**Appendix B: Prior sampling of *Alexandrium* spp. on Georges Bank.**

In the aftermath of shellfish toxicities on Georges Bank exceeding the threshold for safe human consumption in the spring of 1990, plankton sampling was undertaken in concert with ongoing monitoring of shellfish for the period 1990-1992 (Nassif and Temperi, 1993; Figures B1-B3). Samples in 1990 were collected with a 15μ mesh conical plankton net, whereas those in 1991 and 1992 were collected with Niskin bottles. In all cases the samples were analyzed with standard light microscropy. *Alexandrium* spp. was not found at any of the stations sampled in 1990 and 1992. Most of the samples from 1991 contained no *Alexandrium* spp., but there were a few stations in which low concentrations (< 50 cells $l^{-1}$) were present.

Bank-wide surveys were carried out in May and June 1998 (Kemper, 2000) and June 1999 (Table B1) in conjunction with the U.S. GLOBEC Georges Bank Broad-scale cruises (Wiebe et al., 2006). Although cell detection methods used in these data sets do not permit distinction between *A. fundyense* and other morphologically similar non-toxic species, it is nevertheless valuable to compare the observed distributions (Figure B4) and mean bank-wide concentrations (Figure B5) of *Alexandrium* spp. with the results presented herein. In May and June 1998, the observed abundance was within the range of variability observed in 2008-2010. However, in June 1999 far fewer *Alexandrium* spp. were present, with the mean concentration falling well below the seasonal average in 2008-2010.

Analysis of contemporaneous hydrography suggests that the interannual variations in *Alexandrium* spp. observed in 1990-1992 and 1998-1999 are generally consistent with the present finding that *A. fundyense* populations thrive when waters on Georges Bank are relatively cold and salty. This is precisely the condition that prevailed in 1990 when the spike in shellfish toxicity occurred (Figure B6). Although no *Alexandrium* spp. were found in the plankton tows

(Figure B1), sampling did not begin until late June when the bloom is typically winding down (Figure B5). In light of the high toxin content observed in mussels in May 1990 (White et al., 1993) and the characteristic depuration time of months for *Mytilus edulis* (Silvert and Cembella, 1995), there is little doubt that an *A. fundyense* bloom had occurred earlier that spring/summer.

In contrast, 1991 and 1992 were characterized by an anomalously cold water mass (Figure B6). The temperature minimum on the bank was at least 2°C colder than in the 2008-2010 era sampled herein, and appeared to be accompanied by a freshening in April/May 1991. Sampling for *Alexandrium* spp. was undertaken before, during, and after the time at which the population typically peaks, and no appreciable concentrations were found. The long-term decline in toxicity of surf clams (White et al., 1993), for which the depuration time scale is on the order of years (Silvert et al., 1998), is consistent with the absence of *A. fundyense* blooms while this anomalously cold water mass was present during this period.

Water mass conditions in 1998 and 1999 were more similar to 2008-2010 (Figure B6), as was the abundance of *Alexandrium* spp. (Figures B4, B5). However, abundance was lower in June 1999 than it was in June 1998, despite the saltier conditions. Although this could have been a result of differences in bloom timing, the lack of a seasonal data set for this time period precludes a definitive answer. A more likely explanation is of course the limitations inherent in correlating *Alexandrium* spp. abundance with temperature and salinity. Nevertheless, the observations from 1990-1992 and 1998-1999 offer a means for additional scrutiny of the hypothesized niche of *A. fundyense* on Georges Bank, and to first order they are consistent with the "leaky incubator" model.

**References**

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| Year | Dates | Vessel / Voyage number | Cell detection method |
|---|---|---|---|
| 1998 | May 13-22 | R/V *Albatross IV*, AL9806 | Light microscopy |
| 1998 | June 16-26 | R/V *Albatross IV*, AL9808 | Light microscopy |
| 1999 | June 14-24 | R/V *Albatross IV*, AL9906 | Immunofluorescence assay |

Table B1. Research voyages in the 1990s during which *Alexandrium* spp. populations were sampled on Georges Bank as part of the U.S. GLOBEC Broad-scale sampling program (Wiebe et al., 2006).

Figure B1. Sampling locations in 1990.

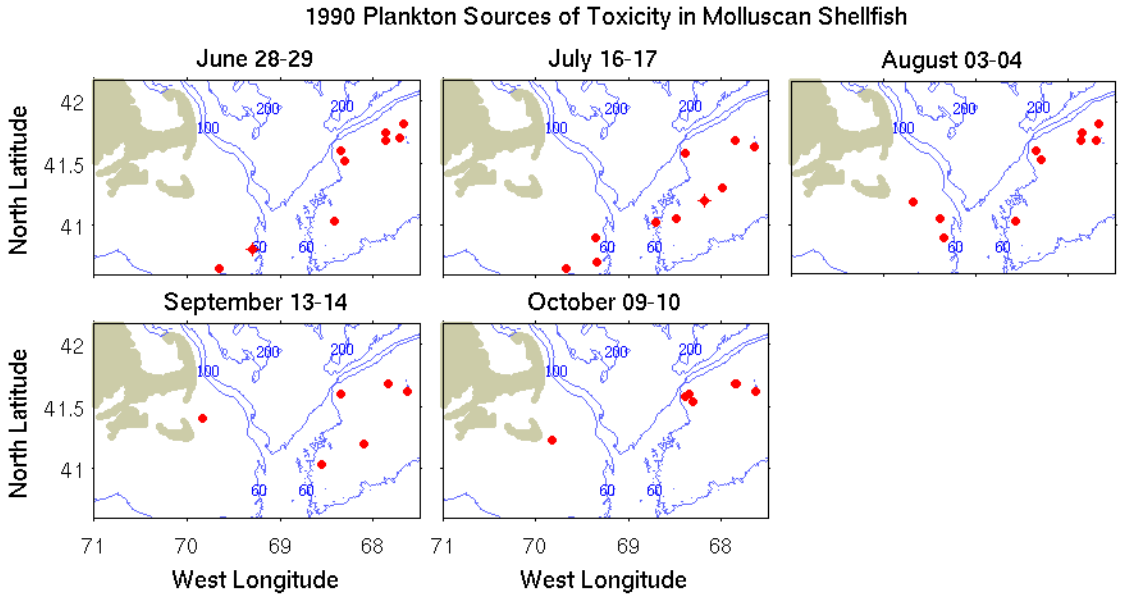


Figure B2. Sampling locations in 1991.

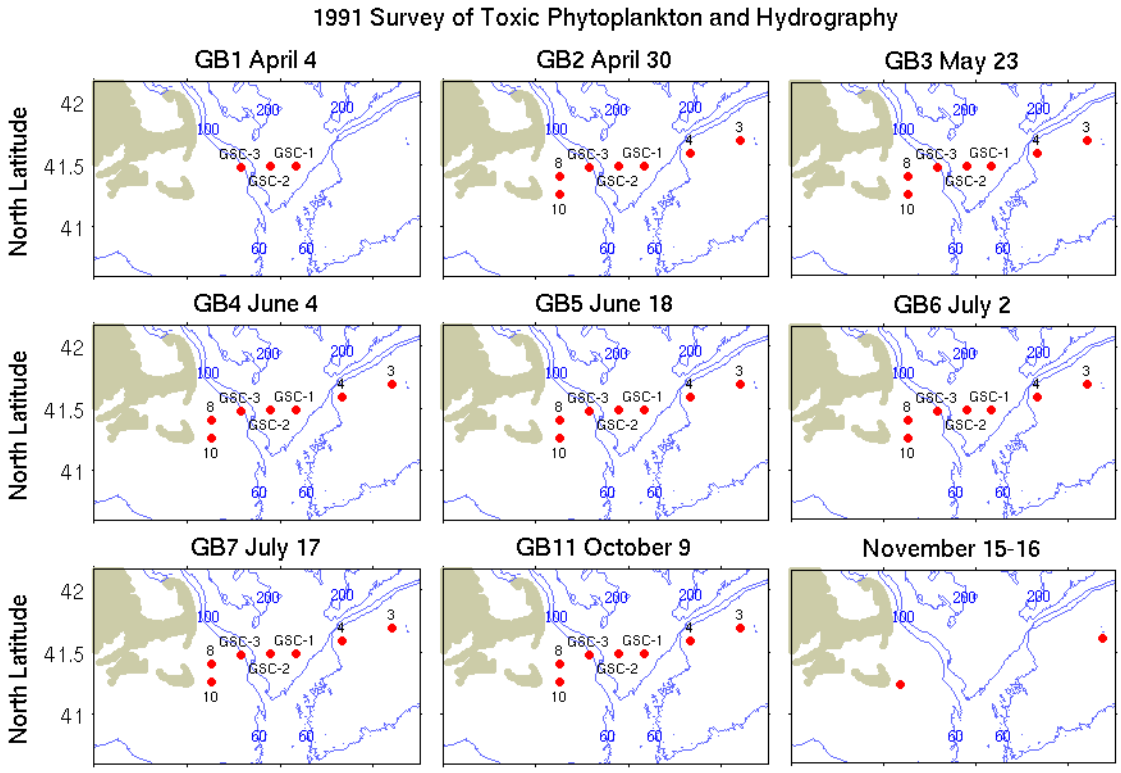

Figure B3. Sampling locations in 1992.

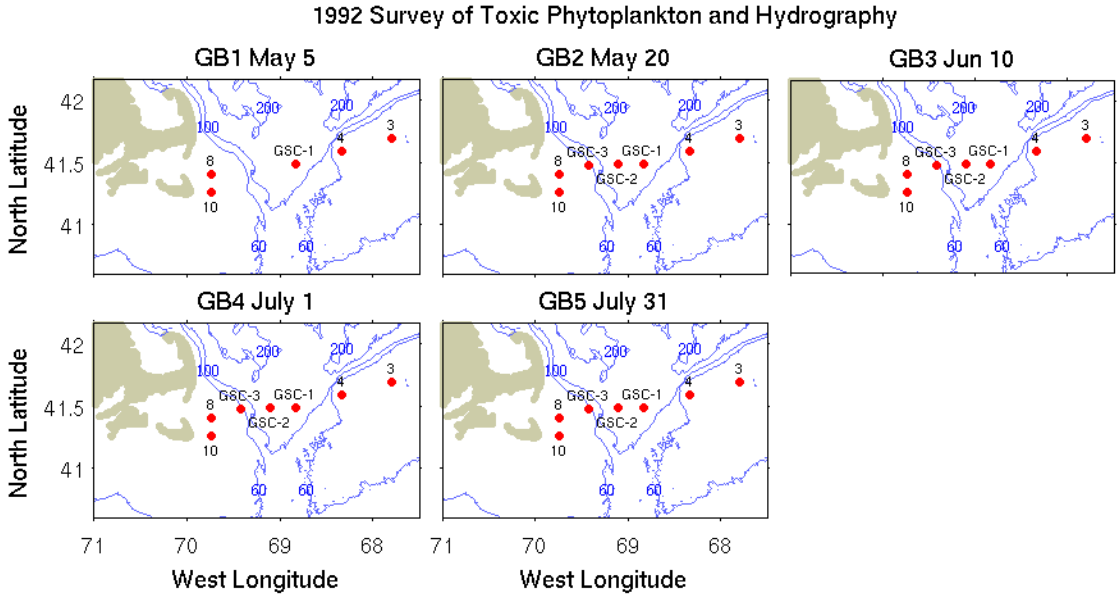


Figure B4. Surface *Alexandrium* spp. distributions derived from the cruises listed in Table B1.

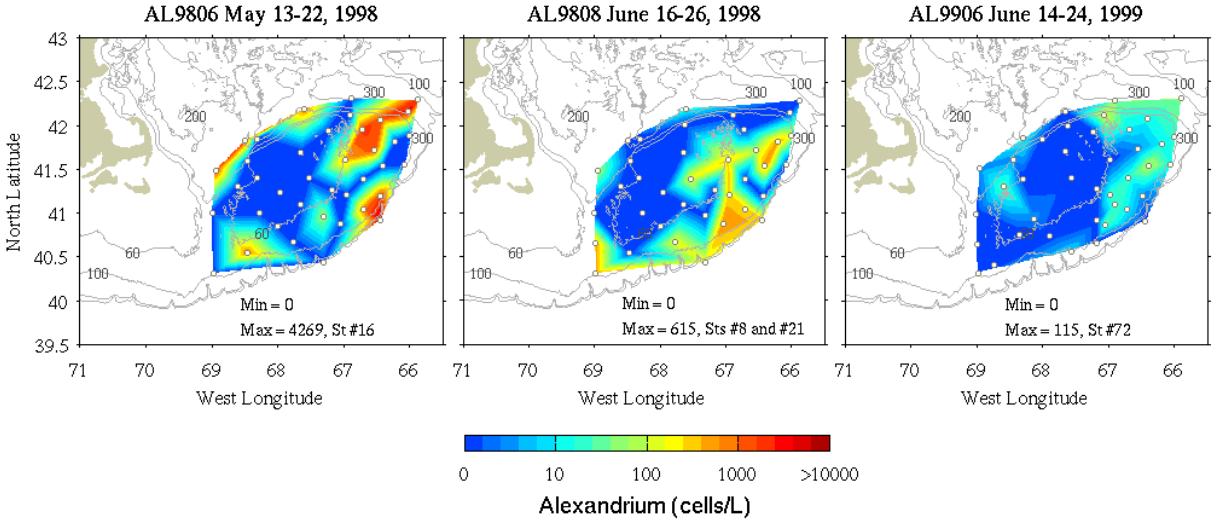

Figure B5. Seasonal to interannual variability in surface *Alexandrium* spp. concentrations on Georges Bank. Monthly means are computed from the 2007-2010 data specific to *A. fundyense*, as in Figure 5. Data from 1998 and 1998 (Table B1) are not species-specific and therefore not included in the monthly means.

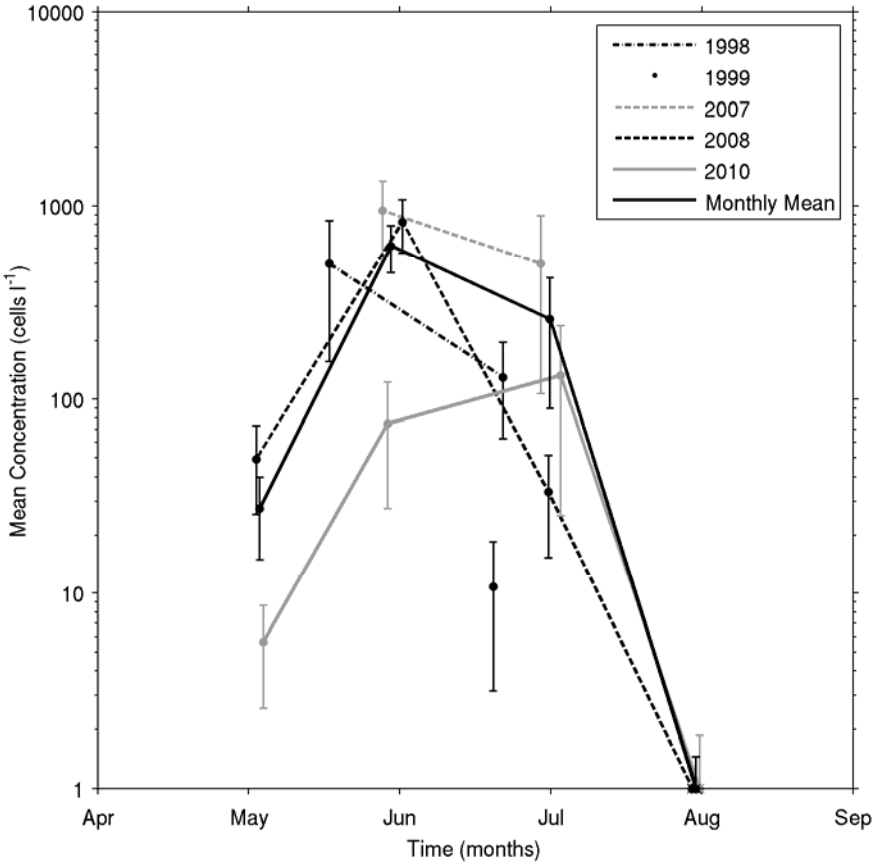

Figure B6. Temperature / salinity characteristics of hydrographic profiles on Georges Bank. Cruises from 2007, 2008, and 2010 (Table 1) are shown in gray. Data from 1990-1992 are from the National Oceanic and Atmospheric Administration's ongoing monitoring of the region by the Northeast Fisheries Science Center (NEFSC; see http://www.nefsc.noaa.gov/HydroAtlas/). Data from 1998 and 1999 come from U.S. GLOBEC Broad-scale survey cruises (Table B1).