Final Report on Remote Sensing of Ocean Color in the high Arctic (NAGW-~~3578~~) 5123

062057

Project Title: Remote sensing of ocean color in the high Arctic.
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Award Number: NAGW-~~3578~~ 5123
Project Duration: 1/1/93-9/30/97

Project Summary--UDU Component (originally UT @ Knoxville)

With four years of NASA SeaWiFS funding I established a completely new capability and expertise for in-water optical measurements nearly from scratch and with very little optical background. My first-year budget included only capital for a profiling spectral radiometer. Over the next 30 months we conducted six cruises and collected almost 300 optical profiles in challenging environments; many were collected from 21' launches. I also changed institutions during this period: it is very disruptive to move, set up a new lab, and hire and train new people, etc. We also did not have access to NASA funds for almost a year during the move because of difficulties in subcontracting and/or transferring funds. Nevertheless, we delivered data sets from six bio-optical cruises from three high latitude regions, although only two or three cruises from two areas were promised for our SeaWiFS research. The three Canadian Arctic field programs comprise the most comprehensive high latitude bio-optical and biogeochemical data sets in existence (Table 1). Optical and pigment data from all six cruises have been submitted to NASA and are being included in the algorithm development test set. Additional data are still being submitted.

Table 1. Investigators responsibilities. Multiple listings imply interactions in experimental design, data acquisition and/or modeling. * complete and available, ** not completed, ND not done.

Observation(s)	Investigator(s)			
	Cota	Platt	Sathyendran.	Harrison
Optical				
Incident spectral irradiance $E_d(0^-,\lambda)$	C*			
Downwelling spectral irradiance $E_d(z,\lambda)$	C*			
Upwelling spectral radiance $L_u(z,\lambda)$	C*			
Spectral absorption & attenuation $a,c(z,\lambda)$	C*			
Sea surface reflectance $L_u(0^+,\lambda)$	C*			
Biological/Chemical/Physical				
Chlorophyll a & phaeophytin (fluoro)	C*			
Phytoplankton pigments (spectro)	C*			
Phytoplankton pigments (HPLC)	ND			
Total suspended matter (TSM)	C*			
Particulate organic nitrogen (PON)				H*

Particulate organic carbon (POC)				H*
Colored Dissolved Org. Matter (CDOM)	C*			
Dissolved Organic Carbon (DOC)				H**
^{14}C-Primary production - 6 & 24h	C*			
^{14}C-&^{13}C-Photosynthesis vs. irradiance	C*			H*
^{14}C-Spectral photosynthesis	C*			
^{15}N-New production ($^{15}NO_3$-&$^{15}NH_4$)	C*			H*
$^{15}NO_3$-&$^{15}NH_4$-Uptake vs. irradiance	C*			H*
Particle absorption spectra	C*			
Phytoplankton species counts	C*			
Inorganic nutrients				H*
Conductivity & temperature	C*			
In situ FRR fluorescence profiles	no instrument			
Ambient				
Sky and sea state photographs	C*			
Secchi depth	C*			
Air and water temperature	C*			
Satellite				
Image processing	none available			
Algorithm development	C*	P**	S**	
Bio-optical modeling	C*	P**	S*	

Our SeaWiFS data clearly show that polar waters have a large dynamic range which must be encompassed in algorithm development. Polar waters have unique bio-optical properties compared with temperate data and models with high pigment specific attenuation in the blue. There are also important regional differences with very high soluble absorption in the Canadian Arctic Archipelago. Our results show that blue-green band ratio algorithms provide good chlorophyll retrievals when properly tuned for high latitudes, and that water-leaving radiance from solar induced fluorescence in the Canadian Arctic may provide reasonable instantaneous estimates of primary production with robust backscatter corrections. However, the degree and variability of nonphotochemical quenching appears to be more problematic in subsequent observations and must be determined for each regime. The universality of any algorithms requires extensive evaluation.

A series of publications are in preparation with several more to follow. Our results have been presented at national and international meetings and workshops (14 total) and in seminars here and elsewhere. I have participated in the SeaWiFS bio-optical algorithm and primary production working groups. I have contributed to the absorption workshop and the resulting technical report. I am also a member of NASDA's OCTS and GLI science teams. Our synthesis, modeling and publication efforts have lagged behind because of the amount of field work, new instrumentation (near prototype with crude software) and personnel, a move to a new institution, and other commitments. Some data sets, particularly our optical data, have been

reprocessed several times because of software, instrument modifications, recalibrations, etc. I take full credit for these delays; I prefer to be confident of the quality control and interpretation of the data before distribution. Even my Co-Is have had to wait for certain data, and their progress has been impeded by my efforts to minimize mistakes. Platt and Sathyendranath are both involved in bio-optical and photosynthesis modeling of this data. We also established a web site to disseminate data and derived products to a number of colleagues.

A total of five undergraduate and two graduate students have participated in field programs or worked in my lab on this project. They have gained invaluable experience and skills.

Our algorithm development efforts encompass most of the potential data products listed for SeaWiFS, and addresses product validation for a specific area of concern, i.e. high latitudes and coastal waters. We are continuing high latitude work with SIMBIOS, and wish to compare high and low latitude coastal systems.

Manuscripts in Preparation

Cota, G.F. and W.G. Harrison. 1997. Record levels of phytoplankton production in the Canadian Arctic. Science.

Cota, G.F. 1997. Bio-optical relationships for high northern latitude waters. J. Geophys. Res.

Cota, G.F. 1997. Algorithms for Arctic remote sensing: Phytoplankton biomass and production. Cont. Shelf Res.

Harrison W.G. and G.F. Cota. 1997. Total and new production in the Canadian Arctic. Limnol. Oceanogr.

Cota, G.F. and W.G. Harrison. 1997. Photophysiological coupling of carbon and nitrogen in Arctic phytoplankton. Cont. Shelf Res.

Cota, G.F. and J.M. Fougerousse. 1997. Pigment packaging effects in Arctic phytoplankton.