PHYTOPLANKTON DISTRIBUTIONS IN RELATION TO MESOSCALE EDDY FIELDS

Principal Investigator: Gary L. Hitchcock
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The primary objective of this research program was to (1) survey the spatial distribution of phytoplankton biomass in the coastal regions of the western Arabian Sea in summer, 1995, (2) deploy surface drifters instrumented with fluorometers to describe surface pigment distribution in relation to summer monsoon forcings, and (3) develop a subsurface float in conjunction with Webb Research, Inc. to profile pigment fluorescence over the upper 200 meters of the ocean.

Results:

In summer, 1995 pigment distributions in the western coastal Arabian Sea were derived from instrumented Lagrangian surface drifters and conventional ship-based surveys. Surface drifters instrumented with solid-state fluorometers recorded variations in pigment fluorescence as surface water parcels were advected offshore in two coastal regions of the western Arabian Sea. Spatial distributions of the near-surface pigment, nutrient, and physical properties were also compiled from CTD surveys conducted in 1995 by the NOAA Ship *Baldrige*. The surveys have been interpreted to describe seasonal patterns of surface salinity, temperature, nutrients, and pigment fields along a zonal gradient in April-May and July-August, 1995 for the coastal waters of Oman and Somalia. The surveys extended offshore to the mid-Arabian Sea moored array deployed by other ONR investigators.

Six instrumented surface drifters were deployed in the coastal waters, three each off the coast of Oman and Somalia. The drifters deployed in the coastal waters of Somalia reveal that during the summer monsoon phytoplankton populations can be rapidly advected offshore within a cool surface filament which defines the northern edge of the Great Whirl. This mesoscale eddy forms each year during the 'spin-up' of the summer monsoon. Three surface drifters launched in August exited the filament after two days, and were rapidly advected north between Somalia and the island of Socotra. Thereafter the drifters traveled east, meandering to 17° N, 63° E by late October. Sea surface temperature imagery showed the drifters were retained in a thermal front separating cooler, nearshore waters from the warmer, oceanic waters of the Arabian Sea. Drifters launched in the Omani upwelling zone, in contrast, remained within the upwelling zone for one to four weeks in August. Trajectories show the drifters meandering along the shoreward edge of a coastal front. Surface temperature (< 24° C) and fluorescence values (2 to 5 $\mu g\ l^{-1}$) from the drifters agreed with surface values derived from SST images and pigment samples from ships. All drifters showed a pronounced diel cycle in fluorescence

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that increased from minimum values at local noon to maximum values at dusk. This cycle reflects mid-day inhibition by saturating solar irradiance. Fluorescence values at dusk were converted to pigment concentrations to estimate daily *in situ* chlorophyll values.

Two prototype ALACE B floats were developed in conjunction with Webb Research, Inc. to profile physical (temperature, depth) and bio-optical (chlorophyll *a* fluorescence) parameters in the upper water column. The floats ascend over a maximum depth interval of 400 meters at predetermined times by expanding a collar with gaseous CO_2. Two profilers were deployed in the Grenada Passage in late March, 1996. Both equilibrated at depths of 200 meters, and each completed more than 10 round trips recording pressure and fluorescence at intermediate depths. Fluorescence profiles revealed a deep pigment maximum in the western Caribbean Basin.

Summary:

Our principal contribution to biological oceanography has been to quantify variability in phytoplankton biomass from a Lagrangian observational frame. Instrumented platforms such as surface drifters and floats provide a means of assessing the spatial variability in phytoplankton biomass through bio-optical measurements. Since plankton are Lagrangian in nature, observations from drifters and floats reveal temporal variation in biomass within water parcels 'tagged' by platforms. The studies in the Arabian Sea, for example, show that coastal phytoplankton populations can be retained in the nearshore environment for periods of weeks or, in more energetic regimes, rapidly advected offshore. Typical ship-based transects do not reveal these patterns. Our surveys of zonal distributions of surface properties across the western Arabian Sea will compliment observations from concurrent GLOBEC and JGOFS studies in the northern Arabian Sea.

Publications, presentations supported by N00014-95-1-0252:

Mariano, A. J., G. L. Hitchcock, C. J. Ashjian, D. B. Olson, T. Rossby, E. Ryan, and S. L. Smith. 1996. Principal component analysis of biological and physical variability in a Gulf Stream meander crest. *Deep-Sea Research.* 43: 1531-1565.

Hitchcock, G. L., D. B. Olson, S. Cavendish, and E. Kanitz. 1996. A GPS-tracked surface drifter with cellular telemetry capabilities. *Marine Technology Society Journal.* 30(2): 44-49.

Olson, D. B., G. L. Hitchcock, D. K. Young, and J. Kindle. 1995. Monsoonal phytoplankton responses: Observations and models. pp. 459 - 468 In: *The Arabian Sea: Living Marine Resources and the Environment.* (Eds.) M. - F. Thompson and M. Tirmizi. American Inst. Biol. Science. Vanguard Books, (Pvt.) Ptd. Lahore, Pakistan.

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Dorson, D., and G. L. Hitchcock. 1995. An expendable fluorometer for oceanic surface drifters. EOS. 77: OS51.

Hitchcock, G. L., A. J. Mariano, and C. J. Ashjian. 1994. A principal component analysis of bio-physical fields in a Gulf Stream meander crest. EOS. 75: 40.

Student Support:

One undergraduate student was supported by this project, Mr. Tao Semko. Mr. Semko graduated Magna Cum Laude, from the University of Miami in 1996.

One high school student was supported in the summer of 1995 and 1996 through the O.N.R. Honors Program; Ms. Heather Mason has now matriculated in the premed program at Harvard University.