the Groundfish Community	EBS	1982-2010	Mueter, F.	
Ecosystem	Diversity	Average Local Species Richness and Diversity of the Groundfish Community	GOA	1990-2009	Mueter, F.	
Ecosystem	Predator	Bowhead whales	ARCTIC	1978-2001	Muto, M	
Climate	Physical	Pacific Decadal Oscillation (PDO)	PACIFIC	1900-2011	Bond, N.	
Climate	Physical	Sea Surface Temperature Anomalies	PACIFIC	1985-2009	Bond, N.	
Climate	Physical	Arctic Oscillation (AO)	PACIFIC	1951-2011	Bond, N.	
Climate	Physical	North Pacific Index (NPI)	PACIFIC	1900-2011	Bond, N.	
Climate	Physical	El Nino Southern Oscillation Index (NINO3.4)	PACIFIC	1950-2011	Bond, N.	
Climate	Physical	North Pacific Gyre Oscillation (NPGO)	PACIFIC	1950-2011	Bond, N.	
Climate	Physical	Sea Level Pressure Anomalies	PACIFIC	1950-2011	Bond, N.	
Ecosystem	Recruitment	Combined Standardized Indices of recruitment and survival rate	EBS, GOA	1970-2006	Mueter, F.	Groundfish recruitment, Mueter et al. 2007
Ecosystem	Diversity	Rockfish along environmental gradients in the GOA and AI bottom trawl surveys	GOA, AI	1990-2011	Rooper, C.	Rockfish distribution, Rooper 2008
Habitat	Physical	Ice Retreat Index	EBS	1973-2011	FOCI	
Habitat	Physical	Surface Air Temperature: Summer	EBS	1915-2011	FOCI	
Habitat	Physical	Surface Air Temperature: Winter - Spring	EBS	1915-2011	FOCI	
Habitat	Physical	Sea Level Pressure: Summer	EBS	1915-2001	FOCI	
Ecosystem	Abundance	Forage - Aleutian Islands	AI	1980-2010	RACE	
Ecosystem	Abundance	Forage - Eastern Bering Sea	EBS	1982-2011	RACE.	

Type	Category	Title	Region	Year St/Sp	Access	Mechanism, Reference
Ecosystem	Abundance	Forage - Gulf of Alaska	GOA	1984-2011	RACE	
Ecosystem	Abundance	Forecasting Pink Salmon Harvest in Southeast Alaska	GOA	2005-2011	SECM	
Anthropogenic	Effort	Observed groundfish bottom trawl fishing effort in the Gulf of Alaska, Bering Sea and Aleutian Islands	EBS, AI, GOA	1990-2010	Olson, J.	
Anthropogenic	Fleet	Groundfish fleet composition	EBS, AI, GOA	1994-2010	Lee, J.	
Anthropogenic	Effort	Observed groundfish pelagic trawl fishing effort in the Gulf of Alaska, Bering Sea, and Aleutian Islands	EBS, AI, GOA	1995-2010	Olson, J.	
Habitat	Biological	Gulf of Alaska Chlorophyll a Concentration off the Alexander Archipelage	GOA	2010-2010	GOA-IERP	
Ecosystem	Abundance	Gulf of Alaska Small Mesh Trawl Survey Trends	GOA	1972-2010	Urban, D.	
Anthropogenic	Catch	Historical trends in Alaskan salmon	EBS, GOA	1900-2010	Whitehouse, A.	
Anthropogenic	Effort	Observed hook and line (longline) fishing effort in the Gulf of Alaska, Bering, Sea and Aleutian Islands	EBS, AI, GOA	1996-2010	Olson, J.	
Climate	Large-Scale	Indicators of Regime Shift	ALASKA	1965-2007	Litzow, M., Mueter, F.	Ecosystem regime shifts, Litzow 2006

Table 2: Ecosystem/Habitat/Climate (E/H/C) linkage table (Link pers. comm.) to various assessment inputs in traditional single-species stock assessment (SSA). Under SSA description includes population dynamics (PopDy) for given assessment input and known limitations. Under E/H/C description includes E/H/C factor that could be used to inform assessment input and potential model integration avenues (Model Input) for use in extended stock assessment models (ESAM) or to inform ecosystem assessments (EA). Examples of use and corresponding reference are included.

Assessment Input	**SSA Description**		**E/H/C Description**		**Indicator, Reference**
Stock Boundary or Distribution	PopDy:	Sometimes estimated through stock structure studies but typically geo-political boundaries area used.	E/H/C Factor:	Large-scale changes in oceanographic processes associated with climate change.	Fish distribution shifts, Link et al. 2011
	Limits:	Difficult to adapt boundaries when based on geo-political terms.	Model Input:	ESAM: decision-tree prior to analysis EA: defines range of potential ecosystem linkages, understand migration rates and climate impacts.	
Natural Mortality (M)	PopDy:	Typically calculated from longevity, life history correlates, or historical age composition for unfished stocks and constant over time. Sometimes estimated internally in model when age data quality is high. Possible M by age as a constant M above age at entry to fishery.	E/H/C Factor:	A portion of M is the result of predation and predators change in abundance. Consumption measurements can help estimate M if sampling of predators is sufficient over space and seasons. Advanced technology (tagging studies) can provide direct, empirical measurement of total and natural mortality.	Predation as fleet for EBS pollock, Livingston and Methot, 1998; Hollowed et al. 2000
	Limits:	Historical studies may not reflect contemporary M in a changed ecosystem. Catch curve studies are very simplistic in comparison to current Integrated Analysis models. Internal estimates as parameters in IA models are confounded with domed selectivity patterns and with long-term trends in recruitment. Recommend treating M as having uncertainty, not as a known constant. M certainly declines from young to mid-aged fish, but sharpest decline before entering fishery, so rarely invoked. Any bias in young fish M is compensated by empirical selectivity estimation. Senescence sometimes observed, but confounded with selectivity. Recommend using Lorenzen curve as default for M by age.	Model Input:	ESAM: use as context, scalar to M, covariate linked to M or other parameters, input as direct removals for M estimate and can treat as another “fleet” of predators. Predation studies naturally provide rates by size class, so inherently will provide M changing with age. Senescence is more physiological, not ecological. Logical output from ecosystem studies that could inform M over time. EA: M from single species empirical analysis can provide ground truth for output of food web models, as well as serve as inputs (or proxies thereof) for food web and ecosystem models, also linked to environmental variables can elucidate community-level patterns. Caution as SSA results of biomass over time would be biased input to EA if	

Assessment Input	SSA Description		E/H/C Description		Indicator, Reference
				SSA assumes constant M. Could directly use from mulit-species models that include both predator and prey.	
Maturity or Fecundity	PopDy:	Usually estimated as constant over time because rarely routinely monitored	E/H/C Factor:	Not an EM output, but could be linked to environment/climate if maturity time series were monitored. Then climate could forecast future maturity levels.	
	Limits:	Could be density-dependent or climate driven. Changes over time will re-define "spawner" calculation, so confounded with spawner-recruitment steepness.	Model Input:	ESAM: parameters defining maturity could be linked to time series of climate factors.	
				EA: NA. Same values probably used.	
Growth	PopDy:	Easily monitored for stocks with good age data and treated empirically in assessment.	E/H/C Factor:	Good candidate for studies to link changes to prey availability or environment. Also climate. Could improve forecast of upcoming changes.	
	Limits:	When time-varying, a conceptual basis for inclusion in MSY and other equilibrium quantities is lacking.	Model Input:	ESAM: use as context, scalar to r, covariate linked to r or other parameters	
				EA: Same logic as M for food web models, but would inform P/B and related growth measures	
Catch	PopDy:	Intensely monitored and commercial catch typically treated as census. In trend based assessment methods, the level of catch has large influence on scale of estimated population.	E/H/C Factor:	Environment used to model fleet dynamics and catchability	
	Limits:	Minor compared to everything else; except for some recreationally dominated fisheries.	Model Input:	ESAM: use as context, covariate linked to q or other parameters	
				EA: Observer & logbook data show species associations, also bycatch and technical interactions could be used in EAs	
Abundance Surveys	PopDy:	Commonly treated as proportional (q) to stock abundance over time. Important source of biological samples.	E/H/C Factor:	Used to model catchability, via many different input properties, habitat, temperature, competition	
	Limits:	Catchability of sampling gear could be habitat specific, so movement of fish could change overall survey calibration. By monitoring just relative changes, much	Model Input:	ESAM: use as context, scalar to q, covariate linked to q or other params,	
				EA: Same surveys used in ecosystem models; critical for calibrating Ems.	

Assessment Input	SSA Description		E/H/C Description		Indicator, Reference
		information absolute abundance comes from the absolute level of catch.		Surveys designed for SSA data also provide platform for collection of consumption data and for spatial comparisions to environmental and habitat factors.	
Selectivity or Catchability (q)	PopDy:	Estimated within models on basis of age/size composition data. Some non-parametric, some with functional forms.	E/H/C Factor:	Spatial analysis of surveys and fisheries might inform age/size patterns in selectivity; q can be micro-habitat dependent so sample-specific habitat and environmental measurements could improve survey calibration to a more constant nominal q. Selectivity and q changes over time could be environmentally mediated. Advanced technology is key to direct measurement of q. Environment used to model catchability, via many different input properties	
	Limits:	Lack technical guidance for invocation of domed selectivity, time-varying selectivity, priors on q; temporal changes in q. Domed selectivity highly confounded with other factors. Topic of upcoming best practices guide.	Model Input:	ESAM: use as context, scalar to q, covariate linked to q or other params,	
				EA: could also benefit from these detailed studies; critical for calibrating EMs, especially, if B is absolutely estimated	
Recruitment	PopDy:	Empirical output of age-structured models on basis of age and size composition data and juvenile fish surveys. Mean relationship to spawning biomass can be basis for direct estimation of MSY if there is enough contrast in time series.	E/H/C Factor:	Scale and curvature of spawner-recruitment relationship probably depends upon several ecosystem linkages, not just the subject species; food web models best at predation on younger fish so could inform (complicate) spawner-recruitment relationship. Recruitment fluctuations could be informed by environment linkage studies and then provide basis for forecasting. Huge environmental element	Advection for sablefish, Shotwell et al. 2012
	Limits:	Lack of range of spawning biomass observations limits contrast; deviations commonly treated as random (no auto-correlation); quality of recruitment estimates dependent on quality of age and	Model Input:	ESAM: use as context, scalar to either R or SSB, covariates in exponent, models linked to R or SSB	
				EA: time series of recruitment produced by assessment models is common input to	

Assessment Input	SSA Description		E/H/C Description		Indicator, Reference
		size data		environmental linkage investigations.	
Movement	PopDy:		E/H/C Factor:		
	Limits:		Model Input:	ESAM:	
				EA:	
Consumption	PopDy:		E/H/C Factor:		
	Limits:		Model Input:	ESAM:	
				EA:	
Target Harvest Rate	PopDy:	Proxies are straightforward to calculate from life history and selectivity. MSY based rates can be estimated if there is sufficient contrast in time series to estimate either a simple production model (with MSY as emergent property) or spawner-recruitment curvature from age-structured model.	E/H/C Factor:	In a multi-species model, the target harvest rate for each species is linked to the abundance and hence target rate for other species.	
	Limits:	Assumes that species' productivity is independent of other species in the regional ecosystem that also are experiencing changing abundance. If life history is changing over time, then the time frame to use for these benchmark quantities is debatable. Most assessments have not observed stock over broad enough abundance range to calibrate productivity, so proxies needed.	Model Input:	ESAM: same as M above	
				EA: used to informed SS Fs in EMs, and also to inform Aggregate Fs in EMs	
Forecast or Projections	PopDy:	Age-structured SSA typically link to forecasting tools that use a probability distribution of future recruitment and current fishery selectivity and allocation and the target harvest rate.	E/H/C Factor:	To the extent that ecosystem models and climate forecasts are better than "random" in the future; where linkages to fish factors have been identified, then fish forecasts can be improved through input from these other sources.	
	Limits:	Hence, forecasts are too simplistic, so appear overly precise because: autocorrelation of future recruitment rarely invoked; time-varying fishery selectivity	Model Input:	ESAM: many applications, use above suggestions to integration into projection model	
				EA: forecasting tools are building blocks for	

Assessment Input	SSA Description		E/H/C Description		Indicator, Reference
		needs to have random changes in future also; growth also will change. Need to acknowledge time lags inherent in collecting data and the adjusting ACL.		development of operating models in Management Strategy Evaluations	

Table 3: Categorization table of assessment input for a given stock or stock complex. Current values by spatial, temporal, or E/H/C factors are scored using 0 to 5 scale (see text) with target levels in parentheses. **Goal** summary metric is a percent based on the sum current scores for a given assessment input over all factors and divided by the sum target scores for those factors. **Priority** summary metric is a percent based on the sum current scores for a given factor over all assessment inputs and divided by the sum target scores for those inputs. The values in this table are an example based on the information in the Alaska sablefish assessment.

Assessment Input	Spatially Explicit	Time Varying	Ecosystem Linkage	Habitat Linkage	Climate Linkage	Overall Goal (%)
Distribution / Boundary	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	**20**
Natural Mortality	2 (5)	2 (5)	2 (5)	0 (0)	0 (0)	**40**
Maturity / Fecundity	2 (4)	2 (4)	1 (4)	0 (0)	1 (3)	**40**
Growth	2 (3)	3 (3)	2 (4)	2 (4)	2 (4)	**61**
Catch	4 (5)	5 (5)	1 (4)	0 (0)	0 (0)	**71**
Abundance Surveys	3 (4)	5 (5)	3 (5)	0 (0)	0 (0)	**79**
Selectivity / Catchability	1 (2)	4 (5)	0 (0)	4 (5)	4 (5)	**76**
Recruitment	0 (0)	5 (5)	3 (5)	3 (4)	3 (4)	**77**
Movement	3 (4)	2 (5)	0 (0)	2 (5)	2 (5)	**47**
Consumption	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	**25**
Target Harvest Rate	1 (3)	1 (1)	2 (5)	2 (5)	1 (5)	**37**
Forecast / Projections	1 (5)	5 (5)	2 (5)	0 (0)	2 (5)	**50**
Priority (%)	**54**	**79**	**43**	**56**	**43**	**TBD**

Table 4: Draft conceptual model template. Sections should be completed sequentially and accompanied by supportive text where necessary.

Property	***Activity and Justification***
Identify Spatial-Temporal Trends	
Spatially explicit assessment steps	Describe evidence for spatial trends in the distribution, rates, data, and/or model results? If none or unknown, describe if research target is priority.
Time-varying assessment steps	Describe evidence for temporal trends in the distribution, rates, data, and/or model results? If none or unknown, describe if research target is priority.
Describe Anthropogenic Activity	
Fishery Data	Describe by life stage (if known) any fishery effects that are thought to influence this stock or complex (e.g. gear changes, management measures).
Non-Fishery Anthropogenic Data	Describe by life stage (if known) any non-fishery anthropogenic effects that are thought to influence this stock or complex (e.g. dredging, effluent).
Anthropogenic Linkages	To what extent have anthropogenic events been investigated to understand the spatial/temporal trends identified for this stock or complex (e.g. context, model scalar/covariate)? Does this information account for the observed trends?
Describe Stock/Complex E/H/C Data and Linkages	
Ecosystem Data	Describe by life stage (if known) diet, competitors, and predators for the stock or complex (e.g. early life history tables).
Biophysical Habitat Data	Describe by life stage (if known) any physical or biological indicators that are thought to influence this stock or complex (e.g. habitat tables).
Essential Fish Habitat Data	Describe by life stage (if known) essential fish habitat, habitat associations, or habitat suitability for the stock or complex (e.g. habitat tables).
Climate Data	Describe by life stage (if known) any climate indicators that are thought to influence this stock or complex (e.g. Aleutian Low)
E/H/C Linkages	To what extent have E/H/C linkages been investigated to understand the spatial/temporal trends identified for this stock or stock complex (e.g. context, model scalar or covariate)?
Develop Stock/Complex Conceptual Model	
Static Life History	Describe and/or draw life history pattern to the extent known (e.g. pictograph with each life stage and associated habitat, see sablefish example).
Trend Life History	Combine trending assessment steps with life history (e.g. recruitment with early life stages) and choose potential mechanism. Complete fillable form online.
Report Card	Connect relevant indicators to draft conceptual model using results from fillable online form. Start with Table 1 and develop feedback loop for report card.

Table 5: Draft conceptual model template example – Alaska Sablefish (*in progress*, not peer-reviewed), supportive text in section titled “Example Application to Alaskan Stocks”

Property	***Activity and Justification***
Identify Spatial-Temporal Trends	
Spatially explicit assessment steps	Evidence for growth, catch
Time-varying assessment steps	Evidence for M, abundance, catch, growth, selectivity, recruitment, and movement based on surveys, fishing, age/size compositions, and tagging study
Describe Anthropogenic Activity	
Fishery Data	IFQ, shift in time of fishery, gear changes from longline to pot
Non-Fishery Anthropogenic Data	Human-induced global warming
Anthropogenic Linkages	Separable, catch at age assessment model, fishery CPUE, fishery age, fishery sizes included in model, time-varying selectivity
Describe Stock/Complex E/H/C Data and Linkages	
Ecosystem Data	Prey: euphausiids, opportunistic, Predators: arrowtooth, halibut, See Table 6
Biophysical Habitat Data	Stage 1 influenced by temperature and transportation, Stage 3 influence by competition, See Table 6
Essential Fish Habitat Data	EFH report and habitat suitability, Figure 2
Climate Data	No large-scale indices related to sablefish (Coffin et al. 2014)
E/H/C Linkages	Echave et al. 2012 (growth); MESA 2010 (recruitment/EFH); Shotwell et al. 2012 (recruitment); Coffin et al. 2014 (recruitment), Yasumiishi et al. *In Review* (recruitment)
Develop Stock/Complex Conceptual Model	
Static Life History	Three stage early life history, followed by adult habitat, Figure 1
Trend Life History	Temporal trends in recruitment during stage 1 related to temperature, advection with hypothesized mechanism being cross-shelf transport, Figure 3 (form)
Report Card	Shotwell et al. 2012 for ODDS model and proxy indicators, Figure 4

Table 6: Early life history table – Alaska Sablefish (courtesy J. Pirtle)

Stage		Region/Depth	Landscape	Substrate	Biogenic	Prey/Predators	Environment
Adult	**Spawning**	shelf edge (>200 m), timing late winter-spring, peak March(1)	shelf break(1)	-	females produce about $120 \cdot 10^3$ eggs(1)		
Offshore to Nearshore Pelagic	**Egg**	slope (>200-400 m)(1)	sink to deeper depths, negatively buoyant(1)	-			
	Larvae	slope (>200-400 m) (hatching to yolk-sac), surface over shelf and slope (yolk-sac to YOY)(1, 2,7), peak late spring and summer(7,16)	ascend as yolk-sac larvae, complete development as obligate neuston (10-80 mm SL)(1,7,16)	-	co-occur with larval cottids, hexagrammids, wrymouths, and also non-obligate neustonic taxa(7)	prey* include (<12.5 mm SL) copepod nauplii, (12.6-20.5 mm SL) nauplii, small copepods, (>20.6 mm SL) small and large copepods(1)	currents that transport onto shelf(1), growth threshold 22°C (lab)(9), survival of first-feeding larvae linked to copepod abundance(11)
	YOY	shelf(1), 60-230 mm FL captured from top 3 m of water column(10)	neuston and near surface waters(1,10)	-	active inshore migration likely(1)	prey* include euphausiids, pelagic tunicates, other crustaceans, larval fish(1,10)	currents* that transport to nearshore nurseries(1,10) growth threshold 22°C SST(9)
Nearshore Settlement	**YOY/ Juvenile**	nearshore (6-214 m)(3.4), 0-90 m(6), (timing is late summer-fall)(4)	inlet, bay, fjord, strait(3,6)	mixed, mud, soft(3), proximity to rock(6)	macroalgae, sponge, anemone, sea whip, sea pen, basket star(3), eelgrass(15)	piscivorous, opportunistic, predators* include halibut, arrowtooth flounder(12)	
	Pre-Recruit	nearshore, shelf (10-207 m)(3,4), (6-90 m)(6),), <600 mm FL(5) age-2+(10)	inlet, bay, fjord, strait, shelf(3,6,8)	mixed, mud, soft(3), proximity to rock(6)	sponge, sea whip, sea pen, coral, basket star, anemone(3)	prey* include pollock, other fish, euphausiids, other crustaceans, cephalopods, jellies (12,13,14)	

Figure 1: Draft conceptual model pictograph – Alaska sablefish life history stages (courtesy J. Fujioka)

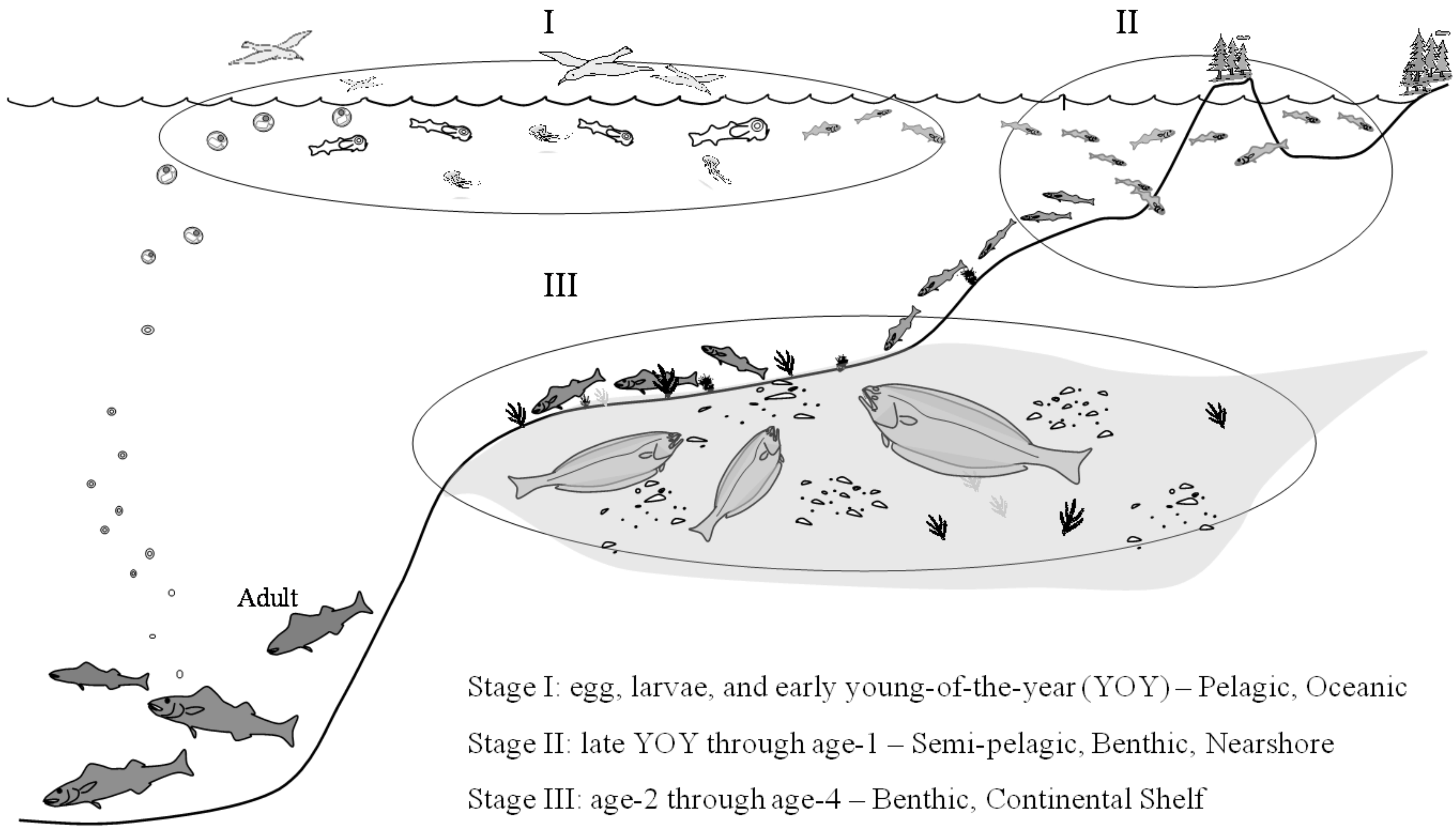


Figure 2: Draft literature based habitat suitability model (LHSM) – Alaska sablefish (courtesy J. Pirtle). Binary values of 0/1 were first generated based on literature information for depth restriction, bathymetric position index (highlights bathymetric highs and lows across the landscape), and entrances to inside waters. This information was then an interpolated to produce a smoothed surface.

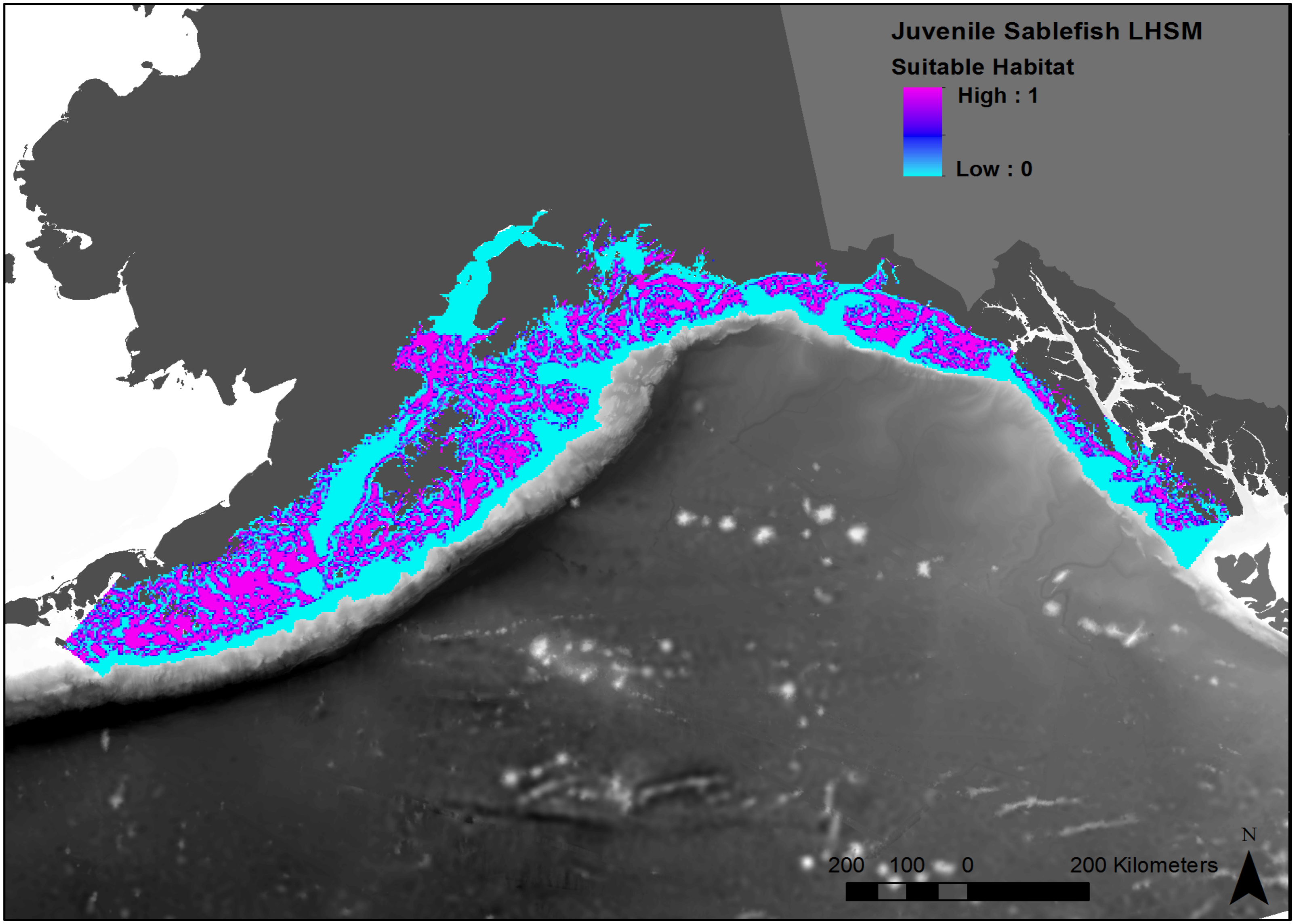
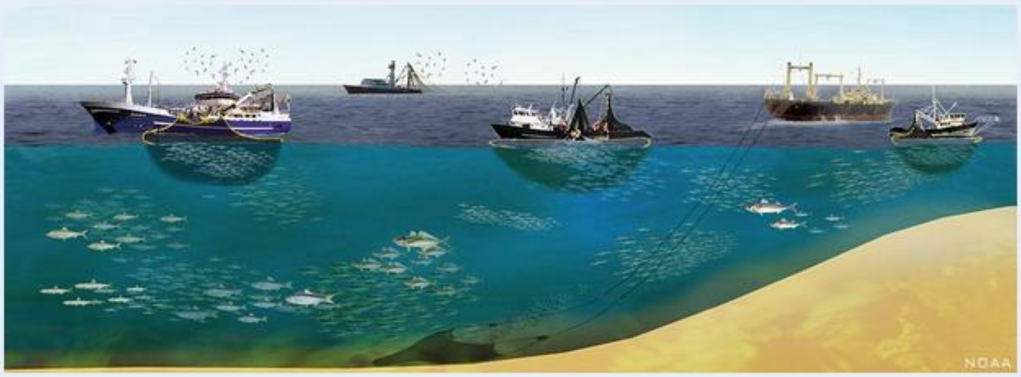


Figure 3: Fillable form to incorporate stock-specific information from conceptual model template - Alaska sablefish example information shown

Stock-Specific Ecosystem Considerations (SEC)

Draft Conceptual Model Template

* Required



Stock or Stock Complex *

Choose stock or stock complex from listed species

Alaska sablefish ▼

Choose Life History Stage

Indicate which life history stage to consider for trending assessment inputs

Stage 1 (e.g. pelagic, oceanic) ▼

Associated Trending Assessment Inputs

Indicate which input(s) are associated with chosen stage

- [x] Recruitment
- [x] Consumption
- [x] Forecast / Projections

Known E/H/C Life History Data

State any E/H/C factors associated with chosen stage

temperature, prey, advection

Choose Mechanism

Select from list of known mechanisms that relate to E/H/C data

Physical transportation (e.g. cross-shelf transport) ▼

Submit

100%: You made it.

Never submit passwords through Google Forms.

Figure 4: Draft report card based on conceptual model and relevant indicators – Alaska sablefish example (chosen indicators are not peer-reviewed and are subject to change)