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JGOFS studies in the equatorial Pacific

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Abstract—This special issue is the third and final volume containing results from the JGOFS Process Study in the equatorial Pacific. Most of the contributions evolved either from the US JGOFS workshop in 1994 on the equatorial Pacific in Scottsdale, AZ or from the NATO Advanced Research Workshop on the Carbon Cycle of the Equatorial Pacific in 1995 in Noumea, New Caledonia. © 1998 Elsevier Science Ltd. All rights reserved

The equatorial Pacific Ocean plays a major role in two aspects of the global carbon cycle: the flux of CO_2 to the atmosphere; and the export of organic carbon and $CaCO_3$ to the deep sea. JGOFS planning for the Equatorial Pacific Process Study began in September 1989 with the Pacific Basin Meeting in Honolulu (JGOFS, 1990a, Report No. 3). JGOFS established the Equatorial Pacific Task Team under the leadership of Margaret Leinen. National plans were discussed in April 1990 at the Equatorial Pacific Planning Meeting in Tokyo (JGOFS, 1990b, Report No. 8). Since then Australia, France, Japan and the United States have conducted major field programs (Table 1). The emphasis is on carbon fluxes and their controls. Some examples of what we learned from these studies have been summarized previously (Murray *et al.*, 1995).

This volume is the last of three special issues of Deep-Sea Research on the equatorial Pacific. It contains 25 papers that reflect the breath and detail of those studies. Five of the papers (Archer *et al.*, 1997; Feely *et al.*, 1997; Berelson *et al.*, 1997; Smith *et al.*, 1997; Foley *et al.*, 1997) are synthesis studies initiated at the US JGOFS Equatorial Pacific Workshop in Scottsdale, Arizona in June 1994. A sixth paper in this synthesis series has been published by Landry *et al.* (1997).

An important step in the synthesis process was the NATO Advanced Research Workshop on the Carbon Cycle of the Equatorial Pacific. This workshop was held at the Centre ORSTOM (Organization de la Recherche Scientifique des Territoires Outre-Mer) de Noumea in June 1995. This was the first opportunity to bring together participants in various national components of the JGOFS Equatorial Pacific Process Study. 51 scientists from nine countries participated. This volume contains 21 papers that were presented at that workshop.

This issue highlights some of the major accomplishments of this JGOFS Process Study. We would like to emphasize some points in this introduction.

We have substantially improved our knowledge of carbon fluxes and their controls in the

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Table 1. JGOFS cruises in the equatorial Pacific

Country	Ship/program	Dates	Location
Australia	R/V Franklin	Aug 1990	10S–10N; 155E
		Jun 1992	10S–10N; 155E
		Aug 1993	10S–10N; 155E
France	Merchant Ships (several)	Oct 1994	equator; 100W
	R/V Atalante (FLUPAC)	Oct 1994	15S–6N; 195E equator; 165E–150W
	R/V Atalante (OLIPAC)	Nov 1994	16S–2N; 150W
	R/V Atalante (EBENE)	Oct 1996	12S–8N; 180W
Japan	R/V Hakuho Maru	Sep 1990	15N–10S; 180W
			equator; 170W
			10N–10S; 160W
		Nov 1990	5N–5S; 179E
			5S; 160E–179E
			5N–5S; 160E
		Sep 1992	
		Nov 1993	5N–8S; 160W
	R/V Hakurei Maru (NOPACCS)	Aug–Oct 1990–1994	48N–20S; 175E
		Apr–Jun 1993–1995	48N–20S; 175E
	R/V Kaiyo	Dec 1993	western-central equatorial Pacific
		Dec 1994–Jan 1995	
		Dec 1995	"
		Jan 1996	"
		Jan 1997	"
U.S.	R/V Wecoma	Nov 1991	140W (trap deployment)
	R/V Thompson (EqPac–NSF)	Feb 1992	12N–12S; 140W
		Apr 1992	equator; 140W
		Aug 1992	12N–12S; 140W
		Oct 1992	equator; 140W
		Nov 1992	12N–12S 140W
		Jan 1993	140W (trap recovery)
	R/V Baldrige (EqPac-NOAA)	Mar–May 1992	10N–10S; 110W, 125W, 140W, 170W
	R/V Discoverer (EqPac-NOAA)	Sep–Nov 1992	10N–10S; 95W, 110W, 125W, 140W, 170W
	R/V Thompson (Zonal flux)	Apr 1996	equator; 165E–150W

equatorial Pacific (Feely *et al.*, 1997; Rodier and LeBorgne, 1997; Hansell *et al.*, 1997; Wakeham *et al.*, 1997; Zhang and Quay, 1997; Zhang and Dam, 1997; Berelson *et al.*, 1997; Smith *et al.*, 1997; Mackey *et al.*, 1997; Walsh *et al.*, 1997; Dunne *et al.*, 1997; LeBorgne and Rodier, 1997 and Nozaki *et al.*, 1997).

Initial estimates were that dissolved organic carbon (DOC) was the major form of exported new carbon production (Feely *et al.*, 1995; Murray *et al.*, 1994). As synthesis has proceeded the contribution due to DOC has decreased. Murray *et al.* (1996) concluded that when integrated over 10°N to 10°S new production and particulate export were approximately in balance. Archer *et al.* (1977) used a simple model to argue that DOC export was roughly half of the new production. In this issue, Hansell *et al.*, 1997; Zhang and Quay, 1997; Quay, 1997, and Loukos *et al.*, 1997, produce arguments, from different directions, suggesting that DOC export is less than half of the new production. Hernes *et al.* (submitted) also support this conclusion by comparing ^{234}Th-corrected POC fluxes for two sediment traps with different designs with new production.

Even though we have improved the uncertainties for individual carbon flux measurements to ±30–50%, there is only a 30% chance that a carbon budget can be balanced to ±50% (Quay, 1997). On the one hand, we have greatly improved the carbon budget for this region. On the other hand, it will be difficult to reduce this uncertainty any further without dramatically lowering the uncertainty on individual flux measurements.

We have made great progress toward understanding the controls on carbon cycling and fluxes (e.g., Coale *et al.*, 1996; Chai *et al.*, 1996; Landry *et al.*, 1997). It is now generally accepted that iron is the nutrient limiting the amount of new production. Loukos *et al.*, 1997 have constructed a one-dimensional ecosystem model with simple physics and biology. Their iron simulation illustrates that iron supply controls the variability of primary production but that grazing balances primary production and controls phytoplankton biomass. The reason this high nitrate environment has low chlorophyll is because of grazing. Both iron supply and grazing control primary production. Models without iron limitation are able to reproduce the nitrate fields, but only models with iron limitation also are able to reproduce biomass and the variability observed in primary production.

Kelvin waves and tropical instability waves (TIW) are two physical processes that influence variability, possibly because they control the vertical transport of iron into the euphotic zone (Eldin *et al.*, 1997; Walsh *et al.*, 1997). High temporal resolution measurements of physical and bio-optical properties made on a moored array documented this variability (Foley *et al.*, 1997). Primary productivity calculated from the mooring-derived chlorophyll a and the ship-board derived chl-specific maximum rate of photosynthesis accurately reproduced primary productivity determined using conventional procedures. These results illustrate a high-frequency variability that is difficult to sample from ships. While more development is needed, such continuous long-term observations from moored and drifting arrays should be an important tool for future studies of ocean biogeochemical cycles.

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