An-AUV Based Investigation of the Role of Nutrient Variability in the Predictive Modeling of Physical Processes in the Littoral Ocean

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LONG-TERM GOALS

Our principal long-term goal is to assess the effectiveness of nutrients as tracers of geophysical fields in the oligotrophic littoral ocean, utilizing various sampling and measurement protocols in a feedback approach with a prognostic physical/biogeochemical model. Ultimately, relevant nutrient gradients are to be measured by a nutrient-sensor package aboard an AUV, and so this capability is also a long-term goal. The nutrients to be studied are dissolved nitrate, nitrite, and ammonia because these have the greatest prospect of exhibiting variations that might be useful as tracers.

OBJECTIVES

One objective for this year's work was to collect field data for validation of the first study of physico-chemical modeling on the spatial scale that seems most relevant to the interactions of physical forcing and resultant patch size and dynamics of biological populations: 100-1000 meters. The effort was to obtain empirical descriptions of nutrient "patch" sizes and/or variations in nutrient distributions to begin a comparison with physical circulation cells (Rayleigh-Benard, Langmuir, etc.) and with phyto-plankton/chlorophyll variations in surface coastal waters. The emphasis was validation data for a Large Eddy Simulation (LES) model of 5-m resolution (Harcourt et al., 1997) embedded within a 5-km cell of a Princeton Ocean Model (POM).

The second objective was related to the first, namely to measure seasonal changes in coastal nutrient distributions in support of studies of red tide patches (ECOHAB) and specification of the depth dependence of inherent optical properties (IOP) in coastal waters (HyCODE). Eventually, the deeper nutrient variations are to be compared to surface nutrient variations in order to evaluate possible linkages between processes in surface and near-bottom coastal waters.

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The third objective was to conduct a field test of the AUV version of our nutrient-sensor package for nitrate, nitrite, and ammonia.

APPROACH

Objective 1:
Our approach involved the laboratory version of our nutrient sensor package. The sampler in this package splits a sample stream three ways and simultaneously feeds seawater to highly sensitive fluorescent analytical modules for nitrate, nitrite, and ammonia. Thus, by linking the sampler to a seawater stream from an intake port in the hull of a vessel, the sensor package can analyze horizontal variations in all three nutrients at 2-3 m depth along a cruise track. Detection limits are <10 nM. Salinity and temperature variations along the track can be determined at the same time. R. Masserini at USF was key to the development and deployment of this system. K. Fanning of USF directed the work, and K. Fanning and J. Walsh of USF are to analyze the data along with R. Garwood of the Naval Postgraduate School.

Objective 2:
The approach here was to analyze frozen seawater samples for nitrate, nitrite, phosphate, and silica collected on monthly ECOHAB surveys along established lines in the Control Volume (CV) of the west Florida shelf (26-28 deg N, 82-84 deg W). Monthly cross sections along the lines were then prepared to show temporal variations in nutrient concentrations at all depths in the CV. K. Fanning and H. Rutherford of USF generated the nutrient data, and J. Walsh and K. Fanning of USF evaluated the monthly trends that were detected.

Objective 3:
The nutrient-sensor package in our AUV nose cone was attached to a AUV propulsion unit of the Ocean Engineering department at Florida Atlantic University (FAU) and, the effectiveness of the AUV version of our nutrient-sensor package in measuring nutrient variations was tested at sea along pre-programmed cruise tracks. Salinity, temperature, and other variables were be measured by sensors on the propulsion unit at the same time. Key personnel included R. Masserini and K. Fanning of USF (nose cone) and J. Jalbert of FAU (maintenance, deployment, and recovery of the AUV).

WORK COMPLETED

Objective 1:
Surface waters at 2-3 m depth in the CV were surveyed on two occasions, once in September of 1998 and again in August of 1999. Transects lasted from 1-5 hours with nutrient samples being analyzed once every 200 seconds.

Objective 2:
Monthly ECOHAB sampling of seawater at various depths in the CV began in June 1998 and is continuing. Frozen seawater from each sampling depth has been returned to our laboratory, thawed, and analyzed for nitrate, nitrite, phosphate, and silica (Gordon et al., 1993).

Objective 3:

The AUV version of our nutrient sensor was successfully tested three times on the same August 1999 cruise where the second determination of surface horizontal nutrient variations in the CV was made under Objective 1. The cruise lasted four days.

RESULTS

Objective 1:
During the September 1998 cruise, each of the ten horizontal nutrient surveys in the CV with the laboratory version of the nutrient sensor package lasted ~1 hour and covered ~10 km. The principal discovery on the surveys analyzed so far was that nitrate and nitrite concentrations varied in a sinusoidal horizontal pattern which matched the horizontal temperature pattern. Peak-to-peak distances on both nitrate/nitrite and temperature trends were 900-1300 m, indicating that the "patch" or "cell" sizes of temperature and some nutrients can resemble each other in coastal waters. By contrast, the ammonia pattern did not match either the nitrate/nitrite or the temperature patterns.

Seven horizontal nutrient surveys were conducted in the CV with the laboratory version of the nutrient sensor package during the August 1999 cruise. These were longer, ranging up to 30 km. On Transect 2, a nearly east-west track across the centerline of the CV at ~27.25 deg N, no clear association between small-scale nutrient variations and temperature variations could be discerned; yet, over a 1000-m distance, a front in both temperature and nitrite was observed (Fig. 1). Average nitrite concentrations increased 35 nM (~4 times the detection limit) and average temperature dropped 0.3 deg C. Nitrate,

Figure 1: Transect 2

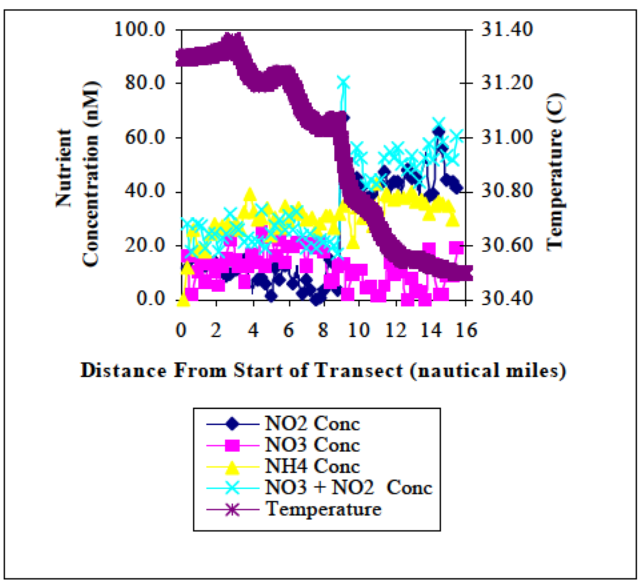
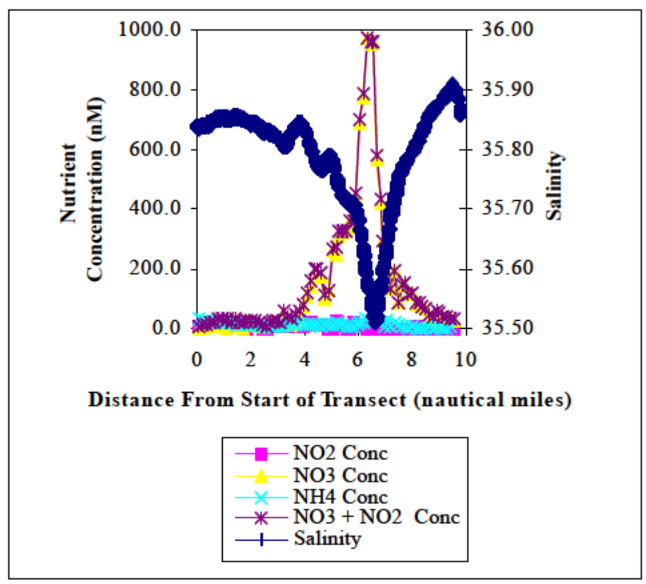


Figure 2: Transect 7



ammonia, and salinity (not shown, but variably ranging from 35.7-36) did not indicate the presence of this front. On Transect 7 through the same waters 2 days later, the situation was very different. A single discrete bolus of lower salinity water (35.5) had moved in (Fig. 2). Interestingly, the low salinity region was also delineated by a tremendous spike of nitrate (up to 1000 nM, or 100 times the detection limit), but not by any distinct changes in nitrite or ammonia. Temperature (not shown) also failed to indicate the bolus and merely oscillated between 30.9 and 31.1 deg C.

These results confirm that nutrients can vary on time and space scales of temperature and/or salinity and that nutrient patterns can provide a strong complement to the study of surface circulation.

Objective 2:
The principal discovery of our monthly nutrient surveys was the existence of a near-bottom region of high nutrient concentration at ~50 m depth all along the west Florida shelf in the CV. The region was first observed in June of 1998 and persisted until January of 1999. Nitrite was the nutrient most frequently showing high near-bottom concentrations (750-1400 nM). A near-bottom nutrient-enriched region appeared again in May of 1999. However, this new region was deeper (~75 m) and poorer in nitrite (500 nM). The ultimate cause and implication of this region is still under investigation, but we anticipate that the structure of the surface circulation in the CV will influence the degree to which any zone of high near-bottom nutrients persists.

Objective 3:
The AUV-version of our nutrient-sensor package was successfully tested three times on the August 1999 cruise mentioned above. Distinct peaks were achieved, showing that the AUV version could distinguish seawater nutrients from wash solutions. Standardization was uncertain due to difficulties with the chemical heaters for the methods, but interesting results were nonetheless obtained. For example, AUV-generated peak heights in nitrate + nitrite were obtained along the same track as Transects 2 and 7 (but further to the west). Whereas those peak heights varied around a more-or-less constant average value of 1.8 millivolts along the track, salinity oscillated around 36.03 for the first half of the track, but then fell sharply to 35.92 during the second half of the track. Temperature, by contrast, varied around 30.17 deg C for the entire track, thus mimicking the variations in nitrate + nitrite. The finding that AUV-generated nutrient results follow temperature better than salinity is consistent with some previous findings using the laboratory version of our nutrient sensor package.

IMPACT/APPLICATIONS

Nutrient concentration distributions obtained by both the laboratory version and the AUV-version of our nutrient sensor package can reveal differences in surface water types that will be useful for applying a non-hydrostatic LES model to compute small scale flows within the POM grid cells. At the turbulence integral scale, physical processes accomplish most of the vertical mixing and dispersion of nutrients (and plankton), and the LES model solutions can be brought to statistical quasi-steady state for a variety of conditions in the Ro, Ri parameter space. This will have applications to SF6 studies, to prediction of red-tide distributions, and to estimates of tempo-spatial variance of IOP.

TRANSITIONS

Once the models replicate these observations of small-scale features of physico-chemical processes on the West Florida shelf, we would anticipate applying them to other ongoing ONR field studies: COBOP at Lee Stocking Island in the Bahamas and LEO-16 on the New Jersey shelf.

RELATED PROJECTS

J. Walsh (N000149910212) is developing a model of plankton succession effecting bio-optical signals on the West Florida shelf. Forty-years of shelf nutrient, plankton, and physical data will be used with the above field studies to validate the model, based on existing circulation and nutrient-cycling models.

R. Weisberg of USF (N000149810158) is applying a primitive equation model at 5-km resolution to observed West-Florida-shelf current fields. It is an adaptation of the POM with topography-following vertical sigma coordinates and horizontal orthogonal curvilinear coordinates. Far-field shelf-break forcing is also being examined using a larger mesh Gulf-of-Mexico model and the present Dynalysis circulation model.

P. Bissett of FERI (N000149810844) is applying Ecological Simulation 2.0 [EcoSim 2.0] to the West Florida shelf to model daily changes in the spectral quality of the downwelling light field. Daily IOP outputs are also coupled with the Hydrolight 4.0 radiative transfer code to predict the upwelling light field at 10:00 am each day. POM, LES, EcoSim 2.0, and the microalgal succession submodel described above will form a 3-D, ecologically complex, bio-optical model of the West Florida Shelf.

REFERENCES

Harcourt, R., L. Jiang, and R. W. Garwood. 1997. Numerical simulation of drifter response to Labrador Sea convection. Naval Postgraduate School Tech. Rept. NPS-OC-98-00, Monterey, CA, pp 1- 70.

Gordon, L.I., J.C. Jennings, Jr., A.A. Ross, and J.M. Krest, A Suggested Protocol For Continuous Flow Automated Analysis of Seawater Nutrients, in *WOCE Operation Manual*, WHP Office Report 90-1, WOCE Report 77 No. 68/91, 1-52, 1993.

PUBLICATIONS

Masserini, R. and K. Fanning, 1999. A Sensor Package for Simultaneous Determination of Nanomolar Concentrations of Nitrite, Nitrate, and Ammonia in Seawater by Fluorescence Detection. Marine Chemistry (in press).

PATENTS

Method for measuring nitrite and nitrate in aqueous medium (US Patent Number 5,858,792).

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