Northeast Consortium Cooperative Research

PULSE:
A Cooperative Partnership for Coastal Ocean Ecosystem Monitoring in the Gulf of Maine

Annual Report
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Award number

Period of performance
January 1, 2007- December 30, 2008

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Project objectives and scientific hypotheses
There have been no changes to the project's objectives, goals and rationale, which were provided in the project proposal as follows:

- Expand an effective and sustainable cooperative partnership for monitoring of key hydrographic, zooplankton and ichthyoplankton variables at 5 stations in Ipswich and Massachusetts Bay.
- Create regional capacity within the commercial fishing fleet to undertake current and future cooperative research. Equip and train commercial fishermen to work independently to undertake the proposed sample collection protocols.
- Provide high quality data products documenting time series of zooplankton and ichthyoplankton for end users. A critical part of the data collection is the record of abundance of *Calanus finmarchicus* at the Jeffreys Ledge station as well as at other stations representing the Ipswich and Massachusetts Bays.
- Consult with fishermen to groundtruth findings based on their empirical knowledge of seasonal fish distribution and abundance in the western Gulf.
- Participate in workshops and information exchange sessions with fishermen and end users. These time series and the physical biological models that will use the data represent new information and approaches to ecosystem based management that need to be presented, discussed and evaluated by the regional fishing and management communities.
- Use the data and time series in physical biological model studies and in combination with other research surveys in Ipswich and Massachusetts Bays to test several hypotheses about interactions between circulation, plankton production cycles and feeding and reproduction of fish in the western Gulf of Maine:
    a) The Jeffreys Ledge station is representative of abundance of *C. finmarchicus* in the deep Scantum Basin, which is also a primary source of *Calanus* for Massachusetts Bay;
    b) Aggregations of adult herring that occur in late summer at the base of Jeffreys Ledge and just south of Jeffreys Basin represent the response of herring to large concentrations of lipid-rich, late stage *Calanus* that concentrate at the head of Jeffreys Basin and overflow onto the ledges;

c) The lower abundance of *Calanus* on Jeffreys Ledge is related to basin scale environmental changes in circulation and temperature, and not to increased predation by herring, mackerel and other planktivores;
d) Climate change is an important determinant of recruitment success of cod and other species in the Gulf of Maine through its effects on plankton production cycles and transport of larvae to nursery areas;
e) Due to the coastal circulation, the western Gulf of Maine cod spawning areas (off Casco and Saco Bays, Ipswich Bay and in Mass Bay) are strongly interconnected, although the extent of connection and contributions of each spawning area to inshore nursery areas depends on the climate forcing.

- Coordinate results from this project with other MFP, university and government research projects studying juvenile habitat and nursery areas,

Methods and work plan

There have been no changes in the experimental design or approach that was outlined in the project proposal. Three stations have been sampled semimonthly in Ipswich Bay by New Hampshire area fishermen and two stations at the entrance to Massachusetts Bay by fishermen from the Massachusetts Fishermen's Partnership (Figure 1).

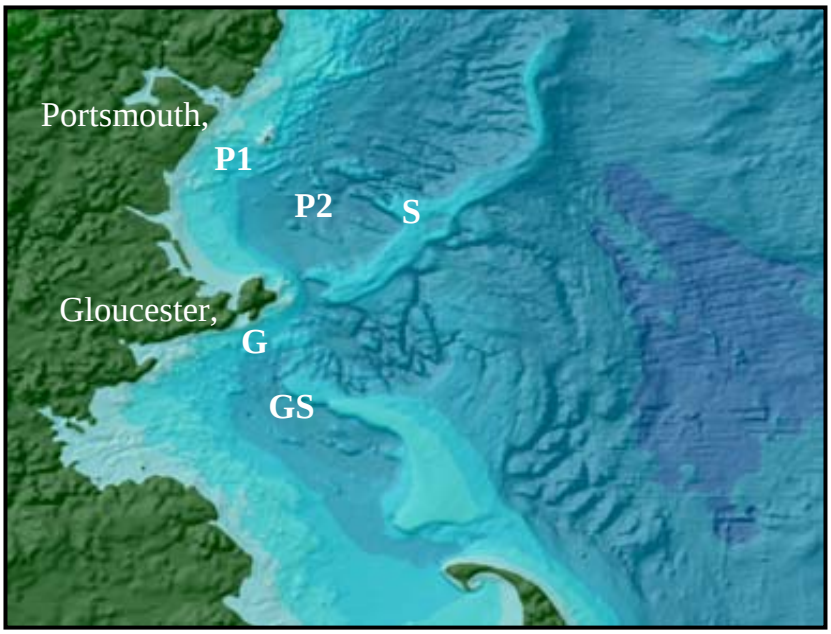

Figure 1: Location of fixed stations sampled twice monthly starting in Jan. 2007 and continuing through Dec. 2008.

Work completed during the performance period

The sampling has been completed as planned (Table 1). Station visits were not always spaced evenly every two weeks, due to weather and equipment limitations. Nevertheless, the samples represent two complete annual cycles at each study area.

Table 1. Number of visits to stations each year in each area.

Year	Ipswich Bay (NH)	Massachusetts Bay (MA)
2007	23	24
2008	24	27

Analysis of samples collected in 2008 is ongoing and will be completed by the end of June, 2009.

Results to date

The two years of sampling add to the 3 year time series collected by the previous PULSE project supported by the Northeast Consortium in 2003-2005. Samples from 2008 are still being analyzed in the laboratory. The results to date show seasonal and interannual variation in the species composition of zooplankton, for example the time series for the Jeffreys Ledge station (Station S). The zooplankton are dominated by a relative small number of species of planktonic copepods, of which *Calanus finmarchicus* is seasonally prominent in spring and early summer, then diminished in fall and winter to be succeeded by smaller copepod species such as *Pseudocalanus* spp. and *Centropages typicus*. A small cyclopoid copepod, *Oithona atlantica*, has recently become more prominent on Jeffreys Ledge throughout the year. These seasonal and interannual changes are hypothesized to impact the feeding, growth and distribution of pelagic fish, such as herring and sand lance, that feed on zooplankton on Jeffreys Ledge, with subsequent impacts manifested higher up the food web.

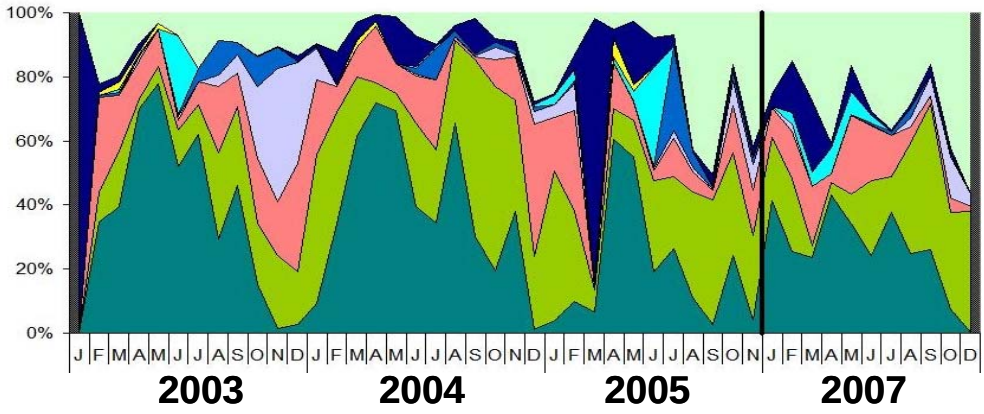

Figure 2. Zooplankton species composition collected with a 200µm mesh ring net at a time series station on Jeffreys Ledge, 1003-2007 (no data for 2006). The three most dominant species groups*: Calanus finmarchicus* (dark green), *Oithona similis* (Olive), *Pseudocalanus* species (orange), *Centropages typicus* (violet). *Oithona atlantica* (light green) has increased in relative abundance recently.

For example, the data show interannual variability in abundance of *Calanus finmarchicus* among years on Jeffreys Ledge (Fig. 3) . *Calanus* abundance was highest in

spring and summer of 2003 and lowest in 2005. The highest CV abundances in late summer, 2003, represent concentrations of 1-10 *Calanus* per liter, depending upon whether they are uniformly distributed throughout the water column (60 m) or in a layer 10 m thick. These concentrations are sufficient to attract foraging herring schools and northern right whales, which feed primarily on *Calanus*. Notable is the decrease in magnitude and extent of the window of availability of the lipid and energy-rich stage CV, the preferred prey for northern right whales, herring and other planktivores, in summer and early fall. The cause of this variation is the subject of active research, and may be related to the high river discharge and early summer storm activity in 2004-2005.

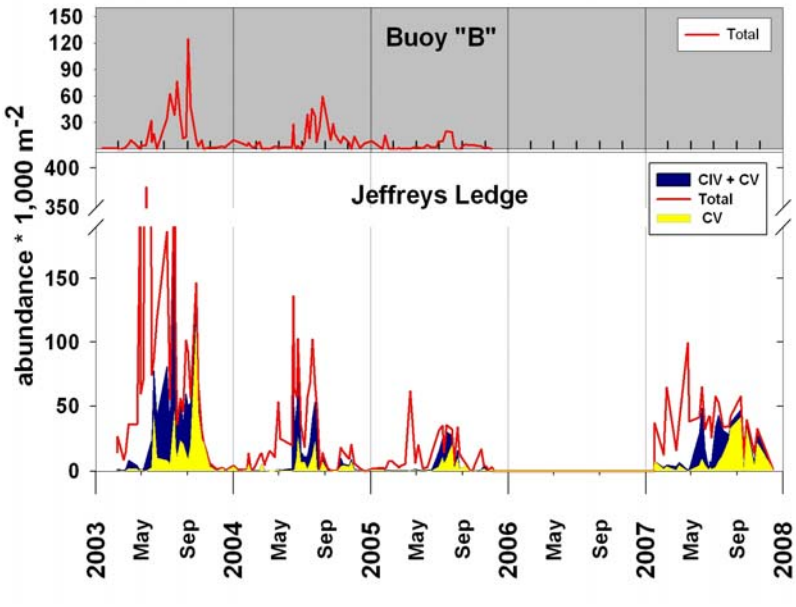

Figure 3. Abundance of the planktonic copepod, *Calanus finmarchicus*, at the Jeffreys Ledge station (2003-2007: no data in 2006) and at a more nearshore station located at GoMOOS Buoy "B" (2003-2005: no data 2006-2007). Red line: total abundance, including nauplius stages. Blue: abundance of Stage CIV and CV. Yellow: abundance of stage CV only, showing interannual variation in window of availability of energy rich forage on Jeffreys Ledge.

The results from the bongo net tows taken at each station and sampling date will also reveal seasonal patterns and diversity of the larval stages of the local western Gulf of Maine fish community. Samples from 2008 are still being analyzed. The 2007 results show that about 15 fish species are captured in the plankton surveys. The data will provide a record of ichthyoplankton that can be used to understand change in the western Gulf of Maine fish community over time.

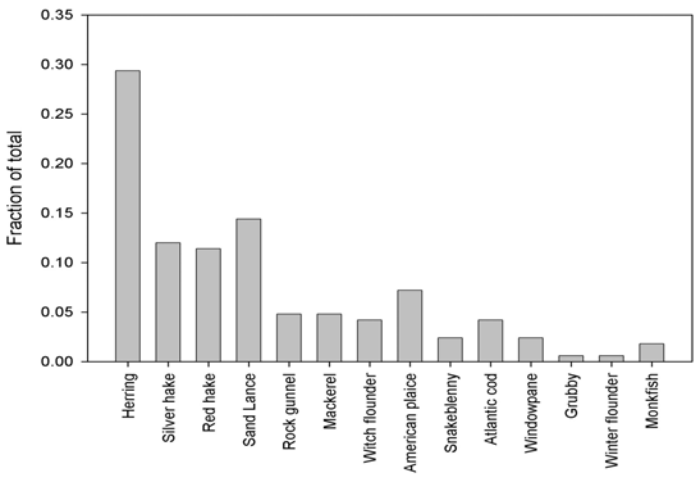

Figure 4. Annual composite of ichthyoplankton community in 2007 in Ipswich Bay, from vertically integrated bongo net samples taken biweekly throughout the year. Y axis represents fraction of total number of fish larvae captured (N>1000).

Future work

Over the next 6 months, we will complete analysis of the 2008 samples and prepare two manuscripts describing the work for publication in scientific journals. The results will be presented to participating New Hampshire and Massachusetts fishermen in a workshop marking the close of the project. We will seek opportunities to present the results at future meetings connecting with both the fishing (e.g. Maine Fisherman's Forum, NEFMC) and scientific communities.

Impacts and applications

This is a successful project that received enthusiastic and responsible participation from the fishing industry. All fishermen involved have been very helpful and receptive to the idea of this cooperative monitoring project being available for the long-term. The project has been well supported by the industry as a means of supplemental income during the seasons of large area closures and has been well supported during the fishing season as well. Many improvements have been made to make the data collection procedures efficient, data analysis of good consistent quality and data widely available

This project will provide baseline information on seasonal patterns of zooplankton and ichthyoplankton abundance and biodiversity in the nearshore and coastal waters of the western Gulf of Maine. The nearshore waters serve as larval and juvenile fish nursery habitat and provide forage for juveniles as well as pelagic fish and diadromous fish adults near river systems where they have spawned. Coastal waters may also serve as zooplankton forage habitat for large right whales, in which case the whales run the risk of injury or mortality due to heavy deployment of fixed and trap/pot fishing gear. Yet, despite this importance, we know relatively little about the spatial and temporal pattern and dynamics of zooplankton that constitute forage and of ichthyoplankton that represent the pelagic phase of the fish community in nearshore and coastal Maine waters.

The information products from this project will contribute to at least three specific living resource problems for which there are potential management responses. First, the data on seasonal abundance and life cycle patterns of planktonic copepods will be used in the development of a coupled physical-biological model that will assess and predict the abundance and distribution of right whale prey in nearshore waters for purposes of evaluating areas of high risk of entanglement and supporting appropriate risk mitigation responses. Second, the coupled physical biological models of zooplankton abundance and distribution will provide information on climate change impacts on prey for planktonic larval fish stages, including western Gulf of Maine cod, as well as forage for herring, sand lance and mackerel. These models will provide information support for understanding variability in recruitment and coastal abundance and distribution of forage fish species. Finally, the data will provide a time series of ichthyoplankton community structure for the western Gulf of Maine. This analysis provides information support for development of area contingency plans and emergency responses to containment of oil spills or other human-source ecological and environmental impacts.