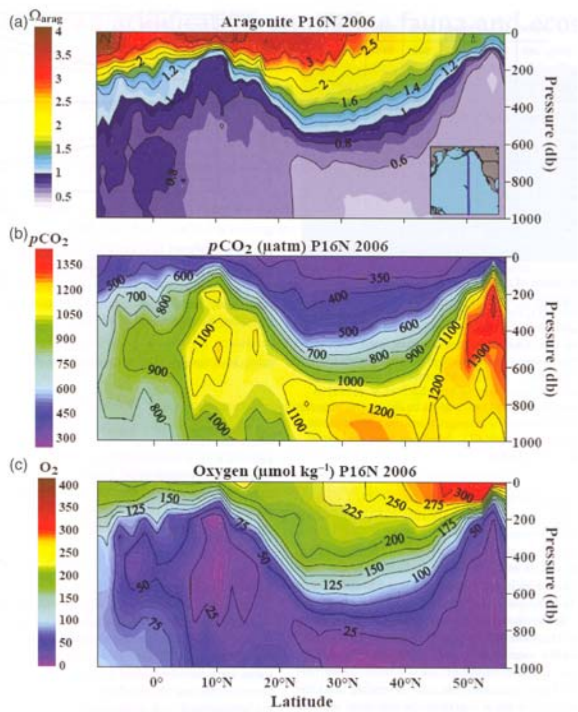
# GLOBEC RESEARCH HIGHLIGHTS 2008

*The aim of GLOBEC is to advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.*

*Since 2002 the GLOBEC IPO selects a number of research highlights from GLOBEC publications appearing in the literature over the last 12 months. The GLOBEC publication list can be interactively searched at [www.globec.org](http://www.globec.org). The list includes a total of over 3,100 publications (2,650 refereed).*

1. **Impacts of ocean acidification on marine fauna** (Fabri, V.J., B.A. Seibel, R.A. Feely and J.C. Orr. 2008. ICES Journal of Marine Science 65: 414-432).

Oceanic uptake of anthropogenic $CO_2$ is altering the seawater chemistry of the world's oceans with consequences for marine biota. Elevated partial pressure of $CO_2$ ($p$ $CO_2$) is causing the calcium carbonate saturation horizon to shoal in many regions, particularly in high latitudes and regions that intersect with pronounced hypoxic zones. The consequences of elevated $p$ $CO_2$ in marine organisms are yet difficult to predict, but ocean acidification and the synergistic impacts of other anthropogenic stressors provide great potential for widespread changes to marine ecosystems.

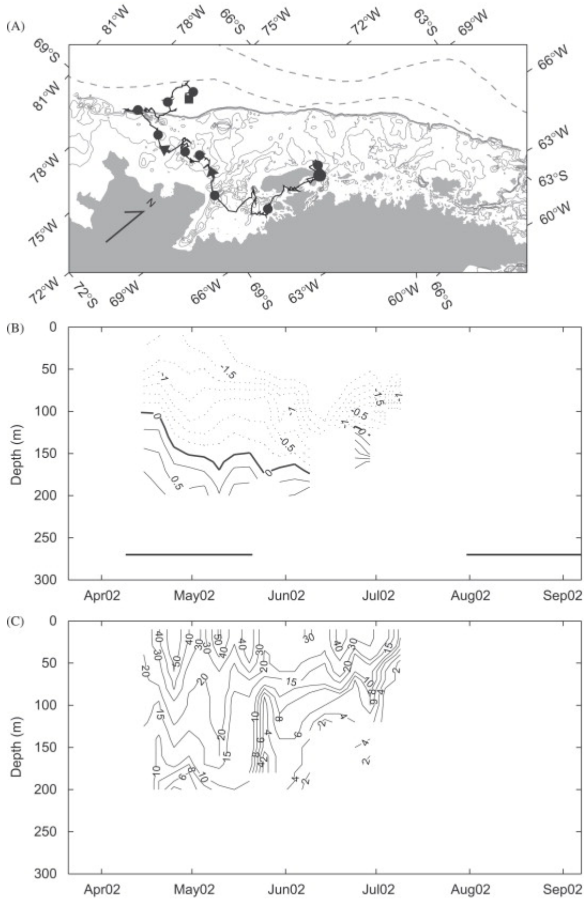



*Distribution of a) aragonite saturation, b) partial pressure of* $CO_2$ *seawater (p*$CO_2$*), and c) dissolved oxygen along the March 2006 P16N transect along 152°W in the North Pacific. In this region the upward migration of the aragonite saturation horizon from anthropogenic* $CO_2$ *uptake is currently 1-2 m.y*$^{-1}$*.*

2. **Upper ocean variability in west Antarctic Peninsula continental shelf waters as measured using instrumented seals** (Costa, D.P., J.M. Klinck, E.E. Hofmann, M.S. Dinniman and J.M. Burns. 2008. Deep Sea Research II 55: 323-337).

Temperature profile data for the west Antarctic Peninsula (WAP) continental shelf waters, collected from freely ranging instrumented seals (crabeater, *Lobodon carcinophagus* and leopard, *Hydrurga leptonyx*), were used to demonstrate that these platforms can be used to supplement traditional oceanographic sampling methods to investigate the physical properties of the upper water column. The seal-derived profiles were combined with temperature profiles obtained from ship-based CTD measurements and from a numerical circulation model developed for the WAP to describe changes in temperature structure, heat content, and heat flux in the upper ocean waters of the WAP continental shelf. The seal-derived data documented the fall-to-winter transition of the surface waters and the shelf-wide presence of modified Circumpolar Deep Water (CDW) below 150-200 m on the WAP continental shelf. The heat content of the upper 200 m calculated from the seal-derived temperature profiles ranged between 1000 and 1500 MJ $m^{-2}$; similar estimates were obtained from simulated temperature distributions.

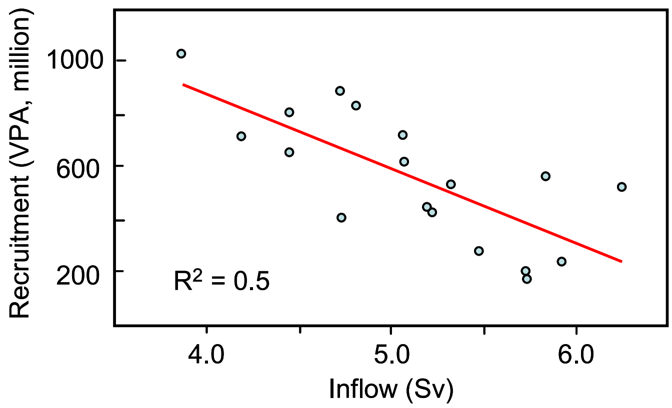
The seal-derived temperature time series provided the first observation of the fall-to-winter transition from Antarctic Surface Water to Winter Water for west Antarctic Peninsula continental shelf waters. The Winter Water layer formed in about 30-40 days from late April to early June. The observed deepening of the -1.5°C isotherm was similar to the simulated temperature distributions. This type of comparison suggests that seal-derived measurements can provide data that are useful for evaluation of the skill of a numerical circulation model.




*(A) Track followed by crabeater seal 1 after being instrumented in mid-April 2002. The start and end of the track are indicated by (●) and (■), respectively, smaller circles along the track indicate 10-day intervals and arrows indicate direction of travel. (B) Depth–time temperature distribution obtained from measurements made by crabeater seal 1. The 0°C isotherm is indicated by the heavy line; negative temperatures are indicated by dashed lines. The seal-derived temperatures were averaged into 5-day and 10 m intervals to obtain the temperature distribution. The horizontal lines indicate the times of the SO GLOBEC survey cruises in 2002. (C) Depth–time distribution of the seal dives that were used to construct the temperature distribution.*

3. **An ecosystem approach to predicting cod recruitment** (Svensen, E., M. Skogen, P. Budgell, G. Huse, J.E. Stiansen, B. Ådlandsvik, F. Vikebø, L. Asplin and S. Sundby 2007. Deep-Sea Research II 54: 2810-2821. In: Effects of climate variability on Sub-Arctic marine ecosystems: A GLOBEC Symposium.)

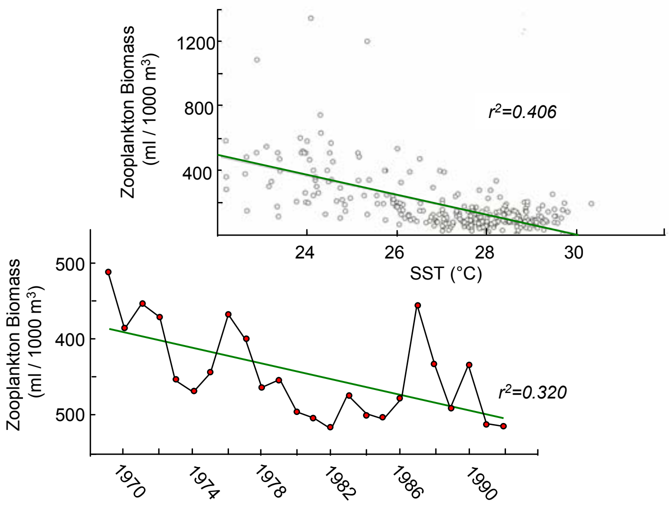
The Norwegian Ecological Model (NORWECOM) biophysical model system implemented with the ROMS ocean circulation model has been run to simulate conditions over the last 25 years for the North Atlantic. Modelled time series of water volume fluxes, primary production, and drift of cod larvae through their modelled ambient temperature fields have been analyzed in conjunction with VPA estimated time series of 3-year-old cod recruits in the Barents Sea Individual time series account for less than 50% of the recruitment variability; however, a combination of simulated flow of Atlantic water into the Barents Sea and local primary production accounts for 70% of the variability with a 3-year lead. The associated regression predicts increased recruitment between 2007 and 2008 from about 450-700 million individuals with a standard error of nearly 150 million.




*Mean fourth quarter modelled total inflow of water through the Bear Island–Fugloya section at the western entrance to the Barents Sea (in Sverdrups) versus cod recruitment as measured by numbers of 3-year olds 3 years later.*

4. **Impact of climate change on long-term zooplankton biomass in the upwelling region of the Gulf of Guinea.** (Wiafe, G., H.B. Yaqub, M.A. Mensah and C.L. Frid 2008. ICES Journal of Marine Science 65: 318-324)

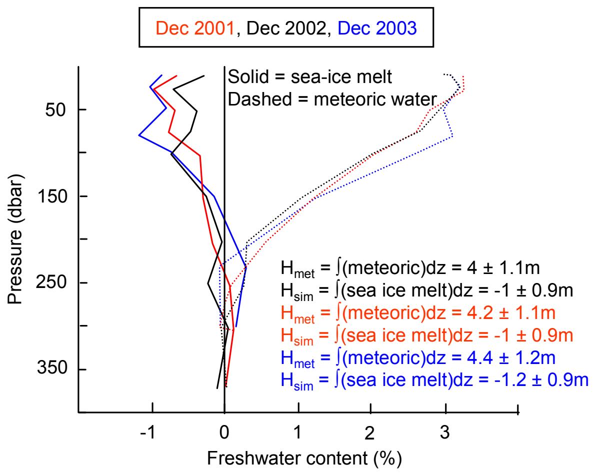
Long-term changes in coastal zooplankton in the upwelling region of the Gulf of Guinea have been investigated over the period 1969-1992. Over the 24-year period there was a downward trend in zooplankton biomass equivalent to 6.3 ml/1000 $m^3$ per year. It is believed that the main cause of this decline is the gradual warming of surface waters which has influenced the abundance of *Calanoides carinatus,* a species sensitive to waters warmer than 23°C and which appears in coastal waters only during the upwelling season. Global warming and predation control by *Sardinella* fish may be responsible for this long term decline.




*Relationship between zooplankton biomass and SST (top panel) and interannual variation in zooplankton biomass (bottom panel) in the upwelling region of the Gulf of Guinea.*

4. **Variability in the freshwater balance of northern Marguerite Bay, Antarctic Peninsula using $\delta^{18}O$ isotopes.** (Meredith, M.P. , M.A. Brandon, M. I. Wallace, A. Clarke, M.J. Leng, I.A. Renfrew, N.P.M. van Lipzig and J.C. King 2008. Deep-Sea Research II 55: 309-322.

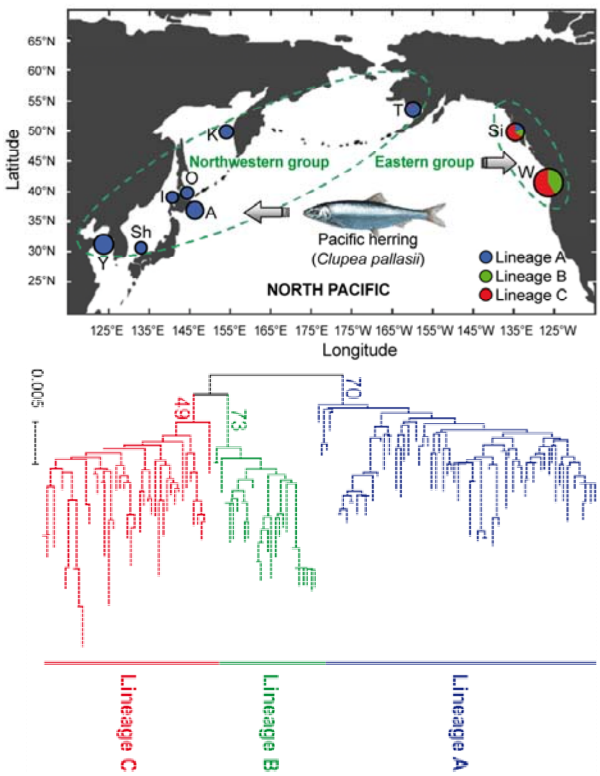
The authors investigated the seasonal variability in freshwater inputs to the Marguerite Bay region (western Antarctic Peninsula) using a time series of oxygen isotopes in seawater from samples collected in the upper mixed layer of the ocean during 2002 and 2003. They found that meteoric water, mostly in the form of glacial ice melt, was the dominant freshwater source, accounting for up to 5% of the near-surface ocean during the austral summer. Sea-ice melt accounts for a much smaller percentage, even during the summer (maximum around 1%). The seasonality in meteoric water input to the ocean (around 2% of the near-surface ocean) is not dissimilar to that of sea-ice melt (around 2% in 2002 and 1% in 2003), contradicting the assumption that sea-ice processes dominate the seasonal evolution of the physical ocean environment close to the Antarctic continent. Three full-depth profiles of oxygen isotopes collected in successive Decembers (2001–2003) indicate that around 4 m of meteoric water is present in the water column at this time of year, and around 1 m of sea-ice formed from this same water column. The predominance of glacial melt is significant, since it is known to be an important factor in the operation of the ecosystem, for example by providing a source of nutrients and modifying the physical environment to control the spatial extent and magnitude of phytoplankton blooms.




*Profiles of freshwater content (%) at the RaTS site derived from oxygen isotope and salinity data collected by RRS James Clark Ross during December 2001 (red), December 2002 (black) and December 2003 (blue). Dashed lines indicate meteoric water percentages, and solid lines indicate sea-ice melt percentages. Note that negative sea-ice melt percentages denote a net sea-ice formation had occurred from these waters. Total column inventories ($H_{met}$, $H_{sim}$) are shown for each year.*

**5. Genetic divergence and demographic history of the Pacific herring *Clupea pallasii* in the north Pacific.** (Liu, M., T. Gao, T. Yanagimoto, X. Jin, Z. Zhuang and Y. Sakurai 2008. GLOBEC International Newsletter 14(2): 29-30).

Pacific herring *Clupea pallasii* is a commercially important fish species, which is widely distributed throughout much of the North Pacific Rim. In previous research, it was thought that the species was derived from Atlantic herring in the Arctic Ocean which dispersed into Pacific after the Bering Strait opened in the late Pliocene. The purpose of this study was to ascertain the population genetic structure and demographic history of the species. This information can help to evaluate the genetic consequences to the species of climatic oscillations and glaciation in the north Pacific, and it is also crucial to the success of long-term fisheries conservation because consistent exploitation of mixed populations often leads to the demise of the least productive stocks.



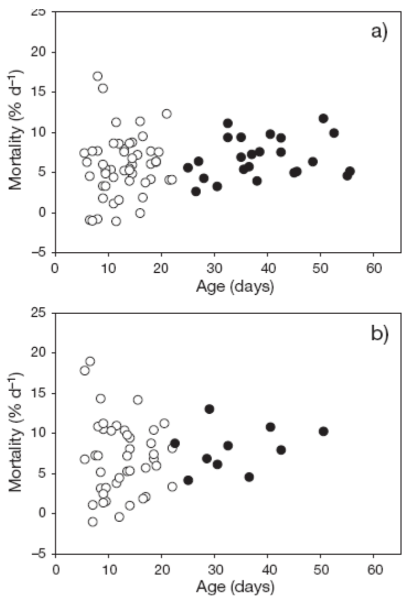

A 479-bp segment of 5' end of mitochondrial DNA control region was sequenced in 319 Pacific herring specimens collected from 9 localities. Three distinct lineages were detected based on the phylogenetic tree of 143 haplotypes, which indicated two geographic groups, the northwestern Pacific group and the eastern Pacific group (see figure). Hierarchical molecular variance analysis reveal significant genetic divergence between the two groups. In contrast to the northwestern

Pacific group, the eastern Pacific group exhibited a higher genetic diversity. The nested clade analysis produced a network with four nested levels, which correspond to the phylogenetic tree. Most clades in the northwestern Pacific group were inferred as a result of contiguous range expansion, while in the eastern Pacific group the demographic events were mostly restricted gene flow with isolation by distance. The neutrality tests and mismatch distribution analysis indicated that Pacific herring experienced a series of range and population expansions. The expansion time of the eastern Pacific group was earlier than the northwestern Pacific group.

From these results, we postulated that the species experienced a long distance colonisation entering the Pacific as a repeated Pleistocene glaciation south of Alaska might have blocked the gene flow and permitted the two geographical groups to diverge. However, the paleogeographic environment in the northwestern Pacific was less stable during the Pleistocene glacial-interglacial changes than the eastern Pacific. The gene flow among the populations of eastern Pacific might reach a dynamic balance earlier than in the northwestern Pacific, which could explain the differences between the two geographic groups.

6. **Growth and mortality of Atlantic cod *Gadus morhua* and haddock *Melanogrammus aeglefinus* eggs and larvae on Georges Bank, USA** (D. Mountain, J. Green, J. Sibunka and D. Johnson 2008. Marine Ecology Progress Series 353: 225-242)

The egg and larval stages of the Atlantic cod *Gadus morhua* and haddock *Melanogrammus aeglefinus* populations on Georges Bank, northeastern USA, were sampled monthly from winter to summer in 1995-1999 as part of the US GLOBEC Georges Bank programme. Seasonally averaged rates of egg mortality were estimated for both species and ranged from 9.9 to 20.4% $d^{-1}$ for cod and 7.8 to 13.4% $d^{-1}$ for haddock. Model results suggest that the interannual variability in egg mortality rate is largely due to wind-driven transport off the southern side of the bank. The estimated number of hatched eggs is strongly correlated with the subsequent recruitment for both the Atlantic cod and haddock stocks. Mortality during the early larval period was estimated for 10 d cohorts within each year, based on the decrease in abundance from egg hatching to the first sampling of the cohort on a survey. For both species, these rates were slowly varying between cohorts within a season, but showed large variation between years. For the 1995 to 1996 period, the annual average mortality rate was about 6.3% $d^{-1}$ for cod and 10.1% $d^{-1}$ for haddock, whereas in 1998 to 1999 the values were 3.9% $d^{-1}$ for cod and 5.4% $d^{-1}$ for haddock. From the larval stage to stock recruitment, haddock appeared to have a survival rate (recruits per larvae) 3 times higher than that for Atlantic cod.




Gadus morhua *and* Melanogrammus aeglefinus*. Relationship between larval mortality rate (% $d^{-1}$) and larval age for (a) cod and (b) haddock, including early larval (open circles) and older larval (closed circles) mortality values.*

Details of these and other highlights can be found on the GLOBEC website, www.globec.org, under GLOBEC Publications.

**Manuel Barange, GLOBEC** International Project Office, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK, globec@pml.ac.uk, www.globec.org