

**GLOBEC CRUISE REPORT**  
**CRUISE HX 271: 24 April – 15 May 2003**

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AFSC = Alaska Fisheries Science Center (NOAA); LUMCON = Louisiana Universities Marine Consortium

**Scientific Purpose:**

The GLOBEC Northeast Pacific program seeks to understand the relationship between climate variability and the success of marine fish, bird and mammal populations. In the coastal Gulf of Alaska, the program focuses on the mechanisms by which climate and weather can influence the physical - chemical structure of the coastal zone, how this in turn affects the coastal planktonic food web, and how food web variations influence distribution and recruitment success of pink salmon. Process cruises will be conducted twice in 2003. On each cruise the aim is to visit four sites representing a diversity of physical - chemical conditions in the coastal Gulf of Alaska. At each of these core sites, rates of phytoplankton growth, zooplankton grazing and zooplankton egg production will be measured, as well as aspects of phytoplankton and zooplankton community structure. These measurements will be related to the physical - chemical environment by means of vertical profiling at the process stations themselves, and by coordinating with sampling done by R.V. Wecoma. In addition to work at core sites, approximately one week will be spent investigating mesoscale physical features (e.g. eddies, east-west chlorophyll gradients). This work will be done in close conjunction with mesoscale survey sampling conducted by Musgrave et al. on the R.V. Wecoma. Comparison with data collected during 2001 process cruises will be important for testing hypotheses about planktonic processes, as well as understanding the effects of interannual variability.

The first 2003 process cruise focused on fully developed spring phytoplankton bloom conditions, the responses of the micro- and macrozooplankton community to the spring bloom, and the conditions leading to mesoscale variability in planktonic distribution and biological rates.

### **Cruise Objectives:**

1. Determine phytoplankton growth rates and rates of microzooplankton herbivory.
2. Determine rates of grazing on phyto- and microzooplankton by dominant copepod taxa including *Neocalanus* and *Calanus*.
3. Measure rates of egg production by copepods *Calanus*, *Pseudocalanus*, *Metridia* and others
4. Assess vertical distribution of temperature, salinity, light, nutrients, chlorophyll and microzooplankton at core process stations.
5. Conduct net tows (CalVET, MOCNESS) for distribution and abundance of zooplankton at core process stations.
6. Coordinate and communicate with R.V. Wecoma for study of mesoscale physical features and related chlorophyll/zooplankton gradients (using the measurements listed above).

## **SAMPLING**

### **DAYTIME ACTIVITIES:**

1. Collected ADCP, sea surface salinity, temperature and fluorescence data using sensors in the seachest, both while underway and while on station.
2. Occupied core process stations at the shelf break (GAK-10), in Prince William Sound (PWS-2), and on the inner shelf (GAK-1i) for approx. 4 d each. Occupied several mid-shelf stations (GAK-3, GAK-6, GAK-8, PR1, PR6; see chart) for 1-2 d each. At these and numerous intermediate stations (see chart), conducted vertical CTD profiles (to near bottom, as for LTOP cruises) for determination of T, S, light (PAR) and in situ fluorescence distribution.
3. Collected discrete water samples from CTD casts (5 to 10 depths per cast) for measurement of nutrients (frozen for analysis by C. Mordy, PMEL), size-fractionated chlorophyll (<5  $\mu\text{m}$ , 5 – 20  $\mu\text{m}$ , >20  $\mu\text{m}$ , analyzed on board), algal pigments (frozen for HPLC analysis by S. Strom) and microzooplankton abundance (acid Lugol's-fixed samples for inverted microscopy, glutaraldehyde-fixed samples for epifluorescence microscopy). (Activities 2 and 3 were conducted upon arrival and at approx. local noon each day on station, with a reduced set of sample types taken during all but first cast on station.)
4. Conducted net tows (Quad Net, Ring Net) for preserved samples (quantitative zooplankton abundance and copepod egg abundance) and live animals (grazing and egg production experiment set-up).
5. Used CTD to collect water from upper mixed layer for set-up of dilution experiments (phytoplankton growth and microzooplankton grazing rates) and copepod grazing experiments.

6. Conducted station work closely spaced in time (CalVET, ring net and MOCNESS tows, CTD casts, water sampling for size-fractionated chlorophyll and nutrient analysis, water collection for phytoplankton growth assays) along transects comprising inner (Gak 1 – Gak6) and outer (Gak 7 – Gak 13) portions of the Seward Line, as well as areas hypothesized to reflect the flow path of the ACC (Hogan Bay to Gak 1i; Pr1 to Pr6; see appended charts).

7. Released drifters just seaward of the Montague Strait entrance to PWS and at Pr1 as part of transect work above.

## NIGHTTIME ACTIVITIES

1. Conducted MOCNESS and Quad Net tows for quantitative enumeration of zooplankton once each night while on core process stations.

2. Conducted night CTD/water sample profiling at core process station (see above).

3. Conducted CTD transects of areas surrounding core process stations to establish temporal variability in location of biological and physical fronts.

## CHRONOLOGY

Departed Seward 1155 hrs (local) 24 April 2003. Steamed to shelfbreak station Gak10, conducting CTD casts, CalVET tows (samples for Hopcroft) and ring net tows (*Neocalanus* collection) at every other Seward Line station on the way out. Arrived Gak10 0645 hrs 25 April and commenced 4-d cycle of process studies, conducting daytime and nighttime sampling and experimental activities (dilution, grazing, and egg production) as described above. Blue water conditions prevailed, with abundant *Neocalanus* spp. copepods, low chlorophyll levels ( $\leq 0.5 \mu\text{g chl/liter}$ ) and abundant *Synechococcus* spp. Work at process station Gak-10 was supplemented by transect work at Gak-13 through Gak-7 to characterize copepod and microplankton communities, nutrient and chlorophyll levels, and phytoplankton growth rates/nutrient limitation.

Just after midnight on 29 April we headed back in to Seward to seek medical attention for two people on board, arriving Seward Marine Center at 1205 29 April. We were also able to meet with members of the Wecoma mesoscale science party at the dock. At 1630 we departed for Prince William Sound, arriving early 30 April at station PWS-2 in the deep waters at the northern end of Knight Island Passage. Commenced another 4-d work cycle and successfully completed 4 sets of experiments, as well as water column and net sampling. Chlorophyll in PWS was largely subsurface in a well-defined maximum layer at 15-20 m; the microplankton assemblage was diverse and appeared to be ageing, as indicated by high levels of detritus and phaeopigments. Pronounced diel vertical migration by several copepod taxa was observed, as well as intense bioluminescence especially to the south of our core study area.

Departed PWS-2 just after midnight on 4 May and conducted transect work on the way to the inner Seward Line. CTD casts at three to four stations each were conducted on the Hogan Bay line, the Montague Strait Line, the PWSW Line, the inner Cape Fairfield Line, and the inner Seward Line (see Chart 1). A drifter was released just SW of the entrance to Montague Strait (black box symbol on Chart 1). The goal was to track the flow of water exiting PWS through

Montague and joining the main flow of the ACC. Samples were taken at a core station on each of these short line sections for zooplankton abundance and composition (ring net, CalVET, MOCNESS) as well as for chlorophyll and nutrient levels. Water was also collected for phytoplankton growth rate/nutrient limitation assays.

Once outside PWS, we established radio contact with the mesoscale survey group on R.V. Wecoma and were able to download finescale survey sections of the inner ACC from the ftp site. Finescale survey data showed the ACC confined to stations shoreward of Gak-2. Accordingly, we began a 3.5-d work cycle at Gak1i on 5 May, conducting experiments (grazing, dilution, egg production) and water column sampling as above. Each day a CTD transect with 2.5-nm spacing was conducted to ascertain the position of the ACC and its seaward frontal boundary (Figs. 1-3). Transects showed core process station Gak1i to be within the region of maximum geostrophic transport in general during this work cycle. The ACC was characterized by a high biomass of phytoplankton mostly confined to the upper 10-20 m. There was a mixed assemblage of copepods, including *Neocalanus finmarchicus*, *Pseudocalanus* spp., and *Metridia pacifica*. A mixture of diatom species was observed; in particular, the presence of *Chaetoceros socialis*, the near-absence of *Thalassiosira* spp., and relatively high levels of detritus distinguished ACC waters from mid-shelf waters seaward of the salinity front (see below).

On 8 May we conducted a CTD, net, and phytoplankton growth assay survey of the mid-shelf portion of the Seward Line (Gak-6 to Gak-2). Based on these data we conducted one set of process experiments at Gak-3, with the goal of contrasting these waters with those inshore of the ACC frontal boundary. Weather dictated the end of sampling operations shortly after experiments were initiated at Gak-3 (9 May), and we spent approximately 24 hr in Three Hole Bay. Re-emerging late on 10 May, we began work to the west of the Seward Line at station PR1 (see Chart 2), historically and at present an area of extremely high spring chlorophyll concentrations as indicated by 7 and 8 May 2003 SeaWiFS imagery and broadscale survey data supplied by Wecoma. Experiments (grazing, dilution, egg production) were set up at PR1; a drifter was then released at this location and we began transect work at intermediate PR line stations (zooplankton abundance and composition [ring net, CalVET], chlorophyll and nutrient levels, phytoplankton growth rate/nutrient limitation assays). A second complete round of process experiments was initiated on 12 May at PR6, the seaward end of the transect. A cross-trough CTD survey (5 nm spacing) of Amatouli Trough was conducted the night of 12 May (stations XAT, see Chart 2) to look for bathymetric effects on hydrography, as well as to provide time series information for comparison with Amatouli transects conducted during the same general time period by R.V. Wecoma (Musgrave) and R.V. Kilo Moana (Kachel).

On 13 May we relocated to the Gak-6 area for a final 1-2 rounds of process experiments. Gak-6 is the center of the mid-shelf finescale survey conducted by R.V. Wecoma. Based on their findings and on SeaWiFS imagery we expected to find a boundary between high-chlorophyll water (inshore) and low chlorophyll water (offshore) in the vicinity of Gak-7i. Just after midnight on 13 May we began a survey of the Gak-6 to Gak-8 portion of the Seward Line and found the green/blue boundary midway between Gak-7 and 7i (Fig. 4). Accordingly we began process experiments at 7i during the morning of 13 May, only to find the boundary had shifted substantially seaward. Experiments (dilution, grazing, egg production) ultimately were set up with blue water rich in ciliates, *Synechococcus* spp., and cryptophytes from Gak-8. On 14 May a final round of dilution and egg production experiments was set up with high chlorophyll water from Gak-6. Three additional CTD transects (2.5 to 1.7 nm station spacing) conducted during the period 13 May to 14 May confirmed the dynamic nature of the green/blue water boundary position (see Figs. 4-7), perhaps related to high tides during this full moon period. At

0000 hrs 14 May we commenced a diel study of the plankton community at Gak-6, sampling the water column at 6-hr intervals (CTD with water collection for nutrients, HPLC pigment analysis, Flowcam; CalVet and MOCNESS tows) through 0000 hrs 15 May. At 0700 15 May we departed station Gak-6 for Resurrection Bay, stopping at Gak-5, 3 and 1 for net tows (*Neocalanus* collection) and associated CTD casts. Arrived Seward 1500 hrs 15 May.

#### Acknowledgements

We thank Captain Bill Rook and the crew of the R.V. *Alpha Helix* for their hard work and helpful attitude during the cruise. Dave Aldrich contributed excellent marine technical support on board, while Steve Hartz assisted with shore-based data communications issues. We also thank Tom Smith and the staff at the Seward Marine Center for their help in cruise preparation and logistics.

#### WORK CONDUCTED:

Microplankton rate processes; water column sampling (Strom, Macri, Bright, Fredrickson, Perez):

A total of 17 dilution experiments was conducted on the cruise, all but one with water from the depth corresponding to 50% surface irradiance. Full dilution series (5 experiments) yielded phytoplankton growth and microzooplankton grazing estimates for three chlorophyll size fractions, as well as information concerning the grazing community functional response. Reduced dilution experiments (12 total) provided microzooplankton grazing and phytoplankton growth rate estimates, and allowed scope for addition of treatments to test for grazing inhibition by DMSP and growth enhancement by ammonium. All dilution experiments contained parallel nutrient-enriched (nitrate-N, phosphate-P) and unenriched treatments to test for nutrient limitation of phytoplankton growth rates, and to ensure that grazing estimates were not affected by dilution. Samples were taken from experiments for analysis of microplankton biomass and composition (inverted and epifluorescence microscopy), size-fractionated chlorophyll analysis, and algal pigment composition by HPLC. An additional 21 phytoplankton growth assays were conducted during transect work described above to gain insight into spatial patterns and environmental correlates of phytoplankton growth rates (3 chlorophyll size fractions) and degree of nutrient limitation. Five “trophic cascade” experiments (utilizing pre-incubation size fractionation to separate different microzooplankton grazer size classes from <10  $\mu\text{m}$  phytoplankton cells) were conducted, each in parallel with a dilution experiment, to indicate multiple trophic level effects on nanophytoplankton and *Synechococcus* abundance. On-board FlowCAM analysis of the microplankton community (during transect and diel cycle work) and of several copepod grazing experiments was conducted. This group was also responsible for all CTD-based water column sampling (nutrients, size-fractionated chlorophyll, HPLC pigments, and preserved samples for micro- and nanoplankton analysis by inverted and epifluorescence microscopy, respectively).

#### Preliminary results:

1. High to very high chlorophyll levels characterized the inner and mid shelf during most of this cruise, with levels increasing dramatically and high chlorophyll spreading offshore during the last week of April. Microplankton community composition (as indicated by FlowCAM) across this high chlorophyll water was variable and appeared to be associated with water mass type.

2. Some degree of macronutrient limitation of phytoplankton growth rates, especially for the >20 µm diatom-dominated size fraction, was evident in Prince William Sound, as well as in waters just offshore of the ACC and near the seaward end of the PR transect. Growth rates of the different phytoplankton size fractions showed relationships with the water mass types as did community composition (above). The >20 µm chlorophyll size fraction generally exhibited higher nutrient-enriched intrinsic growth rates than did the smaller chlorophyll size fractions.

3. In keeping with findings from 2001, microzooplankton grazing rates were generally lowest on the large (>20 µm) phytoplankton. Substantial rates of grazing often measured on intermediate (5 to 20 µm) and small (<5 µm) phytoplankton.

#### Copepod Egg Production/Diet Studies and Zooplankton Abundance (Napp, Harpold and Forcucci )

Two major activities were conducted: 1) shipboard incubation experiments for egg production, egg viability, and diet were conducted at selected stations in Prince William Sound, the Alaska Coastal Current, and the middle shelf, and 2) net sampling (MOCNESS and CalVET) for zooplankton abundance. For the shipboard incubation experiments, females of the target species (*Calanus* spp., *Pseudocalanus* spp. and *Metridia* spp.) were used when available. In addition to the plankton net tows taken at the central station within each shelf regime, CalVET samples were collected on three transects within and between regions: Prince William Sound to the Seward Line, GAK 6 to GAK 2, middle shelf around the perimeter of Amatouli Trough.

#### Activities/Preliminary Results –

- The ocean environment provided a unique opportunity to examine grazing in several very distinct natural assemblages of food particles. Prince William Sound had an "older" subsurface diatom bloom with a high levels of chlorophyll degradation products. The Alaska Coastal Current had a "younger" surface diatom bloom comprised of a mixed assemblage of diatom species, and parts of the middle shelf had a very "young" diatom community that was dominated by a single species of *Thalassiosira*. Nine grazing experiments using females of the target species were conducted in these distinct environments in collaboration with Strom and co-workers. Samples for chlorophyll, microplankton community (Lugol's and glutaraldehyde preserved), and HPLC were collected and will be analyzed to determine grazing rates and diet preferences. Particular effort was expended to conduct parallel grazing experiments for *Pseudocalanus* and *Metridia* females so that we could examine their grazing impact on the microplankton community. Community composition in Prince William Sound allowed us the opportunity to examine grazing by two *Metridia* species, *M. pacifica* and *M. okhotensis*.
- Females of all three genera were in sufficient abundance to allow egg production and viability experiments in three of the four major shelf regimes (PWS, ACC, middle shelf). Thirty egg production experiments were completed. Note that these three regions had very different food assemblages available to the females and should help us to determine the effect of food on egg production.

- All three genera produced eggs in the three regions. *Calanus marshallae* had the highest proportion of females producing eggs (virtually 100% in all regions). In Prince William Sound, a small proportion of the *M. pacifica* females produced eggs, while *M. okhotensis* females did not. Clutch size for *M. pacifica* was smaller in Prince William Sound and the ACC, than at station PR6 (middle shelf). *Pseudocalanus* spp. egg production experiments were preserved without inspection. All samples will be returned to Seattle to complete the analyses and compute the egg production rates.
- Eggs from all three genera hatched in the viability experiments (fourteen experiments in all). Viability rates will be calculated after the preserved samples are returned to our laboratory.
- Approximately 80 samples were collected to determine the carbon and nitrogen weights of the target species.
- Three to four nighttime zooplankton samples were collected at each core station using the NEP GOA GLOBEC protocol (MOCNESS 500  $\mu\text{m}$  and Quad Net 150  $\mu\text{m}$  mesh) to determine the concentration and depth distribution of GLOBEC target species. In addition, tows were taken on transects between regions to look at gradients and fronts (on a coarse scale) and samples were taken over an 18 hr. period on the middle shelf to look at diel migration patterns.
- Two satellite-tracked drogues (provided by P. Stabeno, NOAA/PMEL) were released to support Process Studies. The first was released just outside of Prince William Sound in the ACC to examine the path and rates of travel of water between PWS and the Seward Line. The second drifter was released at station PR1 to examine the flow around the head of Amatouli Trough.

Cruise report from Dagg's group (Hongbin Liu, Greg Breed and Adriana Hashinaga)

During first 2003 GLOBEC Processes cruise HX271 (April 24 – May 15), we conducted 16 *Neocalanus* grazing experiments. *Neocalanus* was most abundant at the outer shelf station with all three species were observed. *Neocalanus* abundance was low at the inner-shelf station and in the Prince William Sound and at the most time only *N. flemingeri* was observed. We conducted grazing experiments mostly with *N. flemingeri* and *N. cristatus*, and only two experiments with *N. plumchrus*. In these grazing experiments, control and treatment (with copepods added) bottles were incubated for 24 hours and various samplings and measurements were conducted at the beginning and end of the incubation. Samplings and measurements include size fractionated chlorophyll *a* (< 5, 5 – 20 and > 20  $\mu\text{m}$ ), HPLC pigment analysis, flow cytometric analysis of picoplankton, Lugol's preserved sea water for microzooplankton composition and abundance, and DAPI stained slides for nanoflagellate enumeration. Samples were also taken from a few (3) experiments for on-board FlowCam analysis (Courtesy Suzanne Strom). In addition, bulk mesozooplankton grazing rate was measured at 3 sites using an experimental approach similar to the *Neocalanus* grazing experiment.

Another main research activity of our group was to conduct cross-shelf sampling of *Neocalanus* for measuring their body length, body biomass and lipid content. We collected samples from 4 transects (twice along the Seward Line, one from PWS to ACC and other one on the Process Stations designed to track a high chlorophyll eddy in the west of the Seward Line). Samples were sorted and frozen, and will be brought back to our lab for further analysis. Water samples were also taken at stations along the Seward Line for flow cytometric analysis of picophytoplankton and bacterial abundance.

We also worked together with Jeff Napp's group in conducting Calvet and MOCNESS net tows regularly at each night and on some other occasions.

Appendices:

[Event Log HX271](#)

Chart 1: Nearshore station locations, Prince William Sound and areas to west

Chart 2: PR, XAT and mid-shelf Seward Line station locations

Figs. 1-3: Hydrographic sections, inner Seward Line (May 5, 6, 7)

Figs. 4-7: Hydrographic sections, mid-shelf Seward Line (May 13, 14)