Observer-Assessed Reproductive Maturity Use in Ecosystem Based Fisheries Management

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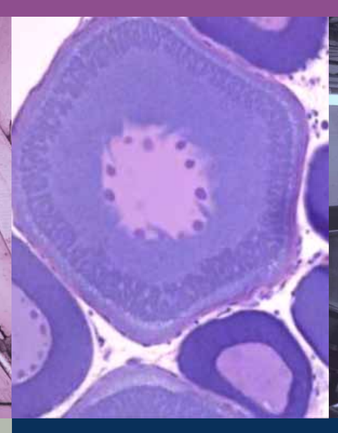
Abstract:

Knowledge of life history strategy and reproductive biology of marine fish is necessary for determining spawning stock biomass in modern stock assessments. In addition, further analysis of the geography and phenology of spawning fish stocks can greatly benefit ecosystem based fisheries management. Knowledge of spawning areas allow researchers to assess interactions between spawning fish and environmental conditions; to assess spawning migrations; to identify early life stage distribution and dispersal to nurseries where young fish develop; and may provide a general understanding of population structure.

Data used to assess the geography and phenology of two gadid species in the Bering Sea and Aleutian Islands was collected by fishery observers trained by the Alaska Fisheries Science Center (AFSC), Fisheries Monitoring and Analysis Division (FMA). Observers used maturity keys to estimate the maturity status of fish. The maturity keys were developed to categorize morphological changes that occur as fish ovaries develop and spawn. Observers also collected ovary specimens from the same fish assessed for maturity status. Histological analysis of ovary tissue samples provides information to assess a species' spawning strategies and is useful in evaluating the validity of the anatomical maturity keys. The maturity status of two ecologically and economically important species, Pacific cod (*Gadus macrocephalus*) and walleye pollock (*Theragra chalcogramma*), have been assessed since 2004 and 2007, respectively. Both species are important components of the Bering Sea food webs, and support the two largest commercial fisheries in Alaska waters.

The application of maturity keys by fisheries observers aboard commercial fishing vessels allowed the collection of maturity data on broad temporal and spatial scales. Because collections were possible throughout the spawning season, these data provided fishery managers with estimates of the timing and location of spawning across regions and between years. Here, we highlight recent analysis of observer-assessed maturity data for Pacific cod along with other potential uses of these data.



Methods for collecting macroscopic maturity

Observers assessed macroscopic maturities using an anatomical maturity keys while on board commercial fishing vessels in the Bering Sea. Fish used for maturity assessments were selected using random sampling methods. Observers compared the visual characteristics of the ovary with maturity stage descriptions and digital images provided in the keys. Morphological characteristics include; the shape and size of the ovary relative to the abdominal cavity, the coloration and transparency of the ovary and individual oocytes, and the fluidity of the oocytes within the ovary. Spawning stage was identified by the flow of ova through the ovipore with light pressure to the abdomen.

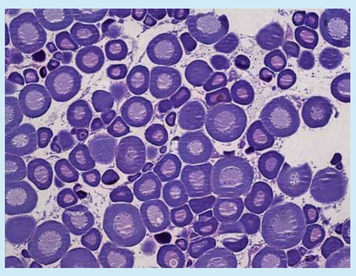
Methods for microscopic maturity collection

Along with the visual maturity, observers collected ovary tissue from a subsample of macroscopically assessed fish. Each tissue sample was preserved in 10% formalin on the vessel. Once in the laboratory each specimen was prepared for microscopic observations by slicing to four microns, staining with a hematoxylin and eosin stain, and fixing to a slide.

Maturity stage assignments based on structural changes seen macroscopically (whole ovary scale) and microscopically (oocyte scale)...

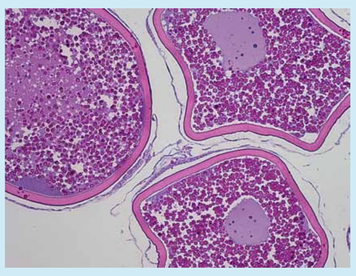
Visual Maturity Stage | **Histological phase**

Immature



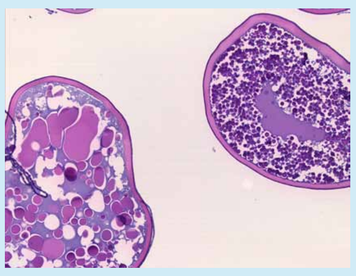
Perinuclear

Developing



Vitellogenesis

Prespawning

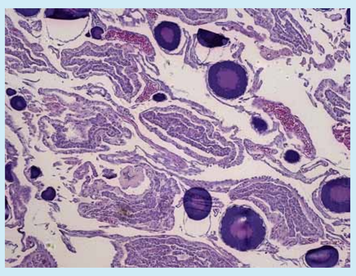


Yolk coalescence

Spawning

Hydration

Spent



Post-ovulatory follicles

Resting

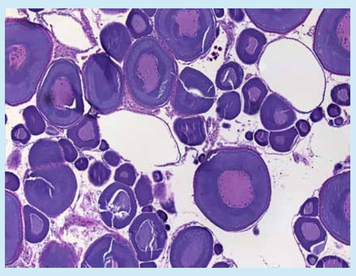


Figure 1 Observers used anatomical maturity keys to assess visual maturity stages of Pacific cod ovaries at sea (left panel). Ovary tissue samples were processed using histological methods to estimate the maturity phase of oocytes within ovaries (right panel). The assigned visual stages of the ovaries and histological phases of the oocytes were compared for the same fish to evaluate the accuracy and consistency of the visual key.

Histological evaluation of ovary tissue provides researchers with information on spawning strategy and visual maturity data shows the seasonal phenology of spawning patterns...

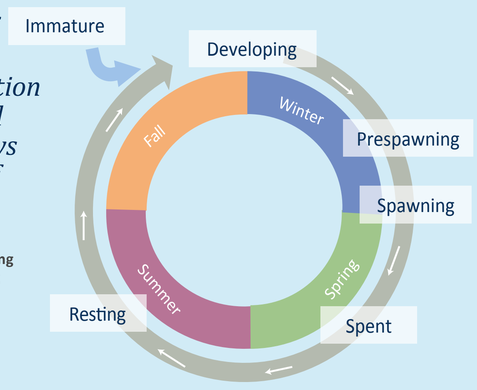


Figure 2. A conceptual model developed using observer-assessed maturity data suggesting a deterministic, single-batch spawning reproductive strategy for Pacific cod.

Observer-assessed maturity data collected aboard commercial fishing vessels provides knowledge of spawning locations across extensive spatial scales in the Bering Sea and Aleutian Islands...

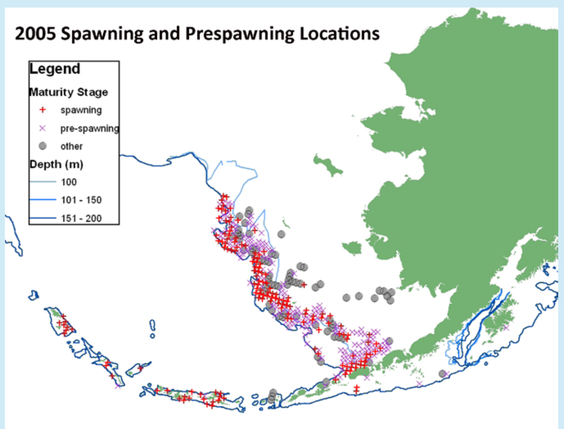


Figure 3. Distribution of prespawning and spawning stages of female Pacific cod from observer-assessed maturity data in 2005 from January-April. Spawning was indicated where observers identified spawning stage fish shown as red x. Prespawning is indicated where prespawning were observed in the absence of spawning stage fish and shown as pink crosses. The locations of observed stages other than spawning and prespawning are indicated with gray circles.

Observer-assessed maturity data collected over extensive temporal range are used to determine spawning phenology in the Bering Sea and Aleutian Islands...

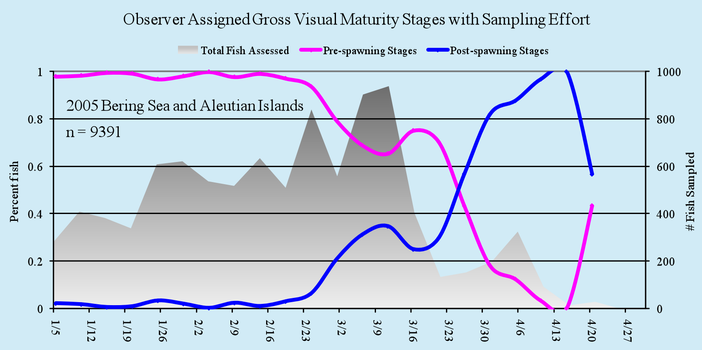


Figure 4. Spawning phenology charts for the Bering Sea and Aleutian Islands for 2005 shows the timing and duration of the Pacific cod spawning season. The left y-axis is relevant to the chart lines and represents the percent spawning stage. The right-hand y-axis is relevant to the grey shaded areas and represents observer sampling effort over time. Spawning began in early March, by the third week of March 50% of the sampled cod were spent, and the spawning season was completed by the first week in April.

Observer assessment of morphometric data such as length, age, and weight obtained from individual fish allows the comparisons of these measurements with maturity data for important spawning biomass calculations ...

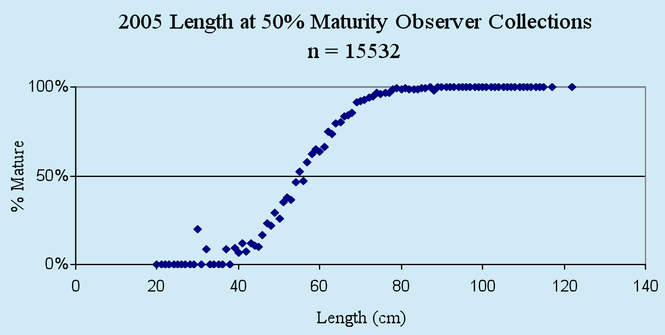


Figure 5. Maturity data assessed by observer aboard fishing vessels in the Bering Sea and Aleutian Islands in 2005 showed 50% of the cod sampled reached maturity at 56 cm.

The timing and location of spawning events can be compared to capture locations of early life stages and environmental data such as current and temperature patterns to analyze larval dispersal patterns...

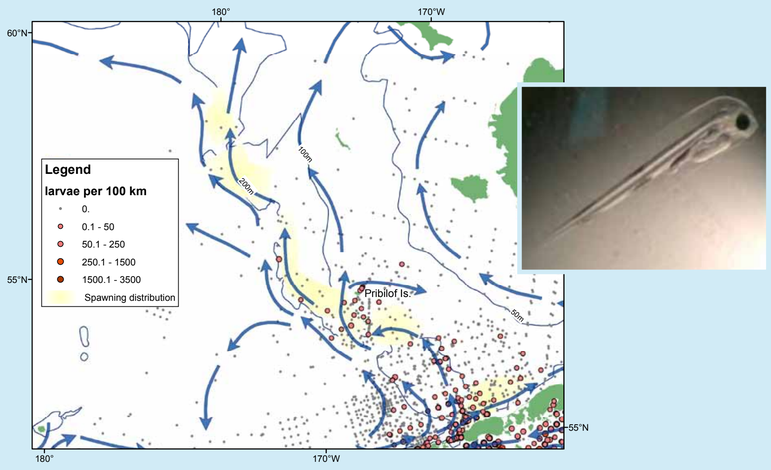


Figure 6. Spatial distribution of spawning locations (yellow shapes) and the range of age-0 Pacific cod (red circles) in larval sampling tows (circles) from BASIS cruises along with the generalized current structure in the SE Bering Sea provide knowledge of larval dispersal patterns.

Knowledge of fishery exploitation patterns particularly those targeting spawning aggregations are important to fishery managers...

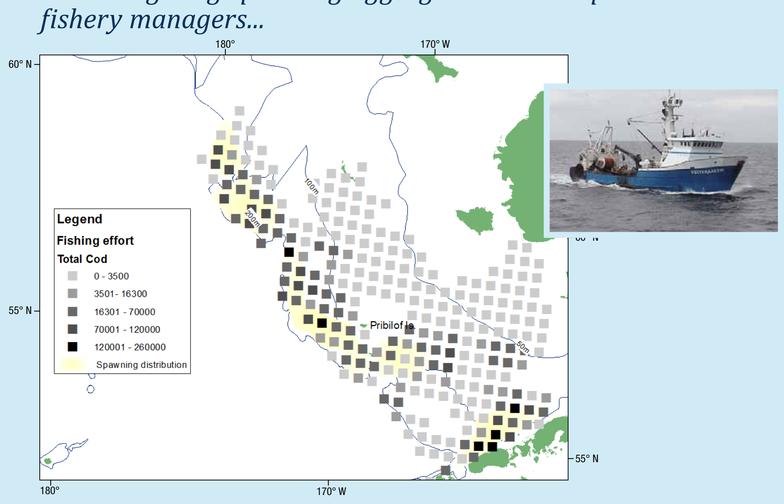


Figure 7. Map showing spawning locations in yellow shaded areas and fishing effort (increasing with darker color blocks) indicated an higher fishing exploitation in these areas during the spawning season (Jan-March).

Knowledge of the location and phenology of spawning fish allows researchers to analyze interactions between fish species, and their predators. Predators often focus on dense spawning aggregations to capture their prey most efficiently.

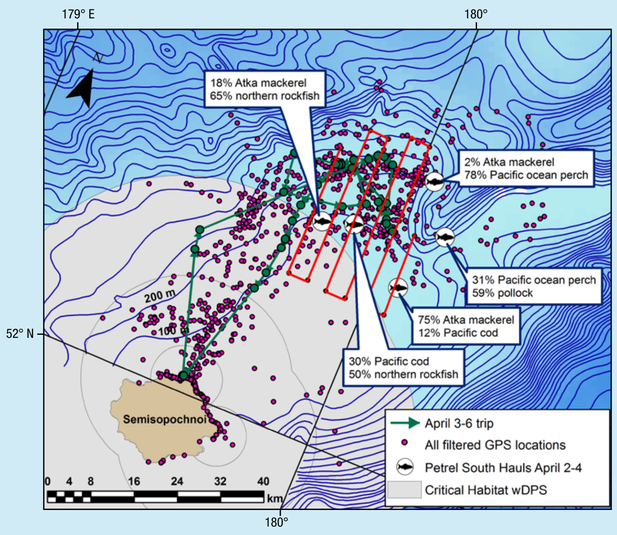


Figure 8. Pacific cod is both a top predator in the ecosystem and an important prey species for sea lions. Current studies at the AFSC link dive patterns, scat analysis, and spawning fish distributions to evaluate feeding patters of sea lions (Lander 2013)

The recommendations and general content presented in this poster do not necessarily represent the views or position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

Fadely, B.S., T. Gelatt, M.E. Lander, M. Haulena, L.D. Rea, J. Vollenweider, S. McDermott, M.J. Rehberg, and K. Beckmen. 2013. Remotely-delivered hemical immobilization of adult female Steller sea lions (*Eumetopias jubatus*) and post-handling foraging behaviors. Presented at the Alaska Marine Science Symposium, Anchorage, Alaska.