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Sinking particles and Pelagic Food Webs in the SE Bering Sea: 2001 Keeping Mooring 2 Alive

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Project Summary: The ecosystem and fisheries of the southeastern Bering Sea shelf are subject to both natural and human-induced change. Our knowledge and understanding of these changes is limited, because long term observations are few and fragmentary in time and space. Since 1995 Stabeno and collaborators have been monitoring site M2, over the Bering Sea middle shelf near 56° N, measuring temperature, salinity, chlorophyll, current speed, and meteorological conditions using instruments deployed on moorings. A time-series sediment trap, which collects particles sinking out of the surface waters, was deployed near that mooring from 1997-2003, with the last two years being supported by the Pollock Conservation Cooperative Research Center. A parallel time series of zooplankton samples has also been collected. The carbon and nitrogen stable isotope composition and selected lipids, including fatty acids, fatty alcohols, and sterols, have been measured in the sediment trap and zooplankton samples. The composition of sinking organic material collected by the trap has reflected changes in oceanographic conditions and the Bering Sea ecosystem during the 1997-2003 period.

Sample and Data Collection and Analysis: Sediment trap deployments supported by the PCCRC occurred in February, May, and September, 2001, May, 2002, and March, 2003. The traps were deployed at site M2 (56°53'N, 164°02'W, 35 m depth of deployment in a 70 m water column), and programmed to collect samples approximately biweekly, over 11 time intervals per deployment period. Instruments on the biophysical mooring deployed by the cooperating Pacific Marine Environmental Laboratory/UAF (Phyllis Stabeno and Terry Whitledge) project measured temperature, conductivity (salinity), currents, fluorescence, chlorophyll, subsurface PAR, and meteorological data.

Mercuric chloride was used as a poison in the trap sample cups (Wakeham et al., 1993). Before analysis, the trap samples were split. One split was preserved in formalin for later microscopic examination. The remainder was screened (to remove the few large, intact zooplankton), filtered, and then the filters were stored frozen until analysis. Samples were analyzed for TOC, TN, $\delta^{13}\text{C}$, and $\delta^{15}\text{N}$ at the mass spectrometer facility located at the University of Alaska Fairbanks. Certain lipid biomarkers indicative of phytoplankton and zooplankton (fatty acids, fatty alcohols, sterols) were measured to assess the relative extent of grazing of the phytoplankton. Lipid methods were as described in Wakeham (1982) and references therein. A Hewlett-Packard GC-MS was used for lipid quantification and identification. Methyl nonadecanoate and cholestane were used as internal standards.

Zooplankton were collected on the mooring deployment /recovery cruises using a 500 μm mesh plankton net in October, 2002, and 333 and 150 μm mesh bongo nets in 2001 and March, 2003. They were sorted to genus or species and analyzed for lipid and stable isotopic composition.

2001 Results

The particles collected by Bering Sea sediment traps consist of intact phytoplankton, diatom frustules, coccoliths, zooplankton fecal pellets, and other detritus resulting from food web processes. By microscopic examination and chemical and stable isotopic analysis of the material, information on nutrient availability, phytoplankton and zooplankton communities, the timing of phytoplankton blooms, relative extent of phytoplankton grazing by zooplankton, and other important ecological information can be obtained.

Some of the 2001 stable C and N isotopic data were reported earlier, but they will be briefly summarized here. The $\delta^{15}\text{N}$ of most zooplankton collected in 2001 resembled that observed from 1998-2000. $\delta^{15}\text{N}$ was significantly greater for copepods, euphausiids, and scyphozoan jellyfish in 1997 than in other years at M2 (Table 1). Stratification was unusually strong in 1997 due to unusually warm and calm weather conditions, and this resulted in unusually great nutrient depletion at M2. The carnivorous chaetognaths did not have elevated $\delta^{15}\text{N}$ in 1997, but their $\delta^{15}\text{N}$ decreased sharply in 2001. As the other zooplankton had similar $\delta^{15}\text{N}$ from 1998-2001, this suggests a change in trophic level of the chaetognaths.

The $\delta^{15}\text{N}$ of spring and summer, 1999-2001 site M2 sediment trap samples was about 2 ‰ less than in 1997 and 1998, ranging between 7 and 11 ‰ (Fig. 1). This change appears to be linked to changes in nutrient availability. During 1997, stratification was strong and nutrients were depleted throughout the photic zone, which extended into the pycnocline (Stockwell et al., 2001).

During fall, the amount of organic matter accumulated by the site M2 traps showed substantial maxima in 1997-1999, comparable to those in spring. These were closely linked in time to increasing wind velocities, which result in a breakdown of the summer stratification and new nutrient supplies to the photic zone. This observation is consistent with fall fluorescence maxima recorded by the biophysical mooring (Stabeno et al., 1999). The 2000 and 2001 results differ, in that the quantity of organic matter collected by the sediment trap varied relatively little from March through October, without pronounced maxima in either spring or early fall. The data indicate that the spring bloom may not be the predominant source of organic matter to the benthos of the middle shelf.

The fatty acid and neutral lipid content of sinking organic matter was also measured in sediment trap samples. A high percentage of the fatty acids 16:1 ω 7, ω 3 PUFA (polyunsaturated fatty acids) and 16 PUFA in sediment trap samples were associated with diatom blooms. (Fatty acids are identified by chain length, number of double bonds, and bond position(s). So, 16:1 ω 7 is 16 carbon atoms long, with one double bond located at the 7th carbon). On the other hand, when much of the material collected was fecal pellets, the major lipid was cholesterol. These observations indicate that there was greater coupling between phytoplankton and zooplankton during years when sea ice was not present at the mooring site in spring (Smith, 2003).

2002-2003

Stable C and N isotopic composition of zooplankton collected during 2002-2003 were generally similar to those for 1998-2000 (Table 1). Chaetognath $\delta^{15}\text{N}$ remained low in 2002, like in 2001, but increased in 2003.

The summer, 2002 sediment trap was damaged during deployment and, unfortunately, no samples were recovered. The subsequent fall-winter deployment, funded by the NPRB, was successful. The novel result of that deployment was that the sediment trap collected diatoms and diatom-derived lipids in February-early March, indicating that substantial diatom production was occurring in late winter. The winter of 2003 was relatively warm compared with the long-term average, and there was no sea ice near the mooring. This is contrary to earlier observations that in the absence of ice, spring blooms do not occur until thermal stratification of the water column, usually in May (Niebauer et al., 1995; Hunt et al., 2002).

A sediment trap deployed in March, 2003, was recovered in October, 2003. However, I was unable to complete the sample analyses before this presentation, in part because of laboratory renovations during 2004. I intend to complete the analyses of 2003 samples and a final report by June, 2005.

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Table 1. Stable isotopic composition of zooplankton collected over the Bering Sea middle shelf, 1997-2003. The 1997-1999 data are from Smith et al. (2002).

Year	Zooplankton type	$\delta^{15}\text{N}$	Standard deviation	$\delta^{13}\text{C}$	Standard deviation
1997	Copepod	13.2	1.5	-22.8	1.8
1998	Copepod	9.8	1.0	-23.2	0.7
1999	Copepod	10.7	1.0	-20.4	0.9
2000	Copepod	10.1	1.1	-22.7	1.1
2001	Copepod	10.2	0.9	-21.4	1.0
2002	Copepod	n.d.		n.d.	
2003	Copepod	9.5	0.2	-22.7	0.4
1997	Euphausiid	12.3	1.7	-20.0	1.9
1998	Euphausiid	10.4	1.4	-20.7	0.8
1999	Euphausiid	10.0	2.5	-19.0	1.1
2000	Euphausiid	10.6	1.7	-20.6	0.9
2001	Euphausiid	10.3	1.6	-21.4	1.2
2002	Euphausiid	10.9		-19.3	
2003	Euphausiid	10.4	1.2	-19.2	0.8
1997	Chaetognath	15.2	1.1	-20.7	0.8
1998	Chaetognath	15.0	1.4	-21.8	0.6
1999	Chaetognath	14.6	1.2	-21.1	0.7
2000	Chaetognath	15.0	1.0	-21.7	0.6
2001	Chaetognath	11.2	0.7	-21.0	0.7
2002	Chaetognath	11.7		-20.3	
2003	Chaetognath	13.7	0.9	-20.2	0.7
1997	Scyphozoan	14.8	2.1	-20.5	0.3
1998	Scyphozoan	12.6	0.8	-20.1	0.9
1999	Scyphozoan	13.0	1.1	-19.7	0.7
2000	Scyphozoan	12.5	0.5	-20.8	1.4
2001	Scyphozoan	10.8	0.7	-19.6	1.6
2002	Scyphozoan	9.8		-19.3	
2003	Scyphozoan	10.3		-20.8	

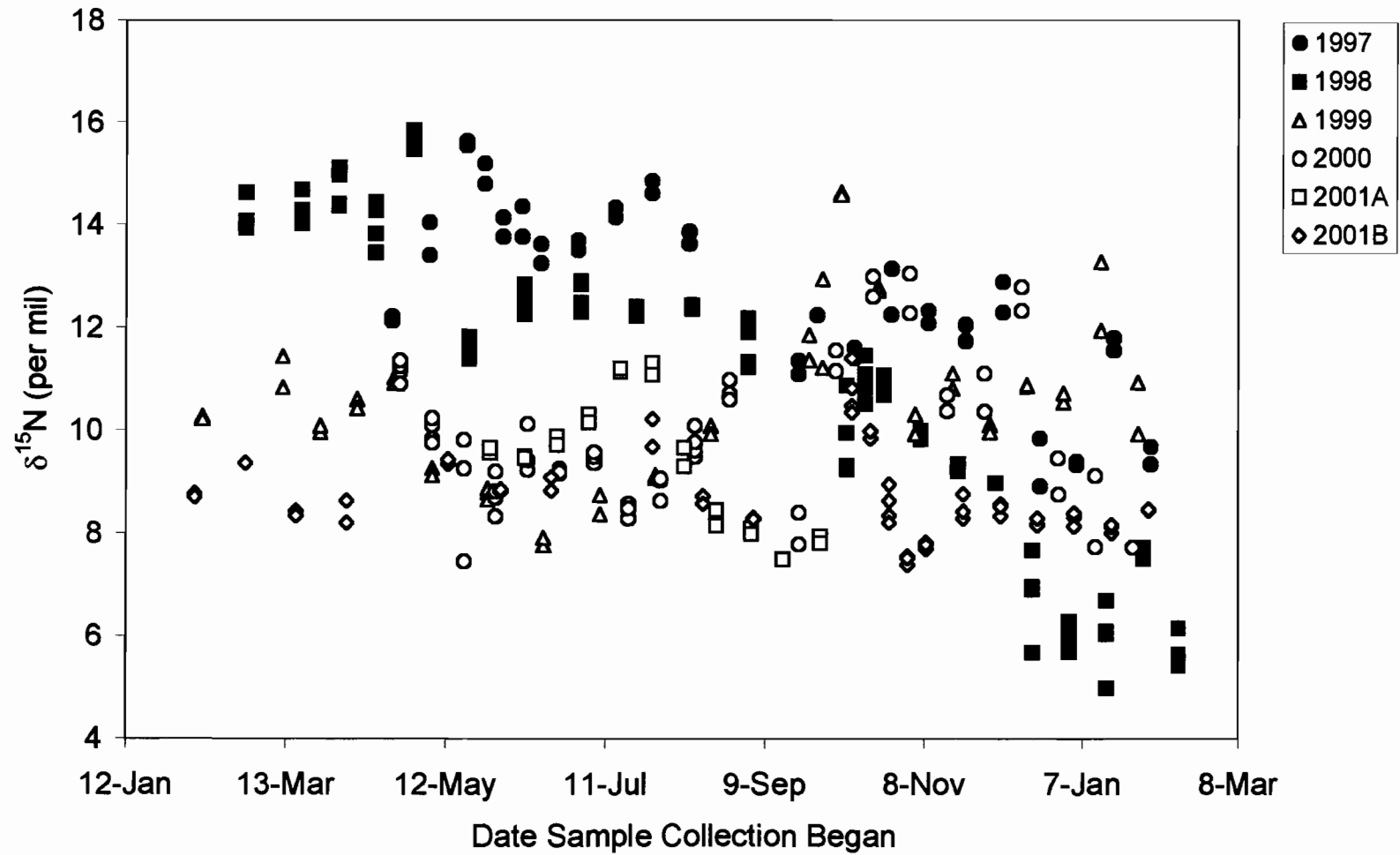


Figure 1. The $\delta^{15}\text{N}$ of sediment trap samples collected over the southeastern Bering Sea shelf, 1997-2002; 1997-1999 data are from Smith et al. (2002).