2. High Frequency Marine Biogeochemical Monitoring from a Japan-Korea Ferry -1991 Results-

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A ferry mounted monitoring system was developed and deployed to investigate the temporal and spatial variations of biogeochemical parameters (dissolved nutrients, phytoplankton biomass, temperature, salinity and pH) along the ship's regular route between Pusan, Korea and Kobe, Japan. Semi-continuous data recording (every 10 seconds, 4 transect cruises per week) and automated bottle sampling with filtration (24 cruises per year) were performed using the sea water taken continuously from the engine cooling system intake at 6m depth. These data are expected to clarify the natural variability in and anthropogenic changes to the coastal and marginal seas and the mechanism of algal bloomimg and to supply the ground truth data for the calibration/validation of algorithms to calculate pigment concentrations from ocean color remote sensing data. Since the start of monitoring (June, 1991), the data have revealed the contrast between the Seto Inland Sea and the outer continental shelf area and the spatial heterogeneities over smaller scales. Among the events apparent in this time series data are the termination of the spring bloom, the mid-summer decrease of phytoplankton biomass due to depletion of nutrients, and autumn blooms, which are characteristic of the periods following storms.

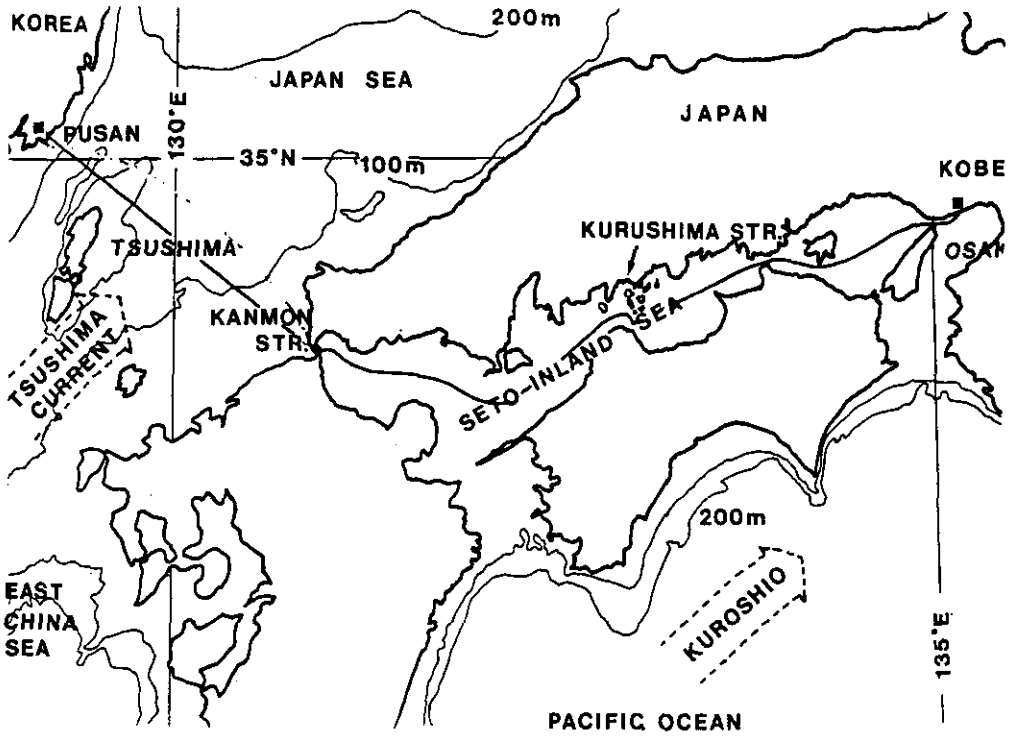
2.1 Introduction

Due to the rapid expansion of human activities, the cycling of elements has been perturbed from pre-industrial or pre-agricultural conditions. These perturbations are thought to have impacted the ocean, particularly through areas called marginal seas (estuaries, bays, and continental shelf seas). Biogeochemical reactions in the marginal seas are of particular importance because of the inherently high rates of processes such as primary production and sedimentation (Mackenzie *et al.* and other papers included in Mantoura *et al.*, 1991). Despite covering only 8% of the earth's surface, such areas are estimated to contribute 26% of global biological production (Holligan *et al.*, 1993). One reason for this high reaction rate is the shallow depth which facilitates the upward transport of nutrients. Another reason is that coastal and marginal seas receive large fluxes of materials through the land-ocean interface via many paths such as river runoff and atmospheric fall-out. Ocean environmental parameters vary over a range of temporal and spatial scales due to both *in situ* reactions and transport processes. Policy makers must know the impacts of anthropogenic activities on coastal and marginal seas. However, the impacts are not clearly discernable without long term records which reveal the natural variations. It should be noted that long term records contain the signals from seasonal variation in addition to secular changes over longer periods. Therefore certain continuous monitoring procedures targeting the more important biogeochemical parameters should be developed. These procedures should be robust to facilitate both the long-term and mission-oriented studies as well as precise to supply basic data for process-oriented investigations. The selection of parameters to be monitored and platforms from which to conduct the sampling are crucial to the success of these efforts.

Physical and chemical parameters such as temperature, salinity, and pH are the basic variables for descriptions of oceanographic conditions. Determination of which element is limiting the growth of phytoplankton in a particular area and season is important as shown in a recent review (Cullen *et al.*, 1992). The pattern of spatial distribution of these parameters is quite heterogeneous despite the broad extent of the ocean. Fully un-manned monitoring system, such as those based on mooring buoys require further research and development. Phytoplankton blooms cause drastic changes in biogeochemical parameters within days. Therefore the monitoring should be more frequent than weekly.

The duration of the monitoring program should be longer than decades. VOS's (volunteer observation ship) or ships of opportunity are one type of platform available which fulfil these requirements. Dandoneau (1983) performed chlorophyll measurements by batch sampling from merchant ships. The present task is to sample sea water continuously or repeatedly along a fixed shipping route. Ships usually take in sea water for cooling their engines. This water can be used for continuous monitoring of sea water characteristics. Passenger ferries are particularly appropriate because their routes and draft depths are relatively invariant compared with those of cargo ships and tankers.

For these reasons, we chose to use the ferry route between Pusan, Korea and Kobe, Japan (see Fig. 1), which is managed by the Osaka International Ferry, Co. Ltd.



Tsushima Strait			Seto Inland Sea		
Pusan(Korea)		Kanmon Strait			Kobe(Japan)
10:00(Tuesday)	←	2:39	Midnight	←	12:00(Monday)
17:00(Wednesday)	→ Midnight	0:28		→	15:00(Thursday)
10:00(Saturday)	←	2:39	Midnight	←	12:00(Friday)
17:00(Saturday)	→ Midnight	0:28		→	15:00(Sunday)
1:00(U.T.C.)	←	17:29(U.T.C.)		←	3:00(U.T.C.)
8:00(U.T.C.)	→	15:28(U.T.C.)		→	6:00(U.T.C.)

Fig. 1 Route of the Japan-Korea Ferry "Dan-Noh" and approximate schedule

The ferry Dan-Noh makes two round trips weekly across the Korea Strait and the Tsushima Strait, which are on the continental shelf washed by the Tsushima Current, and the Seto Inland Sea. The Tsushima Current is thought to be a mixture of Kuroshio water (the northern end of the subtropical gyre) and water of the East China Sea, although this has not been fully clarified.