Movement and Accumulation of Floating Marine Debris

Simulated by Surface Currents Derived from Satellite Data

Masahisa Kubota, Katsumi Takayama and Noriyuki Horii
School of Marine Science and Technology, Tokai University
3-20-1, Orido, Shimizu, Shizuoka
JAPAN 424-8610
e-mail : kubota@mercury.oi.u-tokai.ac.jp

Background and Objectives

Wakata and Sugimori(1990) carried out simulation of movement of floating marine debris using ship drift data and showed that a high density area circulates in the North Pacific for three years and a remarkable high density area exists north of Hawaii (Fig.1). Also Kubota(1994) estimated surface current velocity by combining Ekman and Stokes drifts, and geostrophic currents. Ekman and Stokes drifts are derived from COADS ocean wind data, while geostrophic currents are derived from Levitus salinity and temperature data. He carried out simulation of floating marine debris using the surface current fields and clarified the mechanism of accumulation north of Hawaii. However, the details may be not reliable because he used climatological data in the study.

Our objectives in the present study is to carry out simulation of movement of floating marine debris by using satellite-derived surface current data and to investigate the detail mechanism.

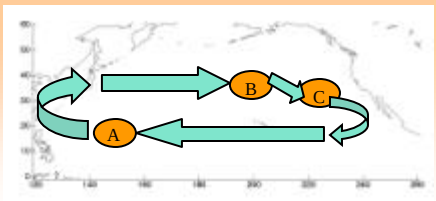

Fig.1 Schematic diagram of movement of floating marine debris.

.Data

TOPEX/POSEIDON
Surface Height Data
1゜grid, 5-days mean

ERS-1/2
Wind Speed and Direction Data
1゜grid, Monthly Mean

↓ Geostrophic Current

↓ Ekman Drift

Daily Mean Value by Linear Interpolation

Surface Current Data
(1゜grid, Daily Mean)
Period: January 1, 1993- January 1, 1998
Region: 1゜N-59゜N, 121゜E-101゜W

.Results

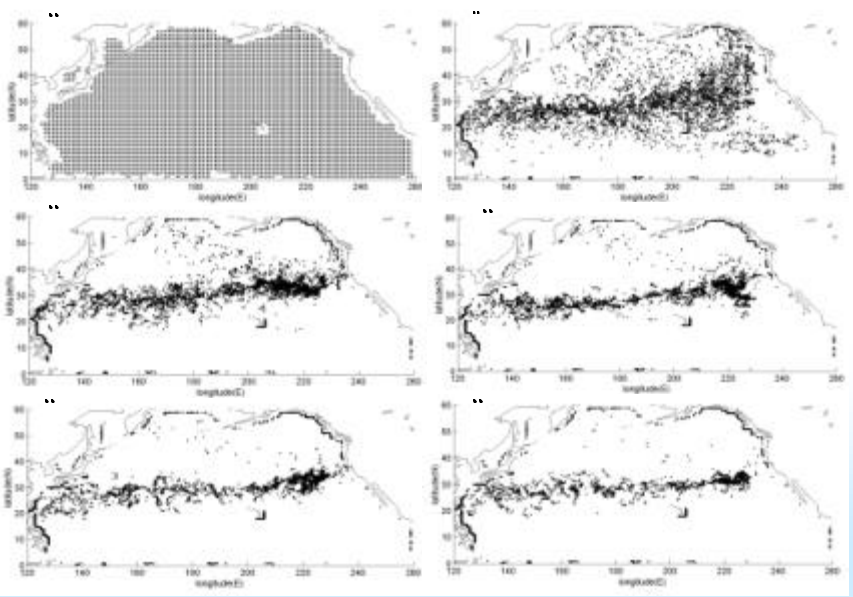

Fig.2 Positions of pseudo marine debris. A. Initial Positions, B. After one year, C. After two years, D. After three years, E. After four years,F. After five years.

Table1. Number of debris existing in each area.

	Start	After 1 year	After 2 years	After 3 years	After 4 years	After 5 years
Total number of floating marine debris	5954	4749	4246	4067	3940	3790
North-east of Hawaii	(496)	1018	1896	2411	2615	2715
Mid-latitudes	(516)	2194	1895	1514	1192	994
Other regions	(4942)	1537	455	142	133	81
Number of drifting buoys		1205	503	179	127	150
along the coast of Japan and east coast China		93	175	25	48	48
along the coast of Philippine		581	136	77	68	99
along the coast of U.S.A. and Canada		30	20	44	0	1
along the coast of Alaska		98	96	8	0	0
Bering sea		59	19	8	8	2
Hawaii		122	54	2	0	0
Other regions		222	3	15	3	0

Definition of each area

North-east of Hawaii	25゜N~40゜N,200゜E~230゜E
Mid-latitudes	20゜N~35゜N,130゜E~200゜E
along the coast of Japan	25゜N~45゜N,121゜E~150゜E
the east coast Philippine	1゜N~25゜N,121゜E~130゜E
the west coast of U.S.A	25゜N~50゜N,230゜E~250゜E
along the coast of Alaska	50゜N~59゜N,190゜E~240゜E
Bering Sea	50゜N~59゜N,160゜E~190゜E
Hawaii	15゜N~25゜N,200゜E~210゜E

Basic Mechanism:

1.Convergence in mid-latitudes by Ekman drifts associated with trade and westerly winds

↓

2.Advection from the western Pacific to the eastern Pacific by the North Pacific Current or the Subarctic Current

↓

3.Accumulation north -east of Hawaii by local Ekman convergence

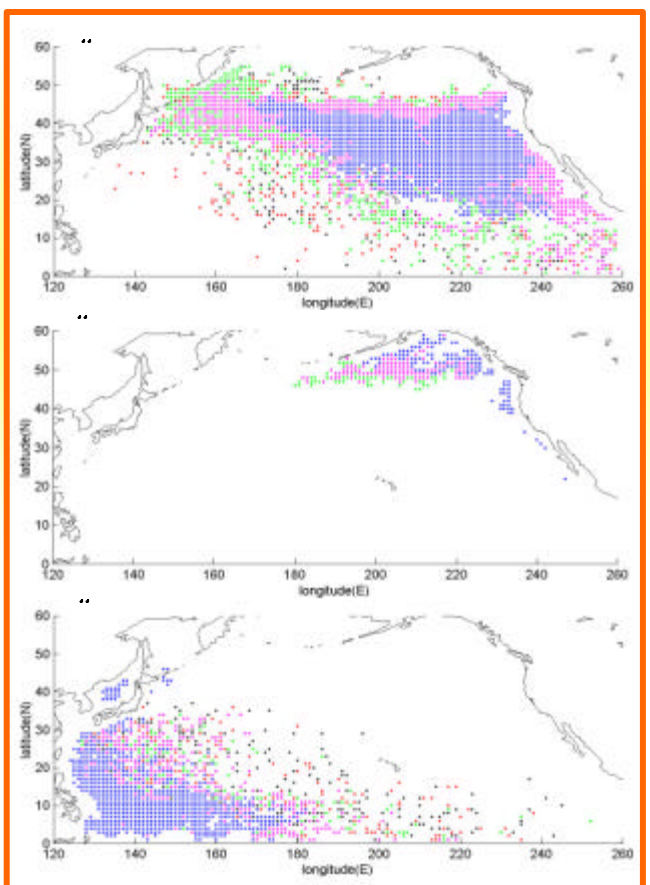

Fig.3 Initial positions of pseud marine debris which are accumulated north-east of Hawaii(A) , and reach to the western boundary (B), and the eastern boundary (C) of the North Pacific. The color means the time taken from the initial position to there. Blue: one year, Pink: two years, Green: three years, Red: four years, and Black: five years.

We investigate the original location of the accumulated debris.

1. Debris accumulated north-east of Hawaii
   (1) Debris north-east of Hawaii ---> continue to exist there
   (2) Debris between 35°N and 45°N -
   --> move north-east of Hawaii by the Kuroshio Extension and the North Pacific Current
   (3) Debris south-east of Hawaii
   ---> move north-east of Hawaii by Ekman drifts related to Trade winds

2. Debris reached to the eastern boundary of the Pacific Ocean
   (1) Debris north of 45°N and west of 180° ---> reach there for two or three years
   (2) No debris in other regions reach there

3. Debris reached to the western boundary of the Pacific Ocean
   (1) Debris along the western boundary and west of 180° in low latitudes
   ---> drfitage there for 1-2 years
   (2) Debris west of 180° in mid-latitudes and east of 180° ---> reach there for 3-5 years

4.Debris around Japan
   (1) Debris north of the Kuroshio
   ---> southward movement by Ekman drifts related to the westerly wind
   ---> eastward movement by the Kuroshio Extension and the North Pacific Current
   ---> accumulation north-east of Hawaii
   (2) Debris south of the Kuroshio
   ---> reach to the western boundary of the Pacific after wandering.

.Summary

We carried out the simulation of the floating marine debris in the North Pacific by surface currents consisting of Ekman drifts and geostrophic currents. The Ekman drifts are derived from ERS-1 microwave scatterometer data, and the geostrophic currents are derived from TOPEX/POSEIDON microwave altimeter data. We arranged about 5200 pseud marine debris over the North Pacific on each grid of 1° at the initial condition. The density area of marine debris is found north-east of Hawaii in this study as pointed out by Wakata and Sugimori(1990) and Kubota(1994). After one year 1205 debris reach to the boundary. 2194 debris exists in mid-latitudes, while 1018 debris exists around Hawaii. However, the number of debris in mid-latitudes decreases and that around Hawaii increases as time goes on. After five years 75% of floating marine debris is accumulated around Hawaii, while 25% of marine debris exists in mid-latitudes.

Acknowledgement

We wish to express our thanks to Tsurane Kuragano for providing us with the TOPEX/POSEIDON gridded data.