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13. ABSTRACT *(Maximum 200 words)*

This project was part of an interdisciplinary study designed to investigate all aspects of seamount oceanography on the local and mesoscale level. The seamount selected for study was Fieberling Guyot, a deep topographical feature that rises to within 430m from the surface, located at 32°25'N, 127°47'W, just over 1000 km west of San Diego. In addition the biological components of the program chose to study, for comparison, two more shallow, near-shore features, Northeast Bank and Sixtymile Bank, that were visited on cruises out to Fieberling Guyot. During the 3 field years (cruises in September 1989, 1990 and 1991) we made near-surface (ie. the euphotic zone, to approximately 100m depth) measurements of nutrients (nitrate, nitrite, ammonium, silicate and phosphate) and new, regenerated and total productivity of the phytoplankton. The nutrient measurements using nanomolar analysis made it possible to clearly delineate the nitracline to be closely positioned near the chlorophyll maximum at about 110m. The productivity measurements made using stable isotopes (^{13}C labelled bicarbonate and ^{15}N labelled nitrate and ammonium) showed ammonium uptake to exceed nitrate uptake with rates typical of oligotrophic waters (i.e. % new prodn. of 9%). There was interannular variability with higher nutrients and productivity in 1991. The shallow Banks showed more nutrients and productivity as apparently, topographically induced physical events there advect sufficient nutrients into the photic zone for a phytoplankton response, unlike at Fieberling,

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Flow Over Abrupt Topography: The Application of Patterns in Nutrient and Productivity in Reflecting Physical Processes Occurring over an Isolated Seamount.

N00014-89-J-1423, 11/15/88-3/31/94

PI's: Richard C Dugdale and Frances P Wilkerson

Abstract

This project was part of an interdisciplinary study designed to investigate all aspects of seamount oceanography on the local and mesoscale level. The seamount selected for study was Fieberling Guyot, a deep topographical feature that rises to within 430m from the surface, located at 32°25'N, 127°47'W, just over 1000 km west of San Diego. In addition the biological components of the program chose to study, for comparison, two more shallow, near-shore features, Northeast Bank and Sixtymile Bank, that were visited on cruises out to Fieberling Guyot. During the 3 field years (cruises in September 1989, 1990 and 1991) we made near-surface (ie. the euphotic zone, to approximately 100m depth) measurements of nutrients (nitrate, nitrite, ammonium, silicate and phosphate) and new, regenerated and total productivity of the phytoplankton. The nutrient measurements using nanomolar analysis made it possible to clearly delineate the nitracline to be closely positioned near the chlorophyll maximum at about 110m. The productivity measurements made using stable isotopes (^{13}C labelled bicarbonate and ^{15}N labelled nitrate and ammonium) showed ammonium uptake to exceed nitrate uptake with rates typical of oligotrophic waters (i.e. % new prodn. of 9%). There was interannular variability with higher nutrients and productivity in 1991. The shallow Banks showed more nutrients and productivity as apparently, topographically induced physical events there advect sufficient nutrients into the photic zone for a phytoplankton response, unlike at Fieberling.

Goal of the study

To understand the interaction between physical processes and water column nutrient productivity patterns in the vicinity of abrupt, deep and shallow topographical changes.

Objectives

- To measure concentrations of algal biomass and nutrients and identify the nitracline at the deep seamount Fieberling Guyot and near 2 shallow topographical features, Sixtymile Bank and Northeast Bank-both occurring near or in the California Current.
- To estimate new and regenerated production in water column around these 3 different topographical features.

Approach

Using conventional AutoAnalyzer methodology, measure ammonium, nitrate, nitrite, silicate and phosphate in the upper depths of the water column at CTD stations. In addition a very sensitive chemoluminescent method was used to measure nitrite and nitrate at the nanomolar level at selected depths (down to 100m).

Incubate water samples with either ^{15}N labelled nitrate or ammonium and assay incorporation by the particulate fraction using mass spectrometry to estimate new and regenerated production respectively.

Results

We completed the only detailed survey of the photic zone and phytoplankton activities around a seamount as part of the TOPO (Flow over abrupt topography) research initiative during 3 month-long cruises in 1989, 1990 and 1991. Fieberling Guyot (the seamount) lies at the outer edge of the California Current, a typically oligotrophic environment, with ambient concentrations of ammonium and nitrate below or at the level of detection at most stations sampled during the TOPO-Water Column Biology 1989 cruise (except in 1991 surface nitrate concentrations reached 1 μM) in the upper 100m using Autoanalyzer methodology.

By using a chemoluminescent method for measuring nitrate and nitrite that is sensitive at the nanomolar range signals that might be lost in the noise of micromolar analysis systems have been identified in the waters above Fieberling and so the nitracline clearly delineated. The system uses technology originally designed by atmospheric chemists to measure atmospheric NO_x molecules for pollution studies. Following the Garside (1982) methodology, seawater is acidified, converting NO_3 or NO_2 to NO_x which is introduced into the NO_x analyzer in a stream of helium. The machine combines the NO_x with ozone and the chemoluminescent product is measured by a photomultiplier. The nitracline was at about 120m and nanomolar nitrate profiles from the upper 125m from four stations occupied around the guyot in September 1989 suggested spatial variability of nitrate in the upper euphotic zone with extremely low values to the southeast, confirming the mesoscale observations of Roden (1991) of a warm anticyclonic intrusion from the southwest and a cooler cyclonic intrusion from the northeast. Nanomolar nitrate profiles from a northwest to southeast transect showed higher nitrate upstream from the guyot, with an apparent frontal feature above the down-stream edge in the upper 90m. The nitracline was located just within the deep chlorophyll maximum at 110m at Fieberling Guyot at all stations suggesting that the populations are probably nutrient limited and not light limited in the euphotic zone and that primary productivity is nitrate limited.

Primary productivity is fueled by two sources of nutrients, newly supplied nutrients such as nitrate that are typically supplied from depth, and regenerated nutrients (eg. ammonium) that are recycled in the upper waters as phytoplankton are grazed and elements are released by grazer excretion. Using this concept new production can be equated to nitrate uptake and regenerated production to ammonium uptake and the sum is equivalent to total or primary production. Each type of uptake can be measured using stable isotopes, ^{15}N labelled nitrate and ammonium and ^{13}C labelled bicarbonate to measure primary production. The values of new production and *f* (% new

production) at Fieberling Guyot (f = 9-16%) resemble other oligotrophic areas such as the Sargasso Sea (f = 4%), Gulf Stream (3%) and Mediterranean Sea (21%). During all TOPO cruises ammonium uptake was greater than nitrate uptake at all stations and showed high values to the east of Fieberling. Interestingly higher values of new production and f were observed in 1991 when higher concentrations of nitrate were observed above the seamount. Surface values of f reached 57%, more comparable to an El Niño year at the Point Conception upwelling center

Interannual varaibility was observed at Fieberling Guyot, with higher nutrient concentrations and nutrient uptake occuring in 1991 compared with the previous 2 years. All cruises were carried out in September to October to minimize seasonal variability. Nutrient concentrations and nitrate uptake values were the lowest in 1990.

Using 1991 data the nutrients and nutrient uptake data from Fieberling Guyot were compared with data collected from the shallow topographical features Sixtymile Bank and Northeast Bank (TABLE 1) although only a few stations were occupied at these sites as the TOPO emphasis was selectecto be Fieberling. The 1991 data set for Fieberling may be anomalously high for reasons we cannot explain. However, in 1991, both at the surface and at 15%LPD, nutrients were of greater concentration at Fieberling compared with Sixtymile Bank whereas particulate nitrogen (measure of phytoplankton biomass) concentration and nitrogen uptake were similar in value between Fieberling and Sixtymile Bank. The single vertical profile carried out at Northeast Bank had much higher nutrient concentrations, PON and uptake values than the other two features. The f values (%new production) for the Sixtymile Bank and Northeast Bank were low (20% to 30%) as would be expected for their California Current location in relatively oligotrophic waters (see above), whereas the high value of 50% for Fieberling Guyot was atypical of the area as illustrated by the 1989 and 1990 uptake data.

Data available

For TOPO 89 (8-22 Sept. 1989), TOPO 90 (29 Sept.-17 Oct. 1990) and TOPO 91 (12 Sept.-2 Oct. 1991), for approximately 40-60 CTD stations (nutrients only) and 11-15 productivity stations (^{15}N and ^{13}C and nutrients) each cruise, the following data sets are available from this component of TOPO and are presently being synthesized and used for geographical and interannual comparisons:

NO_3, NO_2, $Si(OH)_4$, PO_4 concentrations at the µM level to 500m depth
NO_3, NH_4 concentrations at the µM level using shipboard AutoAnalyzer to 100m depth
NO_3, NO_2 concentrations at the nM level with chemoluminescent analysis to 100m depth
^{15}N NO_3, and ^{15}N NH_4 uptake, and ^{13}C and ^{14}C fixation
Uptake versus Irradiance curves for ^{13}C and ^{15}N NO_3

Accomplishments

- Defined the nitracline above Fieberling Guyot using nanomolar nitrate measurements and were able to show changes in nitrate at the nanomolar level spatially around the seamount, and temporally over the 3 years of study.

- Collected a full data set of new, regenerated and total productivity measurements for an oligotrophic California Current regime, for comparison with our eutrophic data sets for the California coastal upwelling systems.

Publications/Presentations from this project

Wilkerson, F.P. and R.C. Dugdale. 1989. N-15 and nutrinet measuremnets obtained during TOPO 89 cruise to Fieberling Guyot. TOPO PI Meeting Seattle, WA

Wilkerson, F.P., R.C. Dugdale and C.D. Kopczak. 1990. Measuremnets of new and regenerated production in the water column over Fieberling Guyot. AGU/ASLO Ocean Sciences Meeting, New Orleans. LA

Kopczak, C.D., F.P. Wilkerson, and R.C. Dugdale. 1990. Structure of the nutricline near Fieberling Guyot in the eastern North Pacific, AGU/ASLO Ocean Sciences Meeting, New Orleans. LA

Dugdale, R.C., R. Kudela, C. Kopczak and F.Wilkerson. 1992. Nutrient distributions in the nearfield of a submarine topographical feature. ASLO Aquatic Sciences Meeting, Santa Fe, New Mexico.

Dugdale, R.C. 1991. Nutrient limitation of new production, Brookhaven Symposium. Long Island, NY.

Dugdale, R.C., R.M. Kudela, C.D. Kopczak and F.P. Wilkerson. 1991. Nutrinet regimes and nitrogen productivity around Fieberling Guyot- a seamount located on thr western margin of the California Current, EPOC91, Lake Arrowhead, CA.

Dugdale, R.C., and F.P. Wilkerson.1992. Nutrient limitation of new production in the sea. In: Primary Productivity and Biogeochemical Cycles in the Sea, Falkowski, P.G. and A.D. Woodhead (eds), Plenum Press, NY, pp. 107-122,

In preparation/Draft Publications

Dugdale and Wilkerson 1993. TOPO89 (8-22 Sept. 1989) R/V New Horizon Data Report: Nutrients and Nitrogen Uptake

Dugdale and Wilkerson 1993. TOPO90 (29 Sept. - 17 Oct. 1990) R/V New Horizon Data Report: Nutrients and Nitrogen Uptake

Dugdale and Wilkerson 1993. TOPO91 (12 Sept. -2 Oct. 1991) R/V TGT Thompson Data Report: Nutrients and Nitrogen Uptake

Wilkerson, F.P., R.C. Dugdale, C. Kopczak and R. Kudela. Temporal and spatial differences in euphotic zone nutrients and productivity around Fieberling Guyot during 1989, 1990 and 1991.

Wilkerson, F.P., R.C. Dugdale, C. Kopczak and R. Kudela. Comparison of nutrient and nutrient uptake occuring around a deep versus a shallow topographical feature in the California Current.

TABLE 1 Comparison of nutrient concentrations and nutrient uptake data from Feberling Guyot and Sixtymile Bank and Northeast Bank during TOPO91

	Nitrate μM	Ammonium μM	PON μM	ρNO_3 ng-at $l^{-1}h^{-1}$	ρNH_4 ng-at $l^{-1}h^{-1}$
Fieberling, 1991 surface	1.16±0.77 (n=5)	0.19±0.09 (n=5)	0.21±0.11 (n=5)	3.4±2.7 (n=5)	2.6±0.9 (n=5)
Sixtymile Bank 1991 surface	0.20±0.03? (n=3)	0.11±0.013? (n=3)	0.30±0.03 (n=2)	2.4±0.3 (n=2)	8.4±0.6 (n=2)
Northeast Bank, 1991 surface	1.80	0.29	0.69	7.0	15.6
Fieberling, 1991 15%LPD	1.01±0.71 (n=4)	0.05±0.06 (n=3)	0.31±0.13 (n=4)	1.1±0.9 (n=4)	1.2±0.1 (n=2)
Sixtymile Bank 1991 15%LPD	0.17±0.02 (n=3)	0.09±0.018 (n=3)	0.41±0.16 (n=2)	2.7±0.2 (n=2)	6.2±3.4 (n=2)
Northeast Bank, 1991 15%LPD	1.80	0.29	0.52	2.0	8.9