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US AMLR Vessel Survey (*R/V Yuzhmorgeologiya*)
South Shetlands, Antarctica

Oceanography

Predominantly Northwesterly winds under 20knots occurred during the Joinville and South Area sampling. Periods of mist and rain alternated with clear skies and sunshine. Very few icebergs were present in the southern Joinville Area allowing an additional station to be sampled (A03-14). This is the second consecutive year that we have been able to sample farther south. Limited cruise time precluded extending the survey south however. Because of the fair weather and the lack of ice, all stations in these two Areas were sampled, and 31 successful CTD casts were made. For the first leg the AMLR 2009 survey, 103 CTD casts were made.

14 XBTs were dropped along two transects across the Bransfield Strait to better characterize the sub-surface temperature in this region. 18 XBT drops were made while we crossed the Drake Passage. Drops targeted the shelf-slope and Polar fronts (~hourly) while 2 to 3 hour drops were made between these two important oceanographic zones. These data will be used to analyze the erosion of the Winter Water remnant over the summer season (and will also be conducted at the end of the second Leg of the survey). Five drifter buoys (provided by colleagues at NOAA) were deployed while crossing the Drake Passage. These data continue our development to build a better understanding of the surface circulation in the Drake Passage and the offshore waters that we do not sample during AMLR surveys

All Leg 1 CTD data files were processed, results compared (favorably) to the Portasal salinometer and field water zone classification was performed. Overall the CTD system performed well, with only routine and preventative maintenance required. This was undertaken between stations, so the only downtime was due to the CTD PC having to be replaced at Station 02-02, due to it becoming unstable. One up-cast was lost due to this. Disturbed salinity traces at stations A05.5-04, A04-06 and A02-05 at an average depth of 75m, were probably a result of salps that clogged the CTD intake hose.

Acoustic estimates of krill biomass

Acoustic biomass estimates for the Bransfield Strait (the South Area) were made during the third week of sampling the AMLR grid. Acoustic data was also collected in the Joinville Area, but the number of transects in that Area was too few to produce reliable estimates of biomass. Within the South Area, acoustically estimated krill biomass exceeded the biomass calculated for both the West and Elephant Island Areas. Mean

krill density was 0.7 g/m2 and the biomass for this Area exceeded 17,000 tons. Overall biomass for the three areas was the third lowest on record.

Although these numbers represent preliminary estimates and are subject to some revision, they represent nearly 2 orders of magnitude variability in biomass between 2008 and 2009. The prevailing oceanographic conditions, the dominance of salps, and local variability in the availability of krill probably all contributed to these low biomass estimates.

Krill and zooplankton summary

An estimated total of 11000 post-larval krill were collected by the 101 IKMT tows made during the January 2009 survey effort; 3200 of these were analyzed for demographic information. Krill were broadly distributed over the entire area, as indicated by their presence in 85% of the samples, but their distribution was uneven with greatest catches of 1530 and 2240 individuals (262-562 per 1000 m3) occurring northeast of Elephant Island and in the southwest portion of Bransfield Strait, near Gerlache Strait. Overall mean and median abundance values were greatest in the South Area (52 ± 129 and 0.9 per 1000 m3) and Elephant Island Area (23.2 ± 74 and 3 per 1000 m3). The absolute abundance values within the South, West, Elephant and Joinville Island areas, including the paucity of animals in eastern Bransfield Strait (the Joinville Island area), were quite similar to conditions observed during the January 2004 survey.

Krill lengths ranged from 12 to 56 mm. The overall length frequency distribution was polymodal reflecting a mixture of year classes. Primary modes were at 21 mm, 34 mm, 44 and 48 mm, however 80% of individuals were larger than 29 mm and smaller than 50 mm, reflecting predominantly two and three year old individuals from the 2005/06 and 2006/07 year classes. Accordingly, mature krill dominated the catch (58%) while one-and two-year old juvenile and immature stages comprised 14% and 28%, respectively. Overall, mature males outnumbered females by 50%. Nearly 80% of the mature females were actively reproductive, primarily with developing ovaries and gravid.

As usual the different krill age-maturity classes exhibited different spatial distributions, with the largest individuals (50-55 mm) generally offshore of the island shelf region, small juveniles and immature individuals (<40 mm) in the southern portion of Bransfield Strait, and intermediate sizes (40-50 mm) generally distributed over the island shelves.

In light of an apparently good reproductive effort during the 2007/08 spawning season and good recruitment success from the previous three years (2005-2007) the relatively low krill abundance monitored during January 2009 is interesting. Under-representation of the larger and smaller length categories has been reported in previous years and attributed to their availability within the AMLR grid. Historically krill abundance has increased during the second leg of the AMLR surveys and the low numbers during this survey may reflect this type of seasonal variability. For example,

during both the 1998 and 2005 "salp years" when mean krill abundance increased by two- to five-times over the previous month. These levels of inter-annual variability probably are related to prevailing atmospherically–driven hydrographic conditions.

Larval krill were most frequent and abundant in the Elephant and Joinville Island Areas were they occurred in 40% and 82% of samples with mean concentrations of 10 and 32 per 1000 m3, respectively. Virtually all of the larvae were early *Calyptopis* stage 1 and 2 supporting the recent onset of seasonal spawning. The locations and abundance of krill larvae were similar to those observed in 2005, which was a year of good recruitment success. Given the large proportions of actively reproducing females during this survey and the larval production so far conditions seem favorable for another year of recruitment success.

The January 2009 survey establishes this as a "salp year" when the gelatinous pelagic tunicate *Salpa thompsoni* outnumbers copepods, typically the most abundant zooplankton component. Overall, *S. thompsoni* contributed 42% of the total mean zooplankton abundance across the study region, slightly more than the 38% contributed by copepods. By far the largest salp concentrations occurred in the oceanic waters offshore of the South Shetland and Elephant Island shelf regions. The largest catch of 18,500 individuals per 1000 m3 northwest of Elephant Island was associated with a large eddy formed by flow of the Antarctic Circumpolar Current adjacent to the Shackleton Fracture Zone. Salps were most frequent and abundant in the Elephant Island Area where they occurred in all 47 samples and had respective mean and median abundance values of 1334 and 454 per 1000 m3. Salps were present in 96% of the West Area samples with mean and median abundance of 1077 and 112 per 1000 m3. I n contrast, they were comparatively rare in the South and Joinville Island Areas where they occurred in 75% and 46% of samples and had respective abundance means of 46 and 72 per 1000 m3. Based on deviant CTD records caused by clogging, dense salp concentrations were located between 60 and 130 m and appeared related to the sharp pycnocline associated with winter water in ACC and modified ACC waters.

S. thompsoni has two reproductive forms, an overwintering solitary stage (asexual) that produces several chains of aggregate individuals (sexual stages) during spring and summer months. As typical, the aggregate chain form (consisting of several hundred individuals produced by each solitary salp) dominated, contributing up 93% of the total individuals collected. Aggregate sizes ranged between recently released 4 mm individuals to a mature length of 60 mm, however very few salps longer than 35 mm were found, and 95% were smaller than 28 mm. These sizes indicate a very late initiation of seasonal chain production. Based on an estimated growth rate of 0.4 mm per day, the principal production period started in early December, about two to three months later than normal. Environmental conditions resulting from strong NW winds that prevailed throughout 2008 may have caused this delay.

Mean and median salp concentrations within the Elephant Island Area (1334 ± 2897, 454 per 1000 m3) were among the highest recorded since 1992, rivaling the extremes observed during the previous "salp years" in 1993, 1994, 1998 and 2005. The maximum catch of 18,500 individuals per 1000 m3 this season was the largest so far recorded.

Due to small salp size this sample was not particularly voluminous. However, given continued chain production and somatic growth one can anticipate a substantial increase in salp carbon biomass in offshore regions over the summer season.

Copepod concentrations in the Elephant Island Area (786 ± 1000 m3 mean, 346 per 1000 m3 median) were quite similar to values observed in January 2007 and 2008 and almost twice those of the 2003 and 2004 January surveys. Small unidentified taxa constituted half of the catch while *Calanoides acutus, Calanus propinquus, Metridia gerlachei* and *Rhincalanus gigas* contributed another 46%. Coastal species *M. gerlachei* had relatively low mean and median abundance values (153 and 3 per 1000 m3) comparable to concentrations observed during the January 2003, 2004 and 2005 surveys.

Other relatively abundant zooplankton taxa in the Elephant Island Area included larvae and postlarvae of the coastal euphausiid species *Thysanoessa macrura*, chaetognaths, pteropod *Limacina helicina* and *Euphausia frigida*. With the exception of *L. helicina*, these are typically among the most frequent and abundant taxa here; relatively large concentrations of *L. helicina* were collected during the January 1996, 2003 and 2004 surveys. Their distribution along the outer shelf of the South Shetland Islands extending to the west of the Shackleton Fracture zone clearly establishes their association with the Antarctic Circumpolar Current.

Phytoplankton and chlorophyll-a

The three easterly lines in the EI box (18 stations) indicated considerable mixing of ACC water with coastal waters as evidenced by the temperature profiles and relatively deep upper mixed layers (UMLs). The in situ fluorometer showed relatively high chl-a concentrations in the UMLs at all these stations, and no pronounced deep chlorophyll maxima (DCMs). Chl-a concentrations in the entire Elephant Island area (47 stations) at 5m values averaged 0.80 ± 0.60 mg m-3; the integrated values to 100 m depth averaged 57 ± 35 mg m-2. The historical 18-year (1990-2007) mean values for the Elephant Island area at 5m and when integrated to 100 m are 0.90 ± 1.0 mg m-3 and 59 ± 51 mg m-2, respectively. Chl-a concentrations in the Joinville Island area (12 stations) at 5m values averaged 1.3 ± 1.4 mg m-3; the integrated values to 100 m depth averaged 102 ± 76 mg m-2. The historical 18-year (1990-2007) mean values for this area at 5m and when integrated to 100 m are 0.80 ± 0.6 mg m-3 and 53 ± 26 mg m-2, respectively. When comparing chl-a values for all the stations occupied during Leg I with the historical means, it is seen that chl- a values were comparable in the West, Elephant Island, and South Areas, but that in the Joinville Island area, chl-a values in 2009 were approximately 2X those of the historical means.

Seabird and mammal observations

Data on the distribution, abundance and behavior of seabirds and mammals were collected during underway ship operations in the Joinville Island and South AMLR

strata. Twenty-two transects were collected totaling approximately 495 nautical miles of survey effort. The seabird community consisted primarily of (percentage-wise): Southern fulmar, chinstrap penguin, cape petrel, Adelie penguin, Wilson's storm petrel, gentoo penguin, Southern giant petrel, black-browed albatross, white-chinned petrel, black-bellied storm petrel, and South polar skua.

The presence of fin whales in the AMLR grid continued well into the Joinville Island and South areas. A total of 28 whales were recorded (10 sightings) and were mainly clustered within the northeastern deep basin of Bransfield Strait. As in past AMLR surveys, we detected a spatial shift from fin to humpback whales as we surveyed further south and east through Bransfield Strait. A total of 101 humpback whales were recorded (52 sightings) that were predominantly concentrated in three hotspots detected during previous AMLR surveys.

In summary, the unique oceanographic conditions observed during AMLR 2009 undoubtedly influenced the foraging behavior and spatial distribution of seabirds and marine mammals. Seabird feeding aggregations were very patchy, due possibly, to the high patchiness of Antarctic krill (a condition observed in 2006). High numbers of prions, blue petrels, and white-chinned petrels (Sub-Antarctic breeders) dominated the offshore avifauna, while fin whales displayed the highest numbers ever recorded during a January AMLR survey. All in all, this survey will yield some interesting comparisons with previous field seasons.

Report submitted from a foggy southern ocean by AMLR researchers aboard the *R/V Yuzhmorgeologiya*, conducting surveys of the pelagic ecosystem in the peninsula region of the Antarctic under the watchful eye of Chief Scientist Christian Reiss. These reports are posted at http://swfsc.noaa.gov/aerd-field.aspx ; blogs from the field are also posted at the same website. Photos by M. Goebel (NMFS/AERD).