During Spring 2015, the ECOHAB team once again collaborated with MBARI's Controlled Agile Novel Observing Network (CANON) project. As described by long-term mooring observations at the mouth of Monterey Bay, the 2015 ECOHAB experiment was marked by anomalously warm and fresh conditions (label 2 in Fig. 1). During the year leading into the 2015 experiment, both the strength and persistence of warm anomalies were unusual in the 15.5-year reference period. This contrasts with the previous Monterey Bay ECOHAB experiment in September – October 2013, which coincided with anomalously cool and saline conditions (label 1 in Fig. 1). This persistent warm anomaly in Monterey Bay during 2014-2015 is probably linked to a larger pattern observed throughout the greater eastern North Pacific.

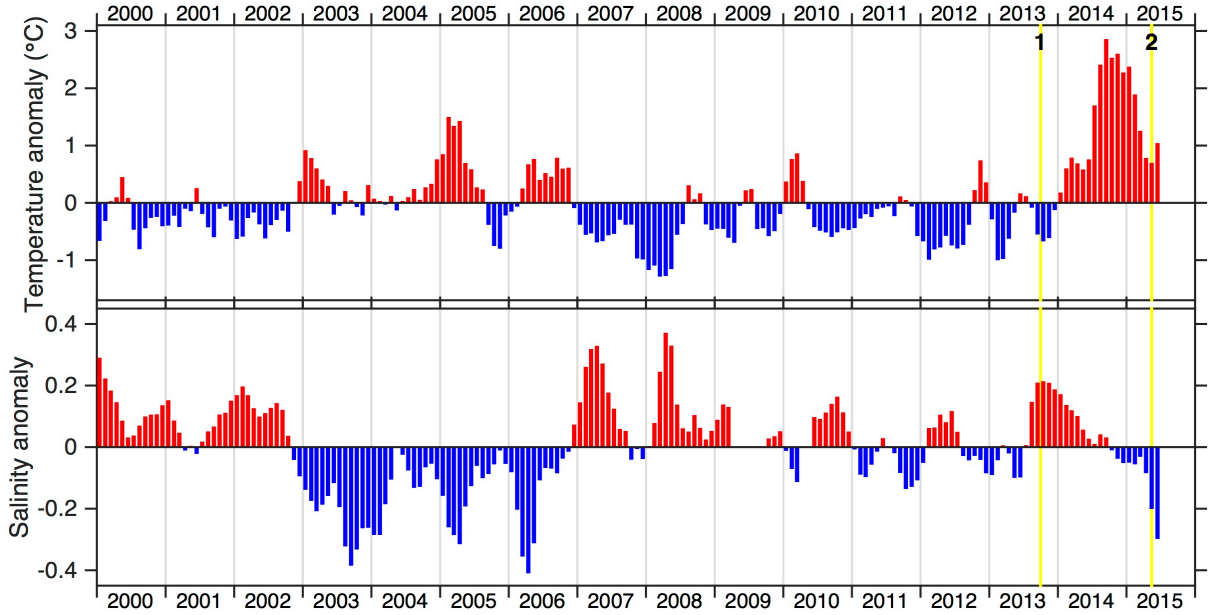
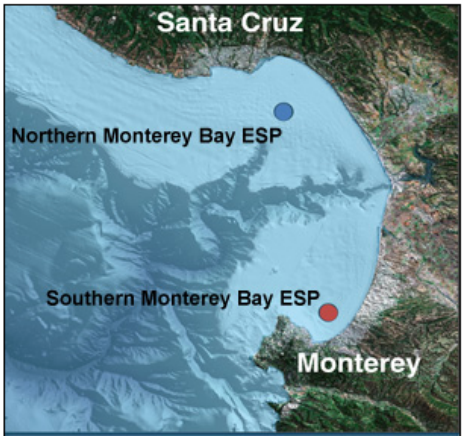


Figure 1. Surface temperature and salinity anomalies at MBARI M1 mooring, at the central mouth of Monterey Bay; anomalies are differences from the monthly climatology, smoothed with a 3-month running mean.



The spring 2015 ECOHAB experiment included deployment of two ESP moorings (map at left). Their deployment in early May was approximately six weeks following seasonal onset of relatively strong and persistent upwelling favorable winds, which caused SST cooling of ~4°C at the mouth of Monterey Bay during February –April (Fig. 2). The shaded period in Fig. 2 defines the ESP deployment period. During the month-long deployment, high-frequency fluctuations in temperature and salinity were superimposed on a trend of warming and freshening. Levels of the toxin domoic acid reached the highest levels ever measured onboard an ESP in situ, and high toxin concentrations were measured throughout the

deployment (Fig. 3). Toxin producing diatoms were dominated by *P. australis* (Fig. 3). Results from other HAB molecular probes on the ESP arrays are being examined, and complementary sampling from ship and AUV platforms are supporting interpretation of the ESP time-series.

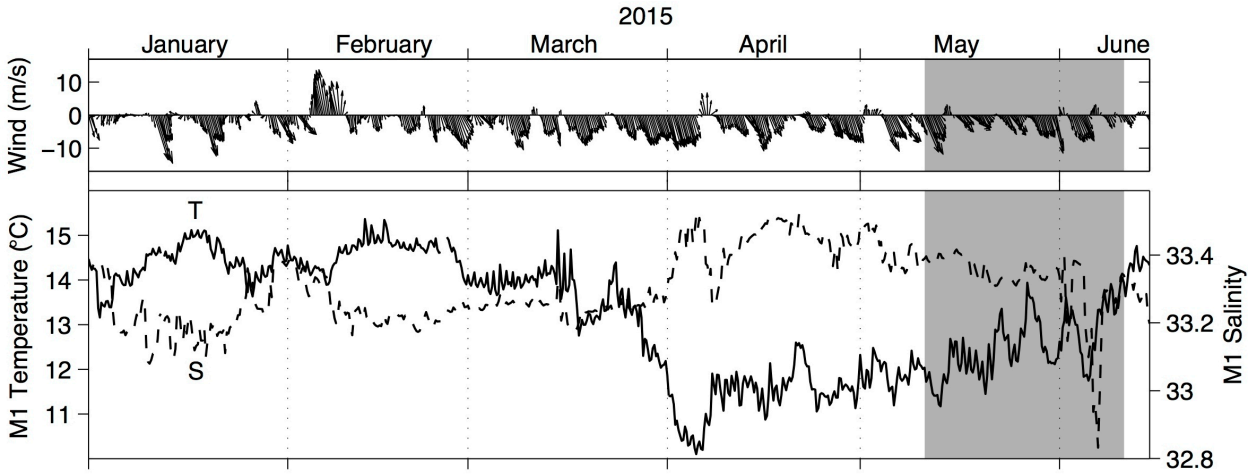


Figure 2. Surface winds at NDBC Station 46042 (top), located 27 nmi WNW of Monterey and representative of regional wind forcing, and surface temperature and salinity at MBARI mooring M1, located in the mouth of Monterey Bay.

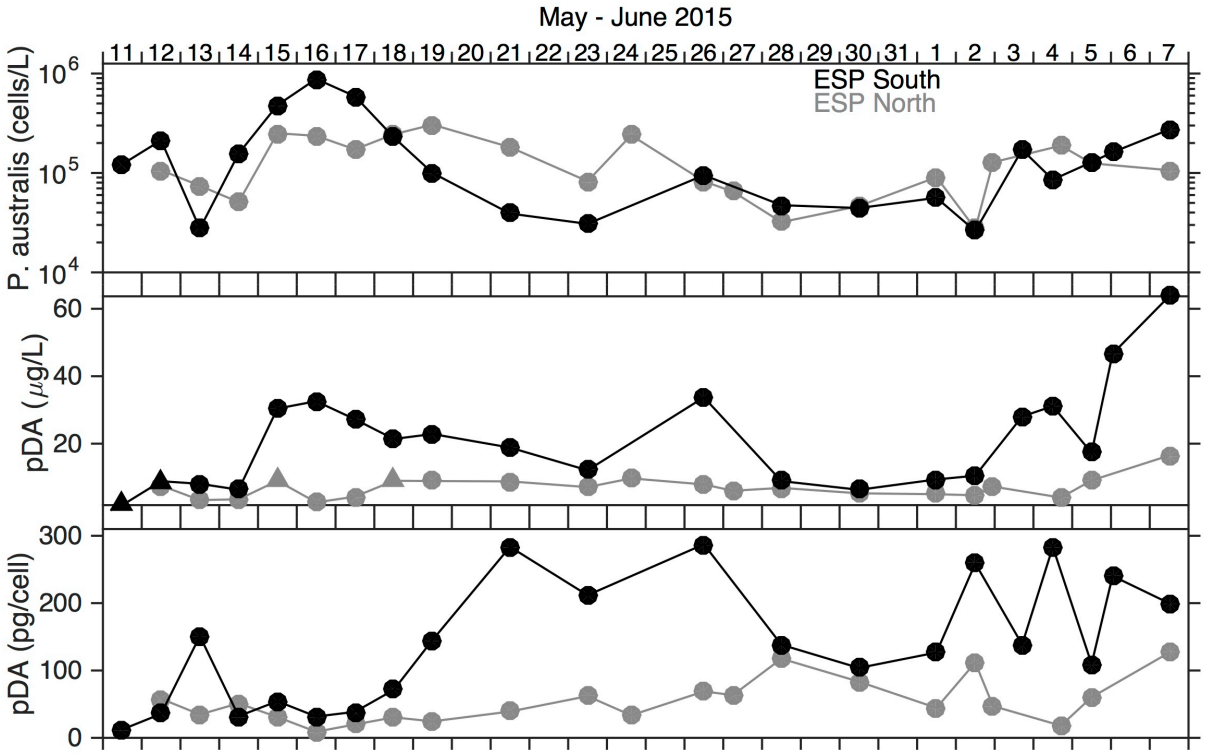


Figure 3. Estimated concentrations of *P. australis*, total particulate domoic acid (pDA), and pDA per cell from both ESP instruments (see map above for locations).

The higher levels of toxin detected by ESP in the southern bay (Fig. 3) motivated application of high-resolution mapping and targeted sampling by the Dorado AUV. Two Dorado surveys were conducted in sections extending across most of the southern shelf (Fig. 4). These surveys revealed that during the period when *P. australis* signal was relatively low at the ESPs in late May (Fig. 3), much of the phytoplankton biomass was concentrated in a layer centered near 20 m depth, below the ESP (Fig. 4, May 28 survey). The increase in *P. australis* signal during early June coincided with shoaling of the subsurface chlorophyll maximum (Fig. 4, June 5 survey). During both Dorado surveys, samples were acquired by the AUV using autonomous detection of chlorophyll maxima.

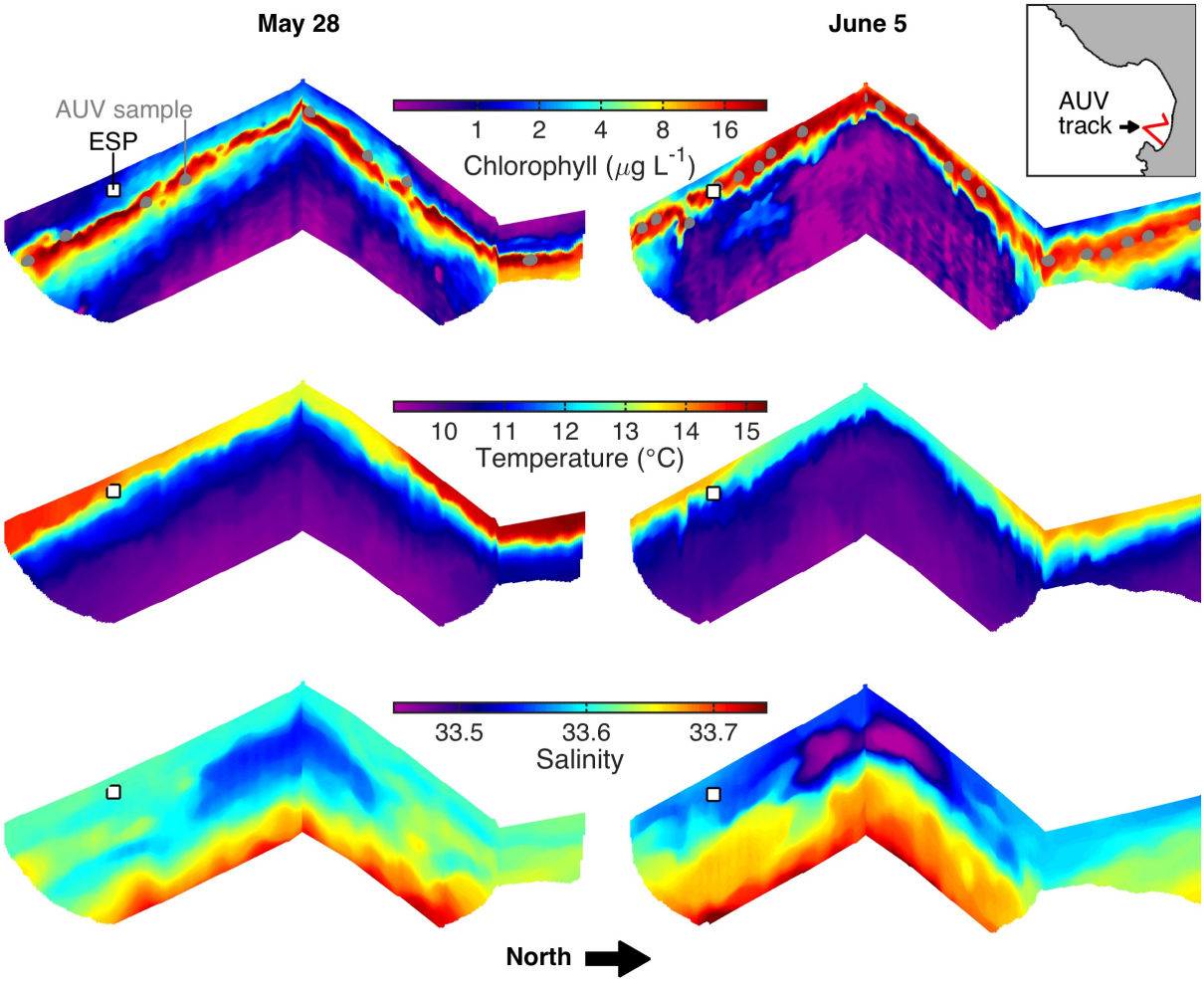


Figure 4. Conditions and sampling locations for each of the Dorado AUV surveys over the southern Monterey Bay shelf. The ESP location shown by the white square corresponds with the southern ESP location shown in the map above. Gray spheres in the chlorophyll sections indicate AUV water sample acquisitions.

A second AUV sampling system was also applied to support high-resolution observations coupled with targeted sampling. This was conducted near the northern bay ESP during the resurgence of HAB signals that occurred in early June (Fig. 3). The long-range AUV Tethys,

conducted a spiral vertical cast and collected samples with 2 m vertical resolution (Fig. 5). These samples will be examined with microscopic and molecular methods to characterize the vertical structure of HAB population species composition and abundance.

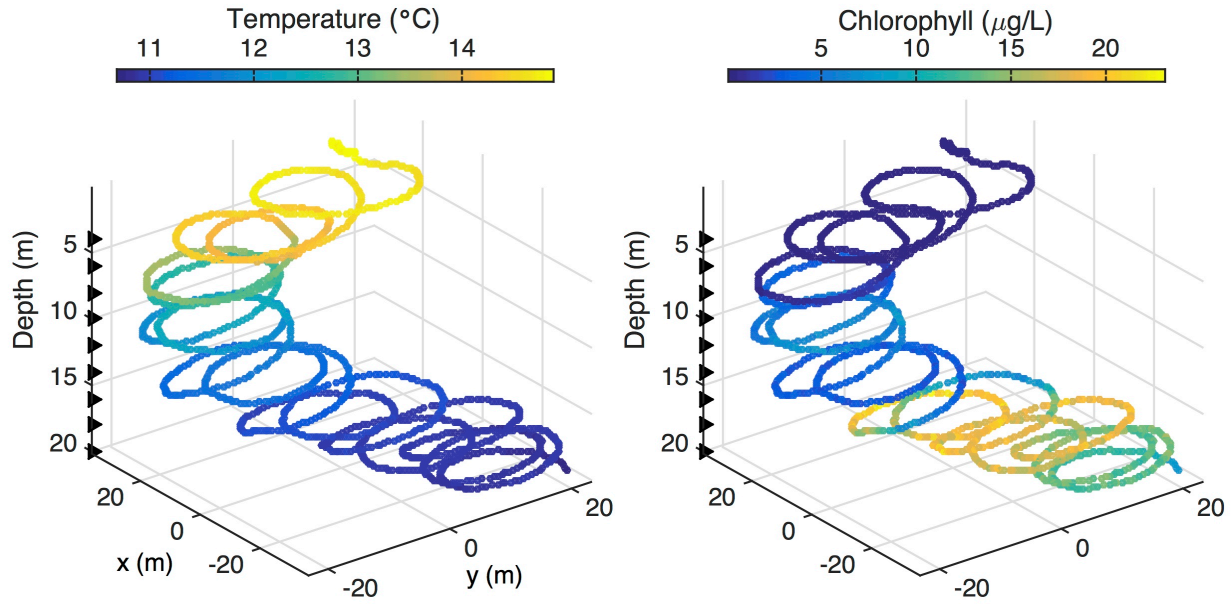
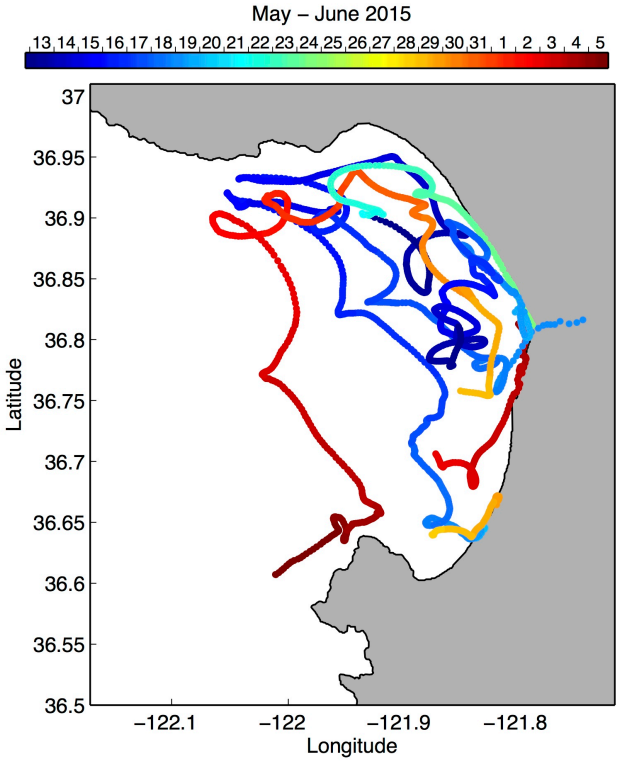


Figure 5. Spiral vertical cast conducted by AUV Tethys near the northern bay ESP location. Triangles mark the depths targeted for sampling.



Deployment of drogued drifters showed the prevalence of retentive shallow circulation patterns during the experiment (Fig. 6). The frequent beaching of drifters suggests shoreward flow convergence, and one drifter was drawn inland through an estuarine channel by tidal circulation (Fig. 6). The primary exception to this retentive flow pattern occurred during spin-up of upwelling late in the experiment, which caused a drifter located near the northern ESP to be exported south of the bay (Fig. 6). Ship sampling at the location of this drifter recovery revealed a very abundant mixed-layer phytoplankton community dominated by diatoms.

Figure 6. Tracks of drifters with drogues between 2-3 m depth, colored by time.

Diversity of *Pseudo-nitzschia* was monitored throughout the 2015 field program as well as before and after. For example, prior to the start of the field program *Pseudo-nitzschia* populations were dominated by *P. multiseries* and *P. fraudulenta* (Fig. 7). However, a transition was observed leading into and during the field program, with *P. australis* coming into dominance (quantitative data in process). Microscopy and molecular analyses applied to samples from ships, AUVs and ESPs will be used to closely examine species composition and its relationships to spatial and temporal variations in the environment.

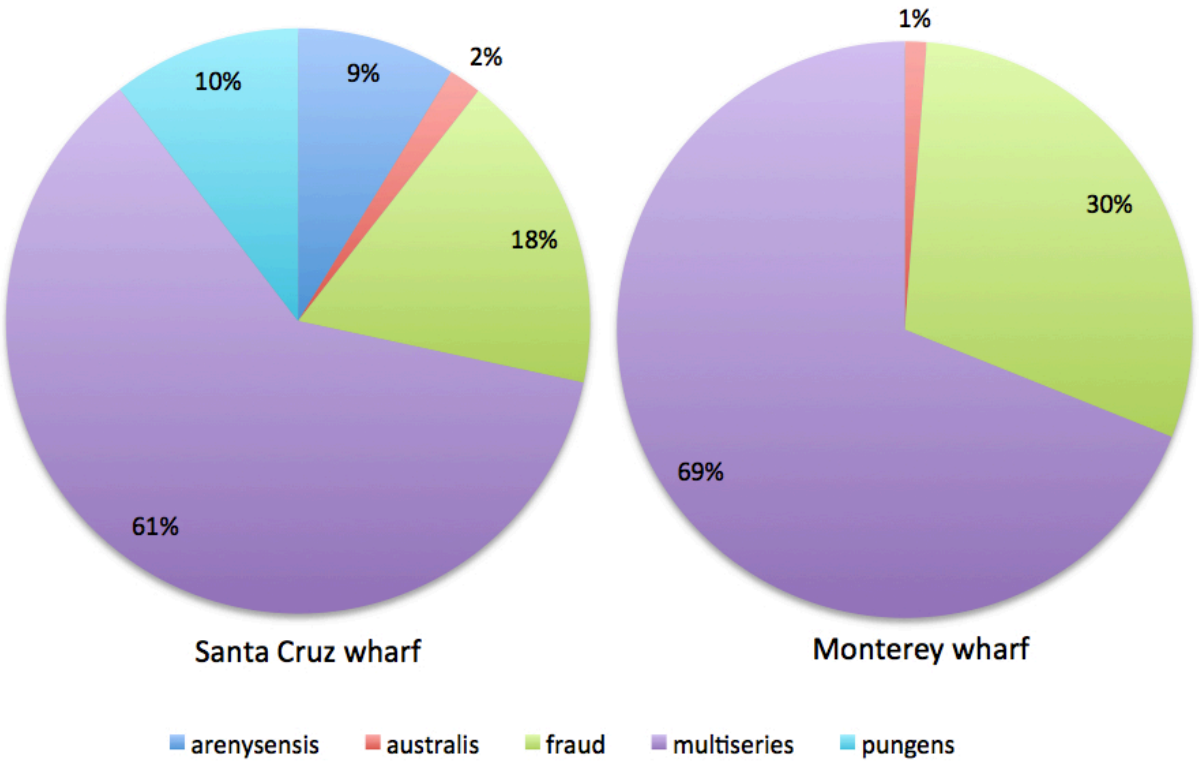


Figure 7. Relative abundances of *Pseudo-nitzschia* sampled on April 8.

Potential toxicity of various *Pseudo-nitzschia* species is being examined with cultured isolates obtained throughout spring 2015. Results thus far surprisingly indicate that *P. multiseries* exhibited little to no toxin production while *P. pungens* exhibited consistent toxin production. Also to our knowledge we have the first report of toxin production in a west coast isolate of *P. seriata*.

Because the domoic acid concentrations measured during the experiment were so high, the research team measured concentrations in tissues of various higher trophic levels. Anchovies are important vectors of biotoxin in the food web, and dissection of anchovies revealed guts packed with *Pseudo-nitzschia* frustules (Fig. 8).

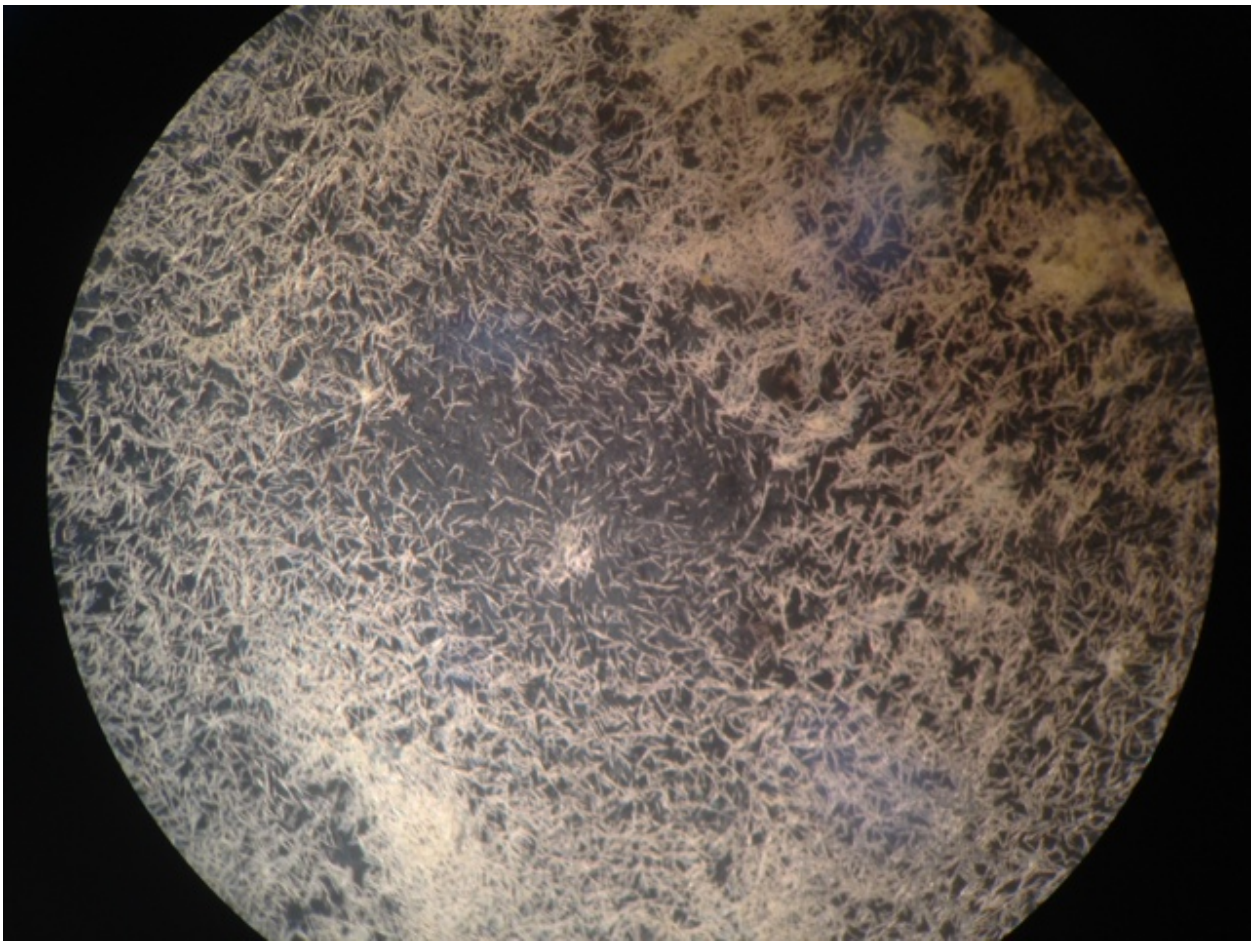


Figure 8. Photo of anchovy gut contents, dominated by *Pseudo-nitzschia* frustules.