Reproductive assessment of the Pacific halibut population

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PURPOSE

To provide the RAB with a description of the studies designed to improve our knowledge on reproductive development in female and male Pacific halibut.

BACKGROUND

Each year, the fishery-independent setline survey (FISS) collects biological data on the maturity of female Pacific halibut that are used in the stock assessment. In particular, the female maturity schedule is used to estimate spawning stock biomass. Currently used estimates of maturity at age indicate that the age at which 50% of female Pacific halibut are sexually mature is 11.6 years on average. However, maturity is estimated with the use of macroscopic visual criteria, implying a relative level of uncertainty associated with the employed semi-quantitative assessment, and the maturity schedules for both sexes have not been revised in recent years and may be outdated. For this reason, research efforts are needed to improve our understanding of reproductive maturity in female Pacific halibut. Unfortunately, relatively little is known regarding the physiological changes that take place in the ovary during reproductive development leading to spawning in this species. The objective of this study is to understand and report the progression of reproductive development in female Pacific halibut during an entire annual reproductive cycle.

DISCUSSION

Biological samples and biological information from female and male Pacific halibut were successfully collected on a monthly basis for an entire year, from September 2017 through August 2018, in the Portlock region in the Central Gulf of Alaska (Appendix I). The period of sample collection covered an entire annual reproductive cycle in female Pacific halibut and therefore included all maturity stages from post-spawning and early gonadal growth and development until spawning. Biological information and biological samples collected included: maturity stage (classified according to current maturity scales), fork length, otoliths for aging, round weight, gonad weight, liver weight, photographic images of gonads, ovarian and testicular samples for histology, ovarian, testicular and pituitary samples for gene expression, blood samples, fin clips, and fat content.

Photographic images of all staged gonads will be contrasted with gonadosomatic index (GSI; gonad weight/round weight X 100) determinations and histological examination of ovarian and testicular staging. This will allow us to revise the morphological criteria currently used for staging the maturity status of the gonads (ovary and testis). Blood samples were collected on all fish in order to conduct a thorough endocrinological assessment of reproductive status and development in order to correlate levels of reproductive hormones and reproductive genetic markers with morphological and histological assessment of the gonads. Finally, the collected data on fat content will provide functional data on the energy stored in the fish in order to relate energy storage to sexual maturity. Energy storage will be determined by the hepatosomatic

index (HSI; liver weight/round weight X 100) and the muscle fat content as measured with the Fatmeter device.

The completed collection of morphological, histological, endocrine, and functional data from female and male Pacific halibut throughout an entire annual cycle will provide us with a better understanding of the temporal and spatial progression of sexual maturation in Pacific halibut, and will allow for a better estimation of maturity for stock assessment purposes.

Analysis of the data analyzed to date indicate that macroscopic (field) maturity staging captures changes in the maturity schedule of female Pacific halibut that are consistent with the expected peak time of spawning (January-February) and that are correlated with the changes in the gonadosomatic index (Figure 1).

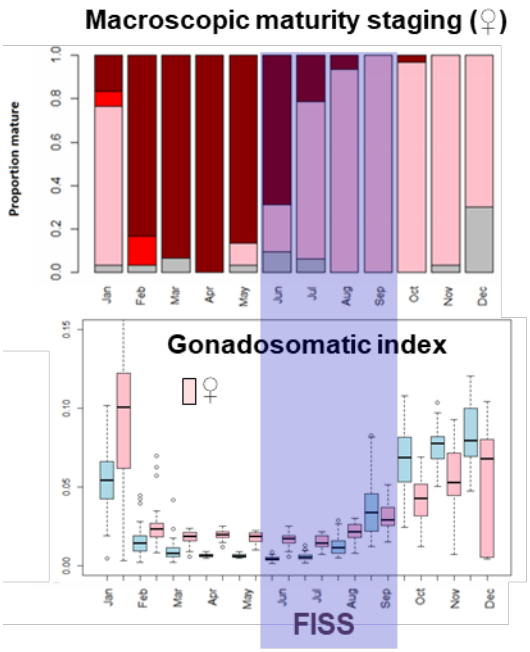

Figure 1. Top, temporal progression of macroscopic maturity stages (grey: immature; pink: maturing; red: ripe; purple: spent) during an entire annual reproductive cycle. Bottom, temporal changes in the gonadosomatic index (gonad weight/round weight X 100) during an entire annual reproductive cycle (pink: females; blue: males). Highlighted over the two graphs is the period during which macroscopic maturity stages used in stock assessment are collected in IPHC's fishery-independent setline survey (FISS).

The IPHC Secretariat has described for the first time the different oocyte stages that are present in the ovary of female Pacific halibut and how these are used to classify females histologically to specific maturity stages. This information is contained in a manuscript that has been recently published in the *Journal of Fish Biology* (Fish et al., 2020). In brief, 8 different oocyte developmental stages have been described, from early primary growth oocytes until preovulatory oocytes, and their size and morphological characteristics established. Maturity classification was determined by assigning maturity status to the most advanced oocyte

developmental stage present in ovarian tissue sections and 7 different microscopic maturity stages were established. Analysis of oocyte size frequency distribution among the seven different maturity stages provided the first direct evidence for the group-synchronous pattern of oocyte development and for determinate fecundity as the reproductive strategy in female Pacific halibut. The results of this study will allow us to establish a comparison of the microscopic/histological and macroscopic/field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment. The results of this study set the stage for and in-depth study on temporal changes in reproductive development, as assessed by microscopic observations of ovarian samples collected throughout an entire annual reproductive cycle, that is currently underway. Preliminary results confirm that the peak period of spawning for Pacific halibut in the central Gulf of Alaska takes place in January and February. Analysis of the temporal changes in female reproductive phase shows that spawning capable females are detected as early as August, therefore marking the beginning of the spawning capable reproductive phase. For stock assessment purposes, the spawning capable reproductive phase comprises females that are considered mature. Importantly, the detection of spawning capable females in July-August is conducive to conducting routine histological assessments of female maturity during the IPHC's FISS sample collection period (i.e. June to late August).

Furthermore, the IPHC Secretariat is also establishing a comparison of the microscopic (e.g. histological) and macroscopic (e.g. visual) maturity classification criteria to determine whether field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment needs to be revised in light of the improved knowledge on ovarian development.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2021-RAB022-10 which outlined the research project describing studies designed to improve our knowledge on reproductive development in female Pacific halibut.

APPENDICES

Appendix I: Geographic location of the sample collection efforts (2017-2018): the Portlock region in the Central Gulf of Alaska.

APPENDIX I

Geographic location of the sample collection efforts (2017-2018): the Portlock region in the Central Gulf of Alaska