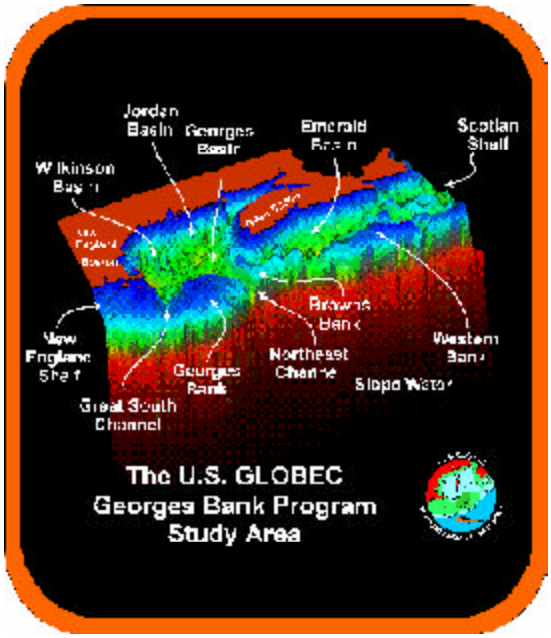
Center for Sponsored Coastal Ocean Research

Project News Update

Science for Solutions **Winter 2003**

Oceanography Journal Focuses on U.S. GLOBEC Research

U.S. GLOBEC (GLOBal Ocean ECosystems Dynamics), funded by the Center for Sponsored Coastal Ocean Research/Coastal Ocean Program (CSCOR/COP), is at mid-life. With an objective of highlighting emerging findings and accomplishments to date and to point to future research direction, Oceanography (Vol. 15, No.2/2002) summarizes the most current U.S. GLOBEC research. GLOBEC research asks the questions: how will climate change and variability translate into changes in the structure and dynamics of marine ecosystems and in fishery production, and how will the interaction of human activities and climate change affect marine ecosystems? Understanding this interaction is essential for the development of sustainable fisheries management practices. Field studies are completed in Georges Bank with synthesis effort now being considered, while field studies are still underway in the Northeast Pacific.



Source:
Daniel R. Lynch - Dartmouth College

Research Highlights Georges Bank

Georges Bank supports a productive, though heavily stressed, fishery as well as the hatching area of several commercially important fish species. In order achieve sustainability, fisheries managers must understand the potential effects of changing climate on the Bank's ecosystem. The target species include the copepods *Calanus finmarchicus* and *Psuedocalanus*, and larval populations of haddock and cod. They are selected for their ecological significance, their sensitivity to climate change, and their economic importance.

Interannual variability in water properties

Observations of water properties made during the GLOBEC field program reveal large variability. Georges Bank has two major inflows of water. The first inflow is surface water from the Scotian Shelf, entering around

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Contact Center for Sponsored Coastal Ocean Research

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From the Director's Desk....

To the Friends and Supporters of the Coastal Ocean Program,

As you may already know, I am leaving the Center for Sponsored Coastal Ocean Research to become the Director of the NOS Center for Coastal Habitat and Fisheries Research in Beaufort North Carolina. Twelve years ago, I came to the office under it's former name, the Coastal Ocean Program (COP), as a program manager for fisheries oceanography. At that time, the COP consisted of a few million dollars. In the intervening years while retaining a small staff, the Program underwent many changes: growing to a funding level of $35 million, initiating a dedicated granting program, initiating major new program responsibilities like ECOHAB and GLOBEC, and fostering interagency participation in projects such that forty percent of the program is jointly managed with NSF. I, also, was afforded the opportunity to grow with the program.

CSCOR's vision is the highest quality science delivered in time for important policy decisions

While there is an open announcement for the new Director, the Program has never slowed. Darrell McElhaney has returned to CSCOR as the Acting Director to provide interim leadership and a smooth transition for the new Director. Darrell worked for the former COP for a number of years and is a highly skilled leader and strong program advocate. In addition, Quay Dortch has joined the office this week as the new program manager for Harmful Algal Bloom research which will allow Sue Banahan more time to focus on her normal responsibilities. I will miss the comradery of the program, and I'd like you to know how much I respect the integrity and capabilities of the program staff.

My new home, the Center for Coastal Fisheries and Habitat Research, shares an island with Duke University Marine Laboratory where I first worked in marine science. My wife and I are also both natives of Beaufort so the move to North Carolina will be a much anticipated homecoming. Please keep in touch.

David Johnson

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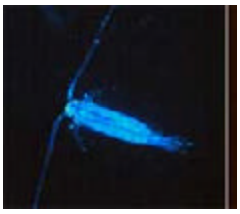
Cape Sable. This water is cold, of low salinity, originates in Browns Bank, and carries plankton. The other major inflow is the more saline, deeper slope water entering through the Northeast Channel. GLOBEC measurements have shown a fundamental change in the quality of these inflows but not the quantity. Measurements in the late 1970's indicate that the total inflow into the Bank was about two parts Slope Water and one part Scotian Shelf Water. The recent GLOBEC measurements indicate the same total transport, but with two parts Scotian Shelf and one part Slope Water. This reversal in proportion of the two inflows causes the general decrease in salinity observed in the Bank since the 1970's. This decadal change in water quality is perhaps due to the North Atlantic Oscillation. The Slope Water entering through Northeast Channel comes from two sources: a warmer deeper source and colder water from a Labrador Sea influence. During 1998, the slope water became colder and fresher, indicating more of a Labrador Sea influence possibly from a westward extension of Labrador Slope Water in 1997. The Labrador Slope Water is believed to be a response to a sharp drop in the North Atlantic Oscillation (NAO) during the water of 1996.



Calanus finmarchicus

Nutrient Dynamics

The deeper and warmer slope water, a major source of nutrients to Georges Bank entering through the Northeast Channel, varies year to year. The NAO appears to control the relative importance of Labrador Slope Water and Warm Slope Water that comprises the deep Northeast Channel influx. The current evidence suggests the Labrador Slope Water supports lower levels of new primary production, perhaps because of lower N: Si ratios, lower nutrient concentration, and lower production of non-diatom species (an important copepod food). In years when Warm Slope Water dominates the Northeast Channel, there are generally higher nutrient levels and higher *Calanus* abundance.

Larval Fish and Zooplankton Population Dynamics

Comparison of laboratory studies with field studies suggests that with increasing temperature, the cod and haddock larvae on Georges Bank are becoming more and more food limited, as their increasing metabolic requirements cannot be met by the available food. *Calanus* and *Pseudocalanus* exhibit markedly different patterns of mortality on Georges Bank For *C. finmarchicus*, which releases its eggs directly into the water, the highest mortality rates occur in the egg and very early first larval stage. For *Pseudocalanus*, whose female carry their eggs until hatching, the mortality rates are uniform. The results show that while the average egg production rate of *C. finmarchicus* is 19 times that of *Pseudocalanus*, there is a compensating difference in mortality such that the fitness of the two life histories is about equal on Georges Bank

Synthesis

In order to bring about data seta integration, GLOBEC Georges Bank synthesis is the next order of business. By reaching a more complete understanding of the physical and biological pro-

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Protecting Reef Fish Pays-off

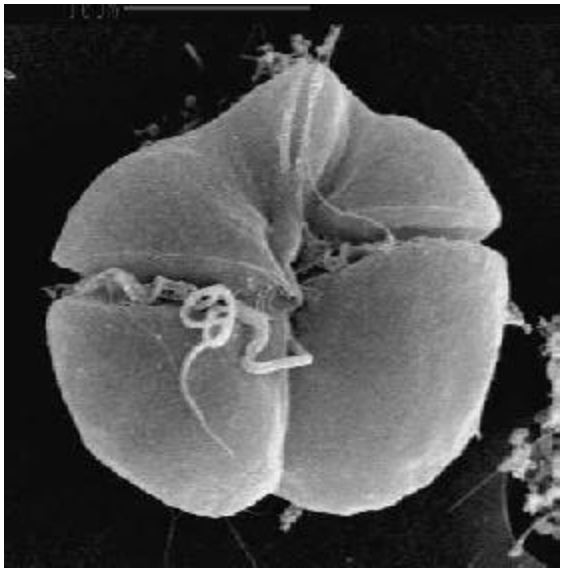
Collection of Hawaii's tropical reef fish for aquariums is causing significant declines in fish populations. These declines are causing conflicts between tropical reef fish collectors, scuba diving tour operators, and Hawaiian native subsistence fishers. Local residents and dive operators claim that coral reef areas that once teemed with colorful fish are being "fished out" by collectors. A recent survey found that in areas targeted by aquarium collectors, populations of eight of the most popular species had fallen by anywhere from 38 to 57 percent. Freshwater tropical fish are cultivated in tanks but most ornamental saltwater fish are caught in tropical reefs. Divers often herd fish into large nets and on a good day, an average diver can catch from 100 to 150 yellow tang. Hawaii's aquarium collecting industry has been generally unregulated, but slowly, Hawaii is restricting the collecting of aquirium fish from certain areas. Hawaii is a major supplier of reef fish for the national and international aquarium market. Collecting reef fish in Hawaii for aquarium use has become big business, going from 90,000 collected fish in 1973 to nearly 423,000 collected fish in 1995. And the catch is growing. But reef protection is growing too. Sponsored by CSCOR/COP, researchers from the West Hawaii Aquarium Project are trying to show that 'no-take' areas will help to increase the populations of these beautiful fish. The research documents significant population declines in areas where fish are collected for the aquarium trade. According to Michael Hamnett, program director of the Hawaii Coral Reef Initiative Research Program, research shows that if resource managers designate 'no-take' reef areas, fish populations will rebound. The West Hawaii Aquarium Project, part of the Hawaii Coral Reef Initiative Research Program, began three years ago to replenish the dwindling reef fish populations. In 2000, the project created nine protection zones that banned collection of reef fish along 35 percent of the coastline of West Hawaii . Twenty-three study sites were set up in protected and unprotected areas, allowing scientists to compare data from before and after the replenishment zones were formed. There is wide interest in 'no-take' areas because they benefit fishery populations, protect marine ecosystems and enhance human activities such as tourism. However, few experimental studies have focused on 'no-take' marine reserves because they require rigorous monitoring. The West Hawaii Aquarium Project shows the efficacy of 'no take' reef areas. For more information, contact the program manager at michael.dowgiallo@noaa.gov.

The heavily collected Yellow Tang (lauipala), which makes up more than half of all aquarium fish caught in Hawaiian waters, is no longer decreasing in the protected areas. *However, there continues to be a decline in open, non-protected areas.*

Can a Virus Minimize Red Tides?

Red colored blooms of the photosynthetic and toxic dinoflagellate *Karenia brevis* are a perennial economic and public health problem on Florida's West Coast. A goal of ECOHAB (Ecology and Oceanography of Harmful Algae Blooms) research is discovering what environmental conditions cause blooms to start and what conditions cause them to stop. Some *K. brevis* blooms have been observed undergoing sudden dissipation, suggesting that a catastrophic event has occurred within the bloom. ECOHAB researcher, Dr John H. Paul of the University of South Florida, hypothesized that lytic viruses play a role in such bloom termination by infection and lysis. His second hypothesis states that changing environmental conditions cause induction of viruses and bloom termination. Dr Paul recently completed a three-year study to find natural ways to influence and regulate bloom termination.

To test his first hypothesis, Dr. Paul participated in an ECOHAB research cruise where he sampled surface waters during a *K. brevis* bloom. He took samples of *K. brevis* cells with accompanying *in-situ* microbial community from two cruise locations. Samples were prefiltered and concentrated to a retentate volume contanting viral extracts. Dr. Paul then added some of the retentate volume to an experimental culture of *K. brevis* while maintaining a control with no retentate added. The number of *K. brevis* cells in the experimental culture increased over nine days and then suddenly decreased over the next two days. Microscopic comparisons of the control culture with the culture containing the viral extract showed very few of virus-like particles (VLP) in the control compared with a tremendous abundance of VLP in the second culture. These results suggest that viruses are important in some aspect of the lytic process causing the demise of *K. brevis*.



The Red Tide Algae Karenia brevis

Dr. Paul additionally sampled surface water from a *K. brevis* bloom off of a Sarasota, Florida pier. Two viral agents were isolated which caused rapid lysis of *K. brevis* cultures indicating a catastrophic event occurred within the blooms.

Testing his second hypothesis, Dr. Paul tried to determine if *K. brevis* blooms terminate because of induction of latent virus by changing environmental conditions. Cultures of *K. brevis* were investigated for the presence of *in-situ* organisms carrying a latent virus within its cells. This presence is detected by viral induction using common procedures for induction such as mytomycin C or UV exposure. To reduce the role of bacteria, the samples were filtered. However, the .2-micrometer filter appeared to leave some bacteria in the culture. Both treatments

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Virus Continued

resulted in increased viral production over controls and a concomitant lysis of *K. brevis* cells. Although these results are indicative of viral induction, it is not known if that was the result of latent viruses in *K. brevis* or in bacterial contaminants present in the culture. Collectively, these results suggest that lytic agents are common in waters supporting red tide blooms and such agents can cause rapid bloom termination. Viruses were observed in all *K. brevis* cultures undergoing lysis from applied lytic agents or exposure to UV or mitomycin C. However, because of the lack of an anexic culture of *K. brevis*, the cultures used in this study contained their own "microbial ecology". Therefore, it is not known if any of these viruses are infective for *K. brevis*. This underscores the need for anexic cultures of *K brevis*. This lack of anexic cultures is a reoccurring problem in ECOHAB research. Isolating anexic cultures is a priority of ECOHAB. For more information, contace the program manager at susan.banahan@noaa.gov.

Early Warning of Deadly Red Tides in Texas Possible

CSCOR/COP is hoping to help mitigate red tides in Texas with new MERHAB (Monitoring and Event Response for Harmful Algal Blooms) research. Lisa Campbell, of Texas A & M, is leading the CSCOR/COP sponsored research team working to establish a buoy- based continuous monitoring system. This *in-situ* system will detect abundance of specific cell types enabling real-time early warning systems for HAB events to be established. The research will test the feasibility of combining a novel optical detection system called FlowCam with the existing Texas Automated Buoy system (TABS). Dr. Campbell will use FlowCam to photograph algae using a computer-controlled video camera linked to a microscope and flow cytometer system. This system draws a water sample through to the microscope and stores the image on a computer. With this successful monitoring and retrieval system, Dr Campbell will be able to ascertain if increases in cell abundance at about 20 km offshore can be detected and correlated with subsequent blooms on the shores of the Gulf and in estuaries. Dr Campbell hopes that once she has perfected the techniques of imaging *K. brevis*, the research will to provide frequent real-time images of plankton in Texas coastal waters for early warning of HABS along the Texas coast. With the capacity of continuous measurements of cell abundance as well as temperature, salinity, currents, nutrient and oxygen concentrations, it will be possible to determine the changes in phytoplankton community structure and to quantify *K. brevis* and other potentially harmful species on a scale never before possible. Numerical ocean circulation models, run as part of TABS, will enable estimation of the trajectories of any HABS detected at buoy. Campbell's MERHAB work is an extension of her use of flow cytometry to study picophytoplankton, the ocean's smallest plants.

The ultimate goal of MERHAB is to transfer state-of-the-art HAB research products into management tools for pro-active detection of these frequent coastal events in local jurisdictions. The first Federal Register Notice for MERHAB was published in March 2002 and 24 principal investigators applied to receive approximately $ 3 million dollars. After a rigorous competitive peer review of the proposals, seven multi-year projects were funded. For more information about MERHAB contact the program manager: marc.suddleson@noaa.gov.

HEAD STARTING A CAREER

CSCOR/COP has a tradition of supporting academic and governmental research that employ undergraduate and graduate students as a backbone of the research team. In a typical CSCOR/COP research grant, students have the opportunity to conduct high quality research with dedicated scientists and learn new and exciting information about marine sciences. They can also develop skills in scientific literature review, project development, data processing and analysis, report writing and oral presentation. As a continuation of this tradition, the CAREER program was launched as a pilot initiative in 2000. The purpose of CAREER is to foster development of qualified professionals in the fields of coastal ocean science, management and policy. Proposals from Minority Serving Institutions (MSIs) or those that collaborate with MSIs, or serve minority students, were strongly encouraged. In addition, this new program augments existing NOAA programs in research and education and hopes to increase the representation of minorities and under-represented students in coastal ocean science and resource management. Proposals selected for funding were chosen by competitive peer review. CAREER projects have varying focus points from helping develop techniques and skills in professional networking, job hunting, and proposal writing to establishing invited speakers series, mini-courses, workshops, or special sessions at invited meetings to establishing mentoring programs and internships with research institutes, management offices and non-governmental offices.

For the 2-year CAREER pilot project, the five proposals listed below were selected and are currently funded through mid 2003.

1. *Experiences for Minorities in Coastal Ocean Science* South Carolina Department of Natural Resources, Marine Resources Division, Charleston
2. *Coastal Resource Policy Seminars for Alaska Native Students*
University of Alaska, Fairbanks, Department of Alaska Native and Rural Development
3. *Visiting Distinguished Coastal Ocean Scientist Program*
University of Alaska, Fairbanks, Institute of Marine Science
4. *Enhancing Professional Development in Coastal Resources Management*
East Carolina University, Program in Coastal Resources Management, Greenville, North Carolina
5. *Professional Society Collaborations*
Whitman College, Biology Department, Walla Walla, Washington

For more information, contact John Wickham at john.wickham@noaa.gov

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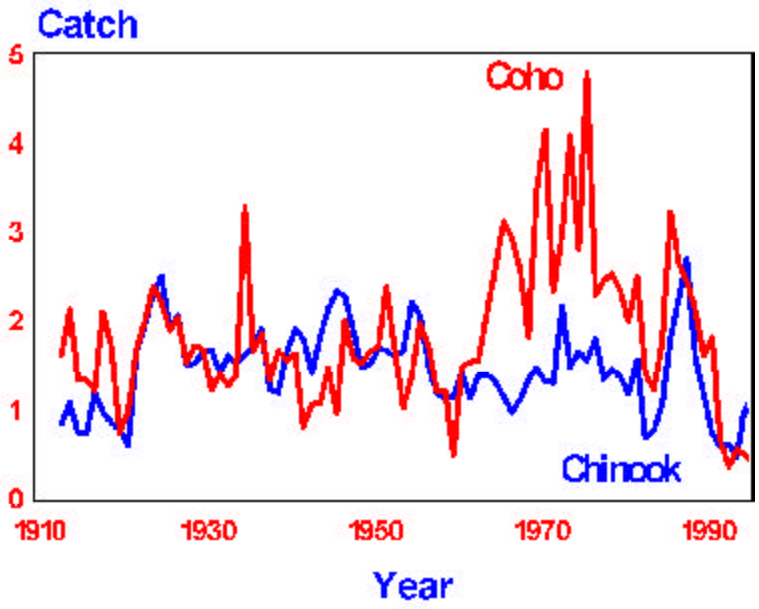
cesses controlling the populations of target species in the region, modelers can coordinate with the diverse users of Georges Bank to develop predictive and analytical tools for better management decisions. This all-important transition from research to application will focus on three activities: adaptation of biophysical models to operational problems; the development of ecosystem and environmental indices; and application of new sampling technologies to enhance monitoring programs.

Research Highlights Northeast Pacific

Recent indications that salmon and zooplankton vary on decadal scales with North Pacific basin-scale climate changes demand a closer look at this system. Researchers for GLOBEC Northeast Pacific seek to identify biophysical interactions that affect zooplankton and salmon populations. The Northeast Pacific Program includes separate studies of the California Current System (CCS) and the Coastal Gulf of Alaska (CGOA). Examination of several basin-scale environmental indices show that the periodicity in the catch of salmon and other fish is at least partially correlated with physical changes in large scale North Pacific climate. There are changes in climate regimes on decadal time scales that appear related to long-term variations in the intensity and position of the Aleutian Low and the Eastern North Pacific and the Siberian High. On shorter time scales, coastal sea levels and temperature anomalies co-vary with the El Nino/ Southern Oscillation (ENSO) events.



Historic Landings in Washington, Oregon, & California
Source: NE Pacific Program website

California Current System

The California Current, transporting southward fresh and cold water, forms near the latitude of Vancouver Island from the shelf break to 1000 km offshore. The strongest current is surface but radiates down 500 meters. In spring and summer, the North Pacific High and the Aleutian Low pressure systems determine the strength of southward winds creating offshore Ekman transport and upwelling. Different conditions dominate in winter creating the northward blowing wind and the Davidson current accompanied by downwelling. The study region of the CCS is from Crescent City to Newport,

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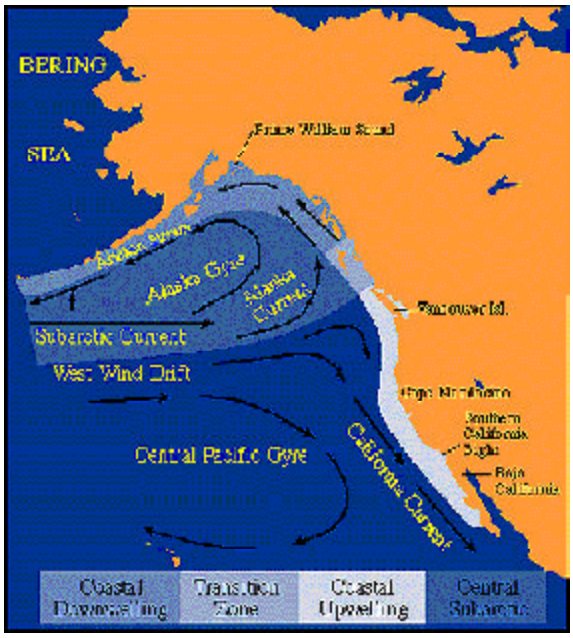
a 300 km region that includes the prominent Cape Blanco and Heceta Bank. Better understanding of how oceanic and climatic variability affect the fluctuations in marine resources will reduce the uncertainty so prevalent in fisheries management. Since salmon are anadromous, a major management question is whether anthropogenic effects on land or natural changes in ocean conditions are responsible for declining salmon populations. The California Current System (CCS) experienced a strong El Nino in 1997-98, and the subsequent La Nina. In 1998 the CCS changed from warm and low production to cool and highly productive, indicating a possible regime shift. There is a strong interaction between currents and shelf topography in determining species distribution, with more than half the coho and chinook salmon coming from the shallowest quarter of the trawl tows, with coho more offshore than chinook. Clear differences were observed in the condition, migration pattern and distribution of species north and south of Cape Blanco. The CCS responds within a day to upwelling and downwelling winds with upwelling conditions mostly confined to the shelf. During the study, a filament of upwelled water was swept more than 100 km offshore and north of Cape Blanco. Net samples from this filament were dominated by a coastal *Pseudocalanus* species. Thus, some of the shelf zooplankton are swept offshore by currents and can survive while others are rarely encountered. With field observations about half completed, we know that coastal ocean conditions and productivity strongly influence the growth and survival of juvenile salmon during their first summer at sea. Juvenile coho and chinook salmon were never found in offshore deep water (>200m).



Coastal Gulf of Alaska

The Coastal Gulf of Alaska supports a large commercial fishery with a considerable variation in harvest and recruitment success. Salmon abundance and climate change as measured by Pacific Decadal Oscillation (an integrated measure of SST) are strongly related. Zooplankton and other fish species abundance also vary in association with north Pacific basin scale climate. Accumulating field data and model runs suggest that the shelf is roughly organized into three distinct physical regimes delineated by salinity fronts whose strength and positions vary seasonally. The three regimes have distinct species assemblages with each having different biological habitats. However, these various shelf regimes have considerable mesoscale variability due to meanders in the boundary flows or the large anti-cyclonic eddies propagating along the continental shelf. As

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they propagate along the slope, the leading and trailing edges of the eddy induce upwelling and downwelling over the eddy center. These upwellings and downwellings are reflected in chlorophyll biomass, rates of primary productivity, and zooplankton biomass. Observations and modeling indicate that there might be preferred sites for on shelf transport of nutrients and zooplankton occurring east of the study area, which suggests a alongshore advection is important in influencing productivity.

Stratification begins when runoff enters the ocean and spreads offshore Since early spring water temperature is uniform, density variations depend on salinity differences. Factors affecting mixed layer development are those affecting vertical mixing and offshore flux of fresh water including percent of winter precipitation delivered as snow vs. ice, timing and rate of snowmelt, and wind strength. Due to short growing season, spring stratification may affect zooplankton. These zooplankton need to arrive from depths after winter hibernation at the proper time to take advantage of spring bloom so dependent on physical processes.

Modeling efforts

In order to fully assess the local impacts of larger scale climate variability, GLOBEC modelers are challenged to bridge the scale gap between the local regions and the global climate system. Many planktonic species grow from planktonic, to herbivorous larvae, to nekton. They must be modeled from being carried along with the flow, to consuming prey at higher tropic levels, able of directed movement and influenced by recent experience. Therefore a nested hierarchy of global/basin/regional/local physical circulation for ocean-atmosphere, food web models are needed embedded within and evolving in response to predicted physical environment and individual based models based on the relevant number of higher trophic level species.

Conclusion

Fisheries managers must make decisions about optimal levels of fishing intensity in order to maintain sustainable yield. In making these decisions, they must consider what factors influence marine natural resources, and how resource exploitation affects the entire ecosystem. Obviously, the state of the environment has direct implications for ecosystem productivity. Understanding persistent interannual and decadal environmental shifts are important in the development of fishery management plans. What is a sustainable level of exploitation under favorable environmental conditions can cause a population crash under environmental conditions causing low productivity. Therefore, fishery managers must consider the synergistic effect of exploitation and environmental variability when setting maximum fishery yields. The recent stark decline of cod on Georges Bank and the decades long waxing and waning harvest of Pacific salmon prove that climate variability must be part of fisheries management decisions. With half of the results now in, GLOBEC research is proving to be an important contributor to this understanding this synergy. For more information contact the program manager elizabeth.turner@noaa.gov.