Introduction

In the recent past the eastern Bering Sea has alternated between periods of warm (2001-2005) and cold (2007-2015) conditions during the spring. Warm conditions had reduced sea ice cover, westward currents, and weak currents. Cold conditions were characterized by significant sea ice cover, winds from the north, and westward currents. Biological differences included changes in zooplankton community composition and abundance (Stabeno et al. 2012).

Flathead Sole Hippoglossoides elassodon is a Pleuronectidae that inhabit the continental shelf waters of the North Pacific Ocean from the northwest coast of North America to the Sea of Okhotsk in Asia. They are also abundant on the continental shelf of the eastern Bering Sea and spawn pelagic eggs there during the spring. Bottom water temperature can influence the spatial distribution of adult Flathead Sole, and thus affect where spawning occurs.

Methods

Egg abundance (number/10 m²) was determined from ichthyoplankton surveys conducted during warm (2002, 2003 and 2005) and cold (2007 - 2015) conditions (sampling methodology is described in Matarese et al. 2003). Eggs were collected during May in the southeast Bering Sea from the same station locations among years (Fig. 2 and 3). Water column temperature was measured at each station using a CTD.

GENERAL ADITIVE MODELS (GAM)

Variable-coefficient general additive models were used to account for temperature effect on egg abundance varying with location (latitude and longitude). Covariates initially tested were spawning in the Southeast Bering Sea among years (Fig. 2 and 3). Water column temperature was measured at each station using a CTD.

RESULTS

Near bottom water temperatures were almost homogenous during warm conditions, ranging between 3° and 5°C (Fig. 4). During cold conditions near bottom temperatures varied greatly, from below 0°C in the northeast to nearly 4°C in the southwest (Fig. 5).

MODELED EGG ABUNDANCE

Both the binomial and egg abundance models had spawning stock biomass, day of year, near bottom temperature, and latitude and longitude as covariates. The binomial model explained 44% of the deviance, and egg catch model explained 67%.

Eggs were more abundant and were present throughout the continental shelf during warm conditions indicating that spawning most likely was occurring there (Figs. 6 and 7). The transport of eggs from the Gulf of Alaska through Unimak Pass may be greater during the warm conditions as indicated by the relatively large area of high probability of egg presence and higher abundance through the pass and into the Bering Sea (Figs. 6, 7, and 8). Area of highest egg abundance contracted and shifted to the southwest during cold conditions, possibly indicating that spawning Flathead Sole were avoiding temperatures less than 2°C that were occurring in the northeast (Figs. 7 and 9). Delayed spawning due to cold conditions could have influenced egg abundance and distribution but it could not be investigated due to lack of surveys later in the spring.

Conclusion

Flathead Sole exhibit some degree of plasticity in spawning distribution related to springtime water temperature. We documented changes of both location and number of eggs spawned, and this could have potential consequences on early-life survival and recruitment of this species by affecting larval drift toward nursery areas, and spatial overlap with predators and prey.

REFERENCES


The objective of this study was to determine how warm and cold conditions affected the distribution and abundance of Flathead Sole eggs spawned in May in the southeast Bering Sea (Fig. 1).