Measurement of the Kuroshio and its Associated Luzon Strait Throughflow by Ocean Acoustic Tomography

Arata Kaneko
Professor
Graduate School of Engineering
Hiroshima University
1-4-1 Kagamiyama, Higashi-Hiroshima 739-8527, Japan
phone/fax: +81-082-424-7625   email: akaneko@hiroshima-u.ac.jp

INTRODUCTION

The Luzon Strait is located at the western edge of the North Pacific subtropical front. ENSO related variability occurring in the tropical Pacific is directly transferred to the strait through the meridional shift and transport change of the North Equatorial Current (NEC). Also the Luzon Strait throughflow, a branch of the Kuroshio, produce a significant source not only to Kuroshio variability in the East China Sea and around Japan far downstream of the strait, but also to the climate variability in the South China Sea. The volume and heat exchange between the western North Pacific and South China Sea by the strait throughflow also serve to be a trigger to global climate changes through the air-sea interaction there. On the other hand, there are intense internal tide activities in the Luzon Strait because of the interaction of barotropic tides with sills at the depth (800-900m) of main thermocline. Strong turbulent mixing, generated by the breaking of internal tides and the associated internal waves, increases eddy viscosity and diffusivity and modifies the throughflow parameterization.

The Luzon Strait is a truly key place to study the climate variability, caused in the East Asian countries by the Kuroshio.

DEPLOYMENT CRUISE

The R. V. Dong Fang Hong II of the Ocean University of China left the Zhoushan Port for the Luzon Strait on April 20, 2008. The deployment of two OAT/ADCP/RCM moorings (stations M1 and M2) and one OAT/RCM mooring (station M3) was performed onboard the ship (Fig.1) during April 23 to 25 (Fig.2, Fig.3). After the finish of several CTD casts following the mooring works, she went back to the Qingdao Port on April 30.

Report Documentation Page

1. REPORT DATE **30 SEP 2008**	2. REPORT TYPE **Annual**	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Measurement Of The Kuroshio And Its Associated Luzon Strait Throughflow By Ocean Acoustic Tomography	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Hiroshima University,Graduate School of Engineering,1-4-1 Kagamiyama, Higashi-Hiroshima 739-8527, Japan, ,**	8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
The Luzon Strait is located at the western edge of the North Pacific subtropical front. ENSO related variability occurring in the tropical Pacific is directly transferred to the strait through the meridional shift and transport change of the North Equatorial Current (NEC). Also the Luzon Strait throughflow, a branch of the Kuroshio, produce a significant source not only to Kuroshio variability in the East China Sea and around Japan far downstream of the strait, but also to the climate variability in the South China Sea. The volume and heat exchange between the western North Pacific and South China Sea by the strait throughflow also serve to be a trigger to global climate changes through the air-sea interaction there. On the other hand, there are intense internal tide activities in the Luzon Strait because of the interaction of barotropic tides with sills at the depth (800-900m) of main thermocline. Strong turbulent mixing, generated by the breaking of internal tides and the associated internal waves, increases eddy viscosity and diffusivity and modifies the throughflow parameterization

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**8**	

Fig. 1. The R. V. Dong Fang Hong II, stopped at Zhoushan Port

*Fig. 2. The EAI 800Hz transducer and the pressure
housings for the system and battery packages.*

Fig. 3. The 150kHz RDI ADCP, inserted in the subsurface float

DEPLOYMENT SITES AND SYSTEMS

The deployment site is the northern part of the Luzon Strait, where the Kuroshio turns to the northeast south of Taiwan and then begins to exit from the strait.

The OAT mooring with a 800Hz transducer are deployed at 100m above the bottom on three subsurface mooring lines, deployed at the stations M1, M2 and M3 of the northern part of the Luzon Strait (Fig.4). The mooring positions and depths are summarized in Table 1. The upward-looking moored ADCP is set at the top of the subsurface mooring lines M1 and M2. The RDI ADCP at M1 and M2 is owned by Hiroshima University and the Second Institute of Oceanography, respectively and has the working frequency of 150kHz for M1 and 75kHz for M2. The deployment depth of ADCP is 300m for M1 and 600m for M2 (Fig. 5).
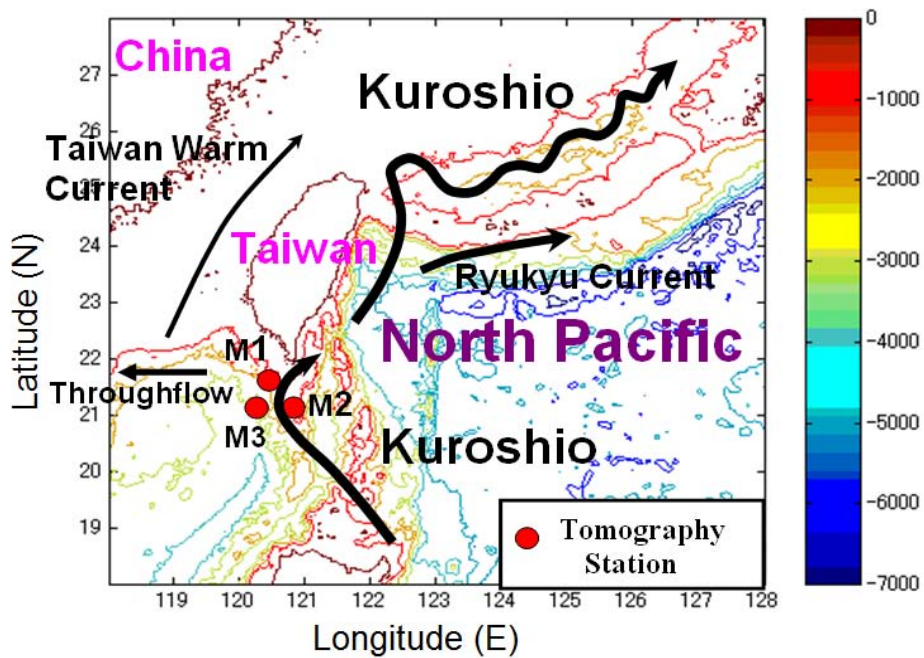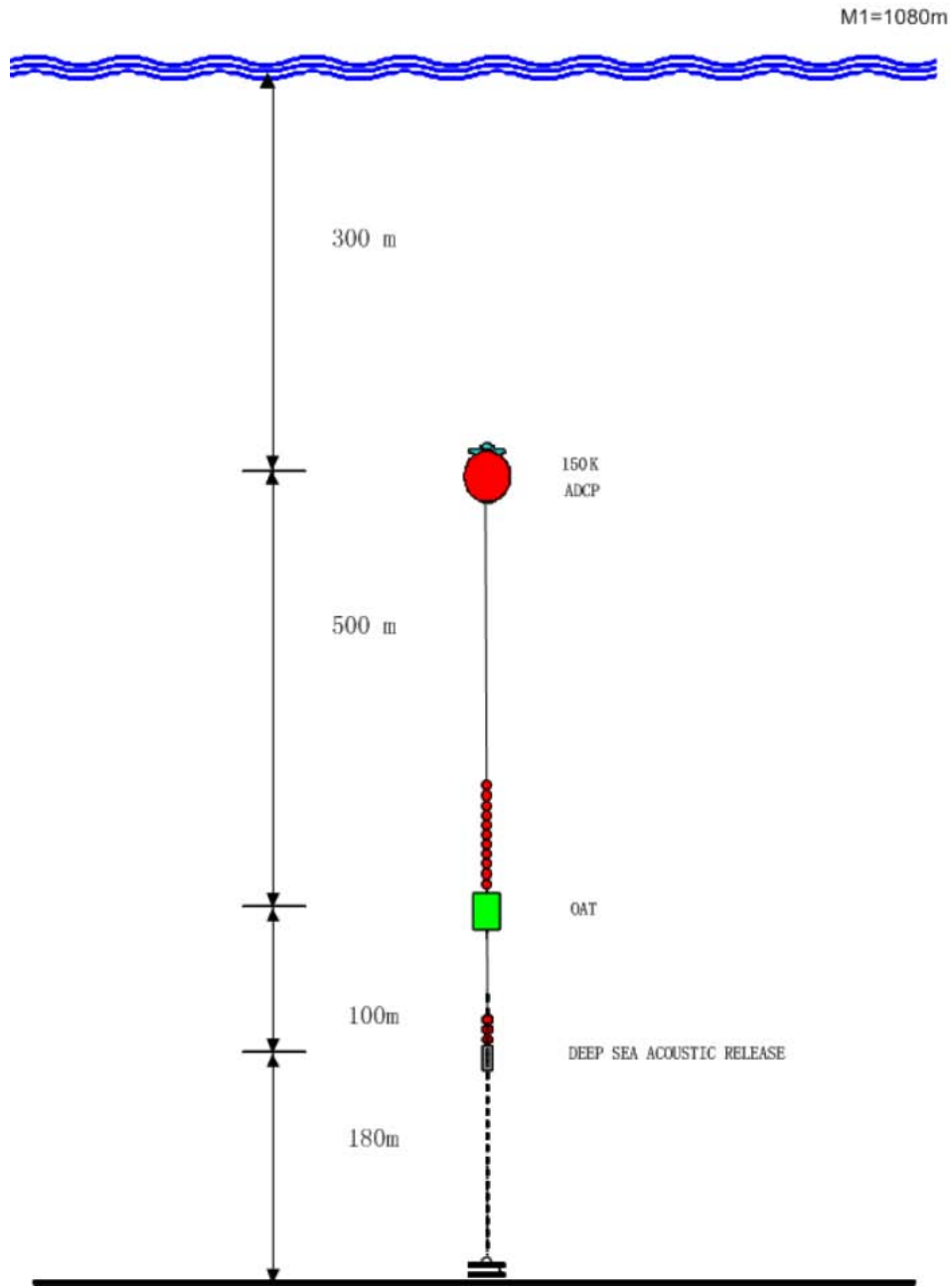

Fig. 4. Location map of the observation site, shown on the bathymetric chart

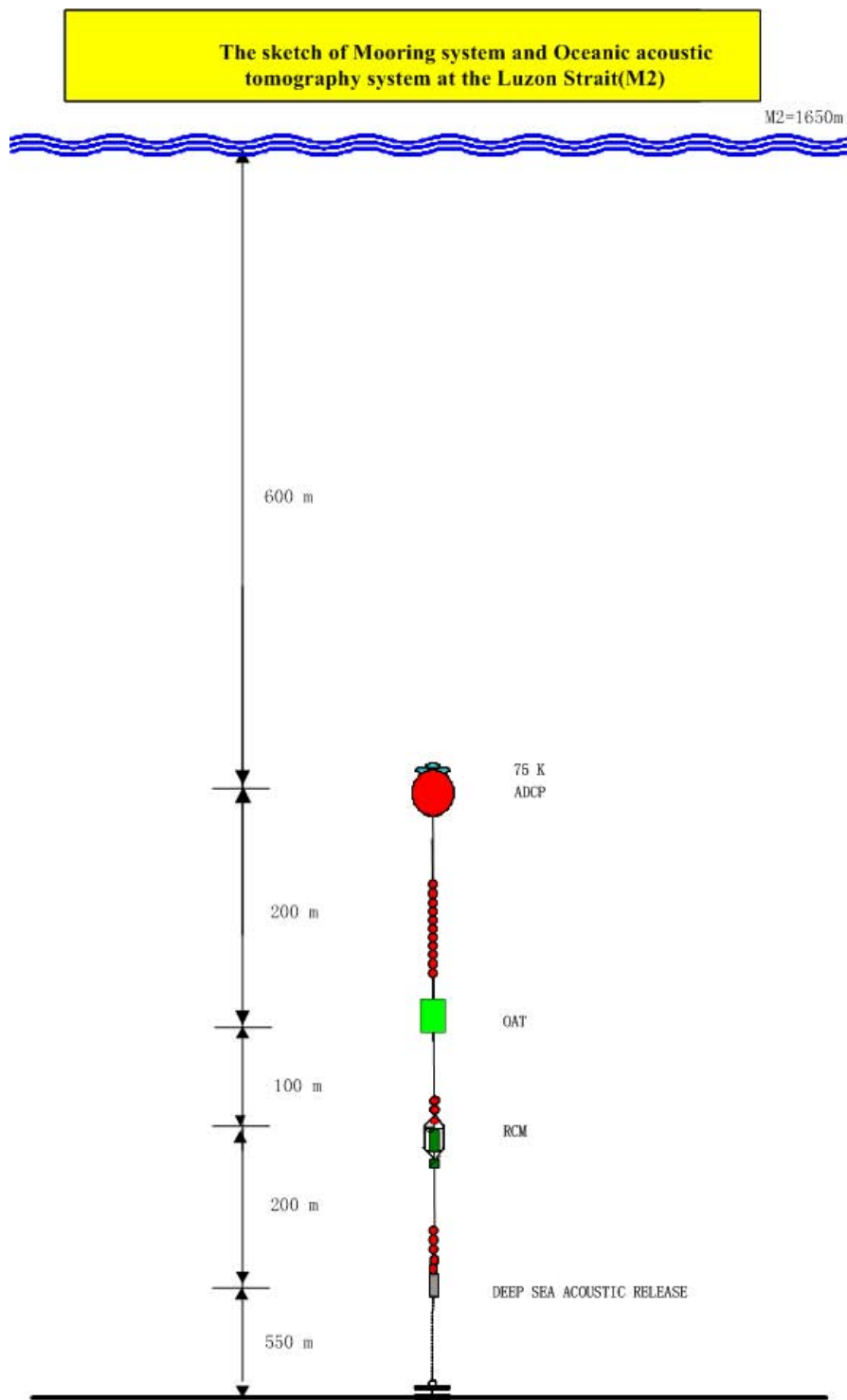*Table 1. Mooring positions and depths*

Station	Latitude (N)	Longitude (E)	Depth (m)
M1	$32\pm18.377'$	$231\pm35.872'$	970
M2	$31\pm59.961'$	$120\pm30.332'$	1633
M3	$21\pm00.385'$	$120\pm52.315'$	970

3

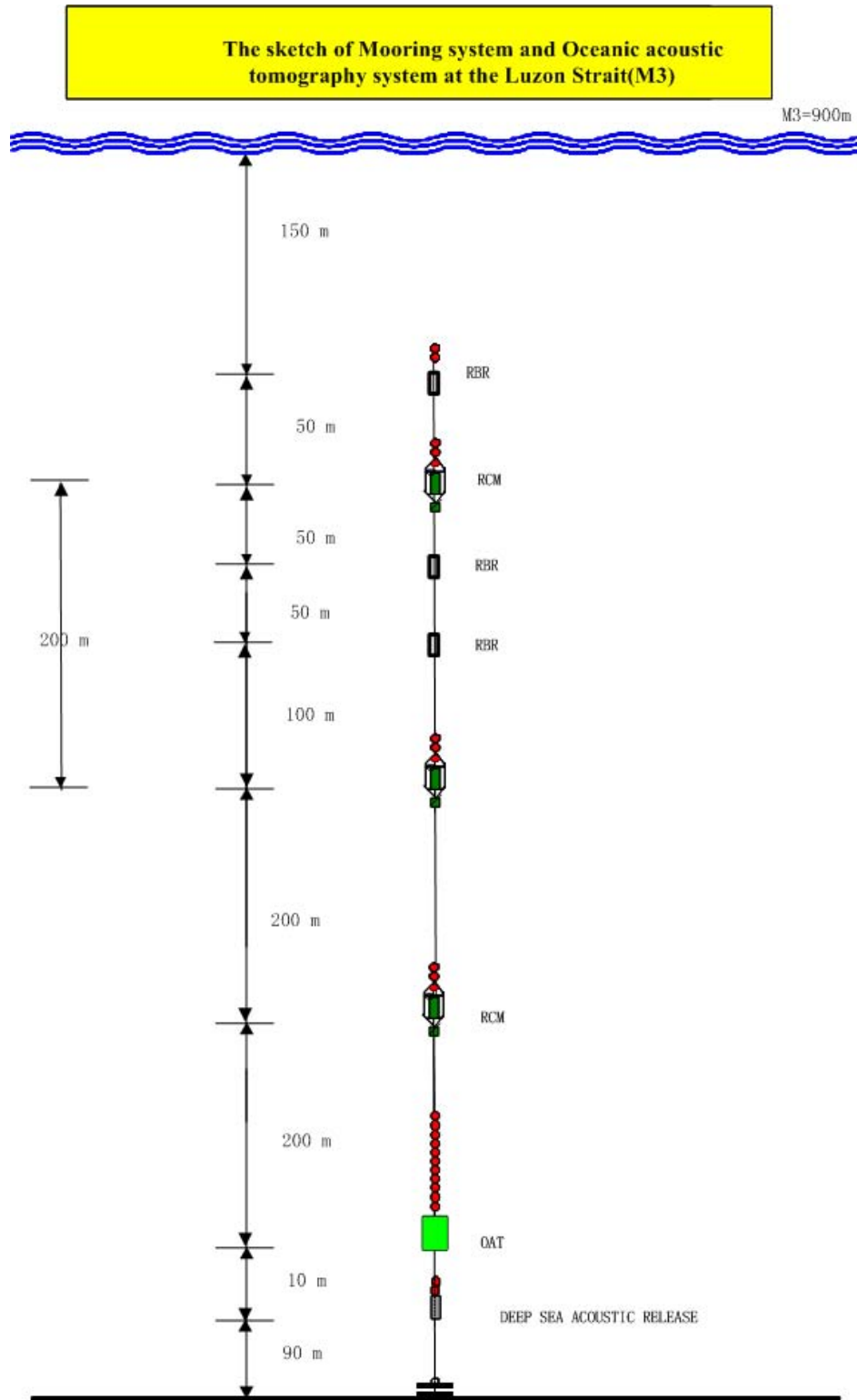**The sketch of Mooring system and Oceanic acoustic tomography system at the Luzon Strait(M1)**

M1=1080m

300 m

150K
ADCP

500 m

OAT

100m

DEEP SEA ACOUSTIC RELEASE

180m

(a) M1
Fig. 5a. Schematic diagrams of the subsurface mooring

The sketch of Mooring system and Oceanic acoustic tomography system at the Luzon Strait(M2)

M2=1650m

600 m

75 K
ADCP

200 m

OAT

100 m

RCM

200 m

DEEP SEA ACOUSTIC RELEASE

550 m

(b) M2
Fig. 5b. Schematic diagrams of the subsurface mooring

5

The sketch of Mooring system and Oceanic acoustic
tomography system at the Luzon Strait(M3)

M3=900m

150 m

50 m

50 m

50 m

100 m

200 m

200 m

10 m

90 m

200 m

RBR

RCM

RBR

RBR

RCM

RCM

OAT

DEEP SEA ACOUSTIC RELEASE

(c) M3
Fig. 5c. Schematic diagrams of the subsurface mooring

SOUND TRANSMISSION SIMULATION

Transmission processes of 800Hz sound between the station pairs M1M2 (Fig.6(a)), M1M3 (Fig.6(b)) and M2M3 (Fig.6(c)) are simulated on the basis of the parabolic equation (PE) model, using the past CTD data obtained in the strait. The transmission loss is estimated as about 90dB for all the station pairs. In the field experiment, the 12th order M sequence with Q=24 (24 cycles per digit) is transmitted at an interval of eight hours.
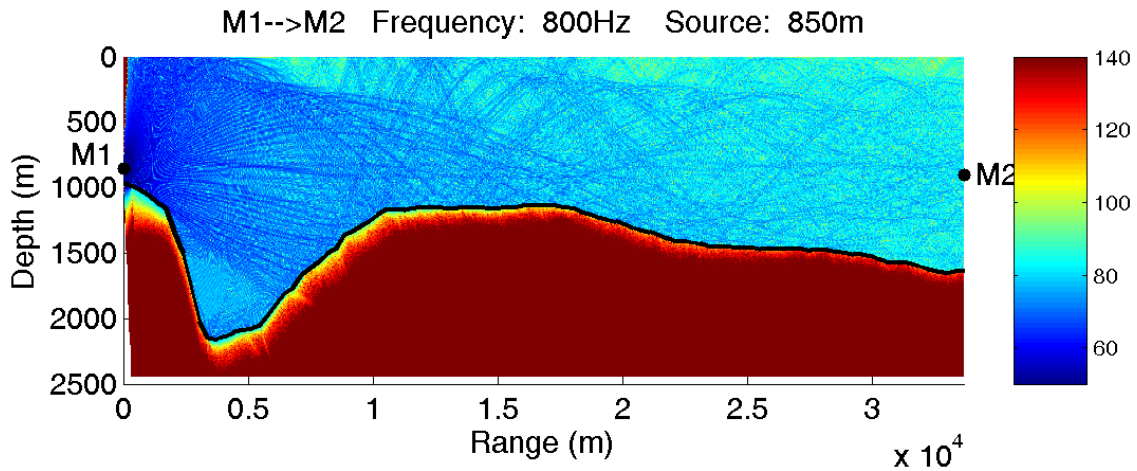

(a) M1 to M2

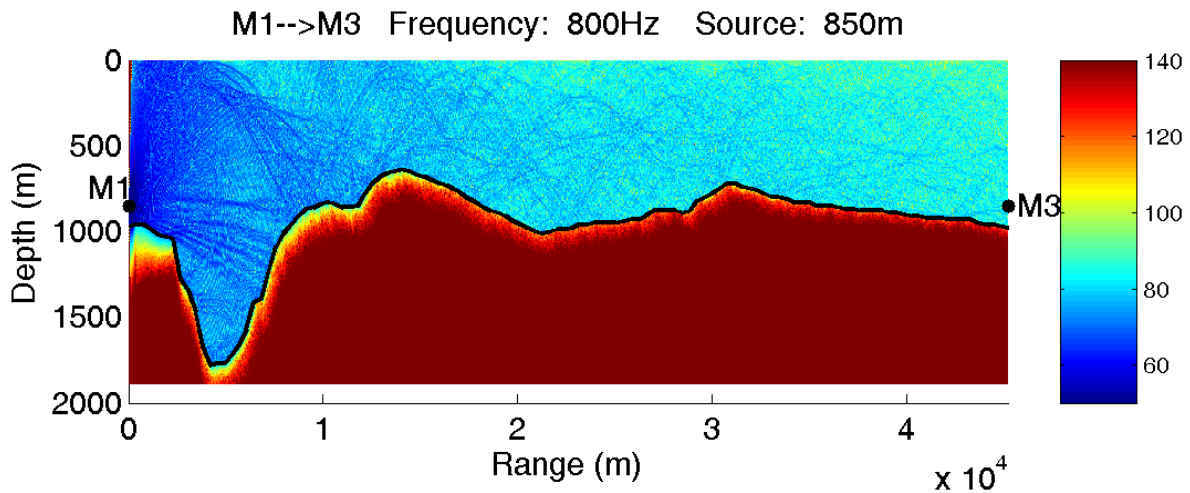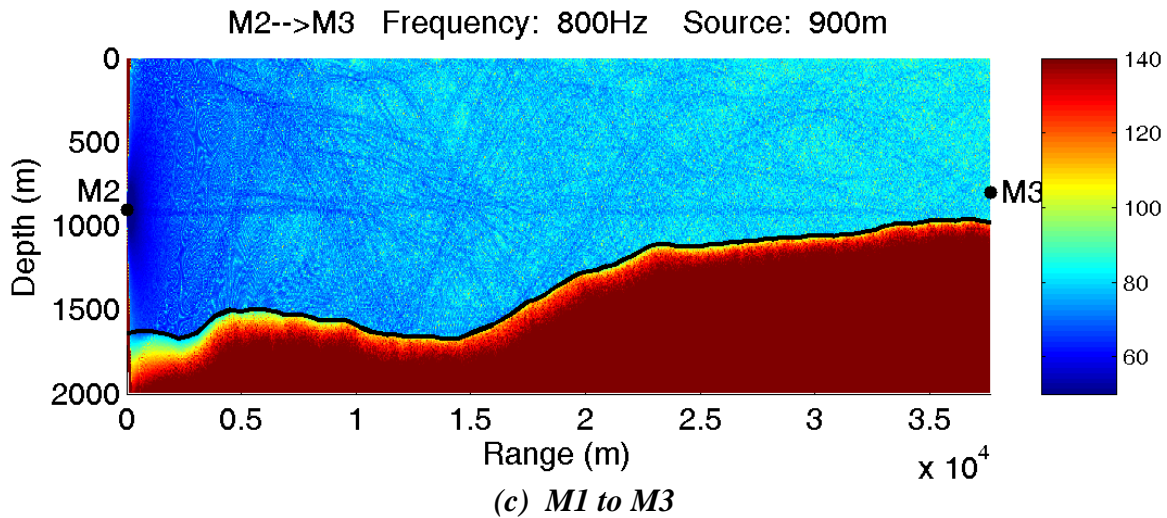**Fig. 6a. Simulation result of sound transmission process**

(b) M1 to M3

Fig. 6b. Simulation result of sound transmission process

(c) M1 to M3

Fig. 6c. Simulation result of sound transmission process

FORTHCOMING ISSUES

The recovery cruise of the mooring systems is scheduled during October 5 to 20, 2008.

The R. V. Dong Fang Hong II will also be operated as in the deployment cruise. The data analysis is a prompt issue to be tackled at the next step. Through the data analysis, we do expect to elucidate the half-year variations of the Kuroshio and its associated strait throughflow. Layered structures of current velocity and sound speed (nearly proportional to temperature) can be reconstructed by using the travel time data, acquired from rays passing different courses in the vertical section. Significant information on internal tides and waves might be retrieved from the ADCP data, acquired every minute.

The major part of the result will be submitted to the IEEE Journal of Oceanic Engineering at the earliest timing.