

Project Title: Improving maturity estimates of sablefish (*Anoplopoma fimbria*) and deep-water rockfish (*Sebastes*) stocks by incorporating skipped spawning and effects of maternal age into stock assessment and using satellite tags to identify spawning habitat

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Industry Support: The Alaska Longline Fishermen's Association (ALFA) has written a letter in support of this project. ALFA is a non-profit association of independent commercial longline vessel owners and crewmembers who are committed to continuing the sustainable harvest of sablefish, halibut, and groundfish, while supporting healthy marine ecosystems and strong coastal communities through resource stewardship and participation in federal, state, and local forums.

This project will provide direct support to the fishing industry in Kodiak with over 75% of the requested funds directed toward chartering a local commercial fishing vessel. The success of the proposed work will rely on the knowledge and experience of the charter captain and crew whose experience fishing for these species and knowledge of local water ways will be critical for the success of the proposed research.

Background and Justification: Skipped spawning (SS) describes a fish that has spawned in the past but is not in the current reproductive year. If SS is occurring and is not accounted for, population models that depend on maturity information could be underestimating population productivity. SS may be a common phenomenon, but has not been previously identified in marine fish in Alaska. Sablefish and deep-water rockfish are commercially important and have stock assessments prepared annually. Maturity information is used in these stock assessments for the purpose of setting Acceptable Biological Catch (ABC) and Overfishing Limits (OFL). Research on the age at maturity of female sablefish conducted in 2011 in the Gulf of Alaska (Rodgveller et al., in prep.) documented SS for the first time in sablefish. Skipped spawners were primarily sampled in a small geographic area; in this area, SS was more prevalent in older fish. SS has also recently been documented in deep-water rougheye rockfish, *Sebastes aleutianus*, blackspotted rockfish, *S. melanostictus*, and shortraker rockfish, *S. borealis* in Alaska. There is some evidence that SS is related to age in sablefish and these rockfish species. Currently the standard model used to describe maturity at age for stock assessment is a logistic function that increases and then asymptotes at 100%; however, the shape of this curve could actually be dome-shaped (for an increasing prevalence of skip spawning with age) or a shallower increase to the asymptote (for a decreasing prevalence of skip spawning with age). This would have effects on estimates of spawning biomass and could impact recommended values of ABCs and OFLs. In an analysis of freshwater and marine fish species that exhibit SS, the rate is positively correlated

with a species' longevity (Secor 2008). From this relationship, SS rates in sablefish and rockfish are estimated to be ~60%. More geographic locations are needed to characterize areas where SS occurs in sablefish and rockfish, how prevalent it is, and more than one year of sampling will provide information on interannual variability. These data are needed to make conclusions about the prevalence of SS in Alaska sablefish and deep-water rockfish stocks.

Another important consideration in incorporating reproductive parameter estimates of sablefish and rockfish into stock assessment models is the effect of larger and/or older females on egg or embryo production (rockfish are live-bearers) and subsequent larval survival. There is some preliminary evidence that older sablefish have larger eggs (Rodgveller et al. in prep.). Also, in some *Sebastes*, older rockfish have higher embryo quality (e.g., *S. melanops*, Berkeley et al. 2004). These factors may lead to higher larval survival. Incorporation of these maternal effects on fitness into stock assessment models can have effects on fishery reference points (Spencer et al. 2014).

There is a longstanding sablefish tagging program in Alaska, however, information on spawning locations is lacking because there are no agency surveys or fisheries in the winter for deploying or recovering tags. Recent advancements in tagging technology have provided a means for collection of geolocation data independent of tag recovery, allowing for the study of sablefish movement during the winter spawning season. Pop-off satellite tags that collect geolocation are programmed to pop-off and float to the surface to transmit data at specified dates. These data can be used to determine the depths and locations of large, mature fish. In a recent winter sampling survey (Rodgveller et al., in prep.) four satellite tags were deployed during the spawning season and programmed to pop-off 30-45 days later. Two fish were released at the capture location and stayed nearby that location. Two others were moved from the slope to the shelf and quickly returned back to their capture location on the slope. Although sablefish move great distances when monitored over long periods at liberty (Heifetz and Fujioka, 1991; Echave et al., 2013), we found that within the winter, at least a portion of prespawning female sablefish exhibit site fidelity. However, it is unknown whether this fidelity is consistent since very few fish were tagged.

Methodology: Our primary objective is to collect additional observations of SS in sablefish and rockfish to determine its prevalence and relationship with age and its variability over time. In Alaska, sablefish spawn in the winter and deep-water rockfish undergo parturition in the spring. The time immediately preceding spawning is the ideal time to sample sablefish for maturity classification and identification of SS. During the same time, rockfish ovarian development is advanced and ovaries are easier to collect than just prior to parturition. We propose to conduct a 10-day research cruise in the central Gulf of Alaska during December 2015. This area has been sampled for both sablefish and deep-water rockfish in previous research surveys; thus far there is data from a single year for each species. A variety of habitat types will be sampled on the continental shelf and slope to evaluate where SS occurs and the rate at which it occurs by habitat type and spawner age. The objective of the sampling design will be to maximize the chance of encountering both immature and mature sablefish and rockfish (these species typically co-occur at the same depths), as well as sampling a variety of lengths (ages) of fish in each habitat for evaluation of SS occurrence and rates by size and age.

Histological slides will be prepared for microscopic determinations of maturity status and evidence of SS. Fecundity will be determined for an examination of a relationship between fecundity and age and weight specific fecundity (eggs per total fish weight) and age. Significant relationships could indicate an age-related maternal effect on egg production. The energy content of ovaries will be analyzed using bomb calorimetry to characterize any relationship between energy content and egg size. Larger eggs could translate into greater energy content or could be related to spawning date and not energy reserves. This can be evaluated by measuring oocyte energy content and developmental stage.

Our goals pertaining to SS and its application for stock assessment are twofold: (1) to develop and evaluate methods to incorporate SS into maturity ogives (the proportion of fish mature at age) used to estimate fishery reference points in the sablefish and rockfish age-structured assessment models, and (2) to then perform management strategy evaluations that investigate the influence of these ogives on reference points when various magnitudes of SS and different levels of variability in SS over time are considered.

We plan to deploy 20 satellite tags, which have been previously purchased, on female sablefish to monitor movement within the spawning and post-spawning periods to determine if sablefish have specific habitat use during the spawning season. Several sablefish will be released at locations away from the capture location to see if tagged fish exhibit site fidelity and navigate back to specific habitats.

Linkage to MSRA priority areas:

This work directly relates to the MSRA priority area of “*collecting data to improve, supplement, or enhance stock assessments, including the use of fishing vessels or acoustic or other marine technology (Section 318(c)(i))*”. The primary objective of the survey is to provide biological information on maturity that is used directly in stock assessments models and is critical for setting ABC and OFL. A commercial fishing vessel will be chartered to conduct the survey. The charter is awarded on a competitive basis. Because a fishery vessel is directly involved with the survey, it establishes a connection and trust for the science supporting groundfish stock assessments. The primary objective of the survey is to provide biological information on maturity that is used directly in stock assessments models and is critical for setting ABC and OFL.

This work also directly relates to the MSRA priority area of “*identifying habitat areas of particular concern as well as conducting projects relevant to the conservation of habitat (Section 318(c)(iv))*”. Habitat use of spawning, skipped spawning, and immature rockfish and sablefish will be identified. Through the use of satellite tags, we will be able to track the movements of sablefish within the spawning and post-spawning periods, therefore identifying potential essential habitats needed for reproduction.

Outreach and education: The results will be presented at North Pacific Fishery Management Council Plan Team meetings and incorporated into the Alaska rockfish and sablefish stock assessments. Several talks will be given at conferences and workshops. Peer-reviewed manuscripts will be published on skipped spawning rates and maternal age effects on egg quality and size in sablefish and rockfish.

Another manuscript will focus on the methods for incorporating skipped spawning and maternal effects into population models used for setting ABCs and OFLs.

Qualifications of Investigators: All four Principal Investigators are NOAA, AFSC employees. Cara Rodgveller, Katy Echave, and Pete Hulson all are stock assessment authors on Alaska sablefish and rockfish stock assessments. Christina Conrath and Cara Rodgveller have experience studying maturity of several fish taxa. Pete Hulson has experience incorporating maturity data into stock assessment population models. Katy Echave is the P.I. of the Alaska sablefish tag program and has experience using pop-off satellite tags and analyzing movement of sablefish.

Please see attached CVs for specifics on education, experience, and publications.

Detailed Budget:

Personnel	0
Fringe Benefits	0
Travel	0
Supplies	5,000
Contractual	106,750
Total Direct Charges	111,750
Total Indirect Charges	0
Total	111,750

The survey would occur in December, 2015 (the first quarter and FY16). The vessel would be chartered in FY15. Work with the vessel would begin in FY15 for planning charter operations and space use on the vessel. Because the survey would occur in FY16, overtime and travel costs are not requested for FY15 Cooperative Research funding.

- Supplies:
 - These will include items such as chemicals for storage of samples, supplies to collect ovarian sections for histology, otolith collection supplies, and other items for fish dissection and measurements (\$5,000).
- Contractual:
 - A vessel will be contracted for the 10-day cruise. We expect the rate to be \$7,500 per day (for 10 days \$75,000) and for fuel to cost \$15,000 (total: \$90,000).
 - A biologist will be contracted to provide assistance processing samples on the vessel (\$5,000).
 - A biologist will be contracted to provide energy density measurements of ovaries for female sablefish preparing to spawn (\$2,500).
 - Preparation of 900 histological slides will be contracted (\$6,750).
 - Fecundity measurements for sablefish preparing to spawn will be done by a contractor (\$2,500).

- Total: \$106,750

Literature cited

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