

# Spawning omission and the productivity of deepwater rockfish in the North Pacific Ocean

**Christina Conrath**— Kodiak Laboratory, Alaska Fisheries Science Center, NMFS, NOAA

**Pete Hulson** — Auke Bay Laboratories, Alaska Fisheries Science Center, NMFS, NOAA



## Introduction

Recent examination of the maturity of three deepwater rockfish species (shortraker rockfish, *Sebastes borealis*, rougheye rockfish, *S. aleutianus*, and blackspotted rockfish, *S. melanostictus*) in the Gulf of Alaska revealed a high proportion of mature individuals were skip spawners. The proportion of skip spawners varied among species but at least 30% of individuals determined to be adults were undergoing spawning omission during the upcoming reproductive season and in at least one species the prevalence of skip spawners was related to size. Specimens for this study were collected during the 2010 reproductive season in the central Gulf of Alaska and additional data are needed to determine the consistency of skip spawning across various temporal and spatial scales. We examined the identification and prevalence of skip spawning in rougheye and blackspotted rockfish and examined how the presence of non-spawning mature fish will influence the stock assessment results for these species. Using a simulation model based on the life-history and assessment of the blackspotted-rougheye rockfish complex we examined how the presence of skip spawners impacts estimates of spawning biomass and recommended catch limits for these species.



## Skip Spawning Identification & Prevalence

**Question:** How do we distinguish immature fish from mature fish that are not spawning?

**Answer:** Mature fish that have previously spawned before are distinguished from immature fish by noting evidence of previous spawning events. These fish will have post ovulatory follicles and/or late stage atresia present within the ovarian section; these fish also tend to have ovaries with larger walls, more connective tissue within the ovary, and other indicators of spawning (e.g., a large amount of blood cells and vessels). The resting type of skip spawner has evidence of a prior spawning but no development occurred during the current reproductive year (Figure 1). The aborting type of skip spawner also has evidence of prior spawning but also initiated development during the current reproductive year that is being resorbed or aborted.

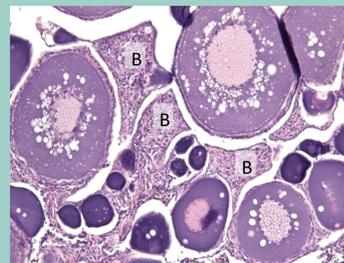


Figure 1. Resting skip spawners are distinguished by the presence of late stage atresia (B).

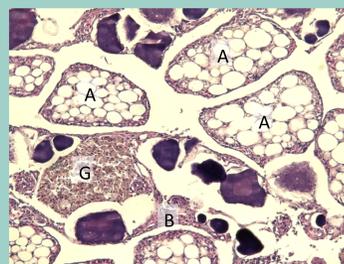


Figure 2. Aborting skip spawners are distinguished by the presence of both late stage atresia (B, G) and early stage atresia (A).

**Question:** How prevalent is skip spawning in deepwater rockfish?

**Answer:** Skip spawning is prevalent in all three species but rates of skip spawning varied between species. Rougheye rockfish had the smallest proportion of skip spawners (36%) and blackspotted rockfish had the highest proportion of skip spawners (94%). These samples were taken from a small area in the central Gulf of Alaska during the 2010 reproductive season (Figure 3). The number of skip spawners decreased with length for rougheye rockfish but was variable for blackspotted rockfish (Figure 4). Additional research is needed to determine if how the proportion of skip spawners varies spatially, temporally, and with biological factors including length and age.

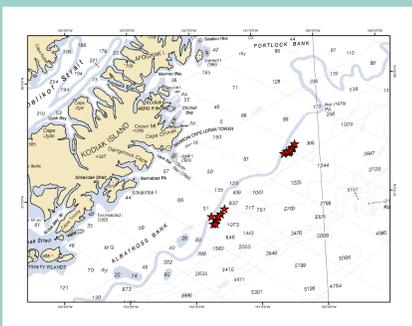


Figure 3. Locations of deepwater rockfish sample collections.

Table 1. The proportion of mature fish that were skip spawners, the proportion of skip spawners that were the resting and aborting types, and the relationship between length and skip spawning for shortraker, blackspotted, and rougheye rockfish.

Species	% SS	% Resting SS	% Aborting SS	% SS related to length?
Shortraker	70	69	31	Y
Rougheye	36	22	78	Y
Blackspotted	94	80	20	N

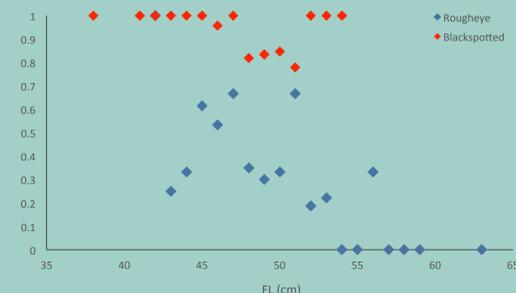


Figure 4. The proportion of skip spawners by length for rougheye and blackspotted rockfish.

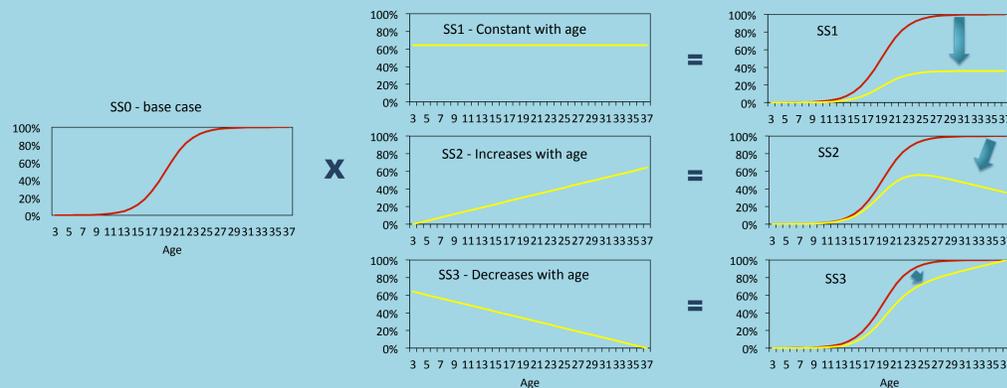
## Implications to Stock Assessment

**Question:** How does the presence of skip spawners and the relationship of skip spawning with age impact estimates of catch limits for these species?

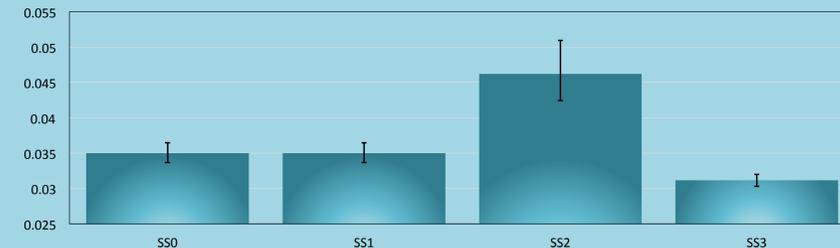
**Definitions:** 'Potential maturity' – overall proportion of mature fish by age currently used in assessment models, skip spawners are assumed to be mature and participating in spawning for purposes of projections. 'Realized maturity' – the overall proportion of fish by age multiplied by the current season's skip spawning rate at age, i.e., the proportion of mature fish that are actually participating in spawning.

**Methods:** We implemented 3 different hypothetical relationships between skip spawning rates and age to the 'Potential maturity' curve to obtain cases of 'Realized maturity'. Using the 2014 results from the Gulf of Alaska rougheye/blackspotted assessment we implemented these 'Realized maturity' curves, with uncertainty, into the projection model used to determine harvest specifications, in particular, the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing.

'Potential maturity' X 'Skip spawning rate' = 'Realized maturity'



### Estimated F40%



**Results:** Compared to the current methodology of using 'Potential maturity' in stock assessment (SS0), a constant skip spawning rate across ages (SS1) results in the same  $F_{40\%}$ , an increase in the skip spawning rate by age (SS2) results in a larger  $F_{40\%}$ , and a decrease in the skip spawning rate (SS3) results in a smaller  $F_{40\%}$ .

## Conclusions

- 1) Skip spawning was prevalent in all three deepwater rockfish species, with over 37 – 94 % of mature adults identified as skip spawners. For at least some of these species there is a relationship with length and the proportion of skip spawners.
- 2) Overall, the relationship between skip spawning rates and age can have an influence on the resulting harvest specifications from fishery stock assessment models and should be incorporated to produce more accurate projections of productivity.

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