The OBSs and the land seismometers were arranged in profiles to provide a continuous seismic record across and along the main tectonic structures of the region. The acoustic sources used for the deep seismic experiment were an air gun array (3850 cubic inches) aboard the R/V *Hespérides* and three 1-ton explosions detonated in 75-meter-deep boreholes at three locations in the Dominican Republic (San Juan, Bonao, and Hato Mayor; see Figure 1).

Researchers are currently processing and interpreting the data recorded by the OBSs and land stations to try to constrain the deep structure of Hispaniola, which has previously been inferred only from seismological data. Because the seismicity is too diffuse in this area to infer the geometry of the plate interface in depth, it was essential to acquire deep seismic data. The deep structure that will be deduced from these data recorded around the Dominican Republic will facilitate tomographic analysis to constrain velocity models in the northeastern Caribbean used, among other things, to relocate earthquakes and study their focal mechanisms. Such information will be key to improving knowledge of the tectonic structure in the region and for earthquake hazard assessments.

Acknowledgments

Marine data were collected aboard the Spanish R/V *Hespérides*. The Dominican patrol vessel *Orion* was used to deploy the OBSs. The cruise was conducted jointly by the following Spanish institutions: Universidad Complutense de Madrid (UCM); Real Instituto y Observatorio de la Armada en San Fernando (ROA); Instituto Español de Oceanografía (IEO); and by the following Dominican institutions: Dirección General de Minería (DGM), Instituto Sismológico Universitario/Universidad Autónoma de Santo Domingo (ISU/UASD), and the Marina de Guerra (MG). We thank the captain, officers, and crew of *Hespérides* and *Orion* and the seagoing technicians from the Unidad de Tecnología Marina for their professional help at sea. The project is supported by the Ministerio de Educación y Ciencia through Spanish project CTM2006-13666-C02-01 and complementary action CTM2008-03325-E/MAR. The following are members of the CARIBE NORTE working group: A. Carbó-Gorosabel, D. Córdoba-Barba, J. L. Granja-Bruña, A. Muñoz-Martín, P. Llanes, D. Núñez, Y. Martos, J. Sánchez-Andradas, J.-A. Jiménez de las Heras, and Ángel Fernández-Rivera, from UCM; J. Martín-Dávila, A. Pazos, M. Catalán, and J. Quijano, from ROA; M. Druet and M. Gómez-Ballesteros, from IEO; O. López and S. Muñoz, from DGM; J. Payero and R. Pujol, from ISU/UASD; F. Pérez Carvajal and P. A. Ventura Polonia, from MG; and U. S. ten Brink, from the U.S. Geological Survey.

References

Carbó, A., et al. (2005), Survey explores active tectonics in northeastern Caribbean, *Eos Trans. AGU, 86*(51), 537, 540.

Granja Bruña, J. L., U. S. ten Brink, A. Carbó-Gorosabel, A. Muñoz-Martín, and M. Gómez Ballesteros (2009), Morphotectonics of the central Muertos thrust belt and Muertos Trough (northeastern Caribbean), *Mar. Geol., 263*, 7–33.

Grindlay, N. R., P. Mann, J. F. Dolan, and J.-P. van Gestel (2005), Neotectonics and subsidence of the northern Puerto Rico–Virgin Islands margin in response to the oblique subduction of high-standing ridges, *Spec. Pap. Geol. Soc. Am., 385*, 31–60.

Manaker, D. M., E. Calais, A. M. Freed, S. T. Ali, P. Przybylski, G. Mattioli, P. Jansma, C. Prépetit, and J. B. de Chabalier (2008), Interseismic plate coupling and strain partitioning in the northeastern Caribbean, *Geophys. J. Int., 174*(3), 889–903.

Mann, P., E. Calais, J.-C. Ruegg, C. DeMets, P. E. Jansma, and G. S. Mattioli (2002), Oblique collision in the northeastern Caribbean from GPS measurements and geological observations, *Tectonics, 21*(6), 1057, doi:10.1029/2001TC001304.

Mondziel, S., N. Grindlay, P. Mann, A. Escalona, and L. Abrams (2010), Morphology, structure, and tectonic evolution of the Mona canyon (northern Mona passage) from multibeam bathymetry, side-scan sonar, and seismic reflection profiles, *Tectonics, 29*, TC2003, doi:10.1029/2008TC002441.

ten Brink, U. S., E. L. Geist, and B. D. Andrews (2006), Size distribution of submarine landslides and its implication to tsunami hazard in Puerto Rico, *Geophys. Res. Lett., 33*, L11307, doi:10.1029/2006GL026125.

ten Brink, U. S., S. Marshak, and J.-L. Granja Bruña (2009), Bivergent thrust wedges surrounding oceanic island arcs: Insight from observations and sandbox models of the northeastern Caribbean plate, *Geol. Soc. Am. Bull., 121*(11-12), 1522–1536.

—A. Carbó-Gorosabel, Departamento de Geodinámica, UCM, Madrid, Spain; E-mail: carbo@geo.ucm.es; D. Córdoba-Barba, Departamento de Geofísica, UCM; J. Martín-Dávila, ROA, San Fernando, Spain; J. L. Granja-Bruña, P. Llanes Estrada, and A. Muñoz-Martín, UCM; and U. S. ten Brink, USGS, Woods Hole, Mass.

New Surveys of a Branch of the Indonesian Throughflow

PAGES 261–263

Global ocean circulation is a primary mechanism for transporting energy and nutrients around the planet. At its most basic level, this circulation transports water from the Pacific Ocean through the Indonesian archipelago into the Indian Ocean; these waters join the Agulhas Current, which loops around Africa and in turn joins the Gulf Stream in the Atlantic Ocean. Upon reaching the North Atlantic, waters sink, creep south along the ocean floor as deep water, trace around Antarctica as bottom water, and move to the Pacific Ocean where they upwell, only to seep back into the Indian Ocean through the straits and channels surrounding Indonesia.

The seepage of warm equatorial waters from the western Pacific Ocean into the Indian Ocean is called the Indonesian Throughflow (ITF). Long recognized as a key component of global ocean circulation, the ITF's magnitude and variability play an important role in determining heat and nutrient exchange to other ocean basins. Scientists' ability to estimate ITF behavior is therefore essential for understanding the global climate system.

Although studies of the ITF have been conducted for more than 2 decades, the ITF branch through the South China Sea (SCS)–Karimata Strait (see Figure 1) has been ignored in past surveys because of its shallow water, which caused many to assume that it had no effect on the main ITF. However, scientists now know that this strait plays an important role in the long-term magnitude and variability of the main ITF—indeed, drifter surveys indicate that it is of comparable importance to the Makassar Strait's role in the ITF during the northwest monsoon (see Figure S1 in the online supplement to this *Eos* issue; http://www.agu.org/eos_elec/) [*Gordon et al.*, 2003; *Tozuka et al.*, 2007]. Further, spatial and temporal patterns of fluxes through the Karimata Strait may influence the effects of monsoons and El Niño–Southern Oscillation (ENSO) events, in addition to modifying marine ecosystems, primary productivity, and seasonal fish migration. Therefore, monitoring the transport, heat, and freshwater fluxes associated with the ITF within this strait is important for verification of ocean circulation models and of primary interest to climate research and regional biology.

In response to the complete lack of direct observational studies in the Karimata Strait, the South China Sea–Indonesian Seas Transport/Exchange (SITE) program was established by scientists from Indonesia, China, and the United States. This partnership will help to determine heat, freshwater, nutrient, and overall fluxes between the SCS and the Indonesian seas through the Karimata Strait.

Investigating Freshwater Flux

The Asian and Australian monsoons affect ITF magnitude and variability. During the northwest monsoon from October to

April with high precipitation in Southeast Asia, major rivers discharge through Karimata Strait, and winds enhance currents that then carry low-salinity water into the Indonesian seas [*Gordon et al.*, 2003]. During the southeast monsoon from April to October, upwelled water in the Banda Sea and Makassar Strait may partially enter the SCS.

As a result, during their traversal to the Indian Ocean through the complex passages of the Indonesian seas, Pacific waters are converted into a distinctly fresh profile indicative of their time in the ITF. This freshwater signature can be observed streaking across the Indian Ocean within the zonal jet of the South Equatorial Current. The characteristic profile (salinity, temperature, and density) of ITF waters also shows rigorous mixing by strong air-sea interactions, wind-driven upwelling, and tidal mixing, as well as remote forcing, such as from ENSO and broad, basin-wide cyclic patterns (e.g., the Indian Ocean Dipole).

Despite comprehensive and simultaneous field measurements of the ITF by scientists from Australia, France, Indonesia, Netherlands, and the United States through the International Nusantara Stratification and Transport (INSTANT) program in 2003–2007, the upper layer variability and freshwater flux of the ITF have not been completely resolved [*Sprintall et al.,* 2004; *Gordon et al.,* 2010]. Hence, it is essential to determine the magnitude and variability of flow particularly through the Karimata Strait on seasonal to interannual time scales associated with monsoons, ENSO, and the Indian Ocean Dipole.

Numerical studies indicate that flow through the Karimata Strait plays an important role in modifying the dynamics of the SCS and Indonesian seas and in reshaping the vertical structure of the primary ITF on seasonal to interannual time scales [*Fang et al.,* 2009; *Tozuka et al.,* 2007]. Despite several numerical studies that have attempted to quantify transport between the SCS and the Indonesian seas, there has not been a consensus among numerical models in terms of flux averages and variability. These discrepancies are obviously because there have been no field measurements in the Karimata Strait to validate the numerical results.

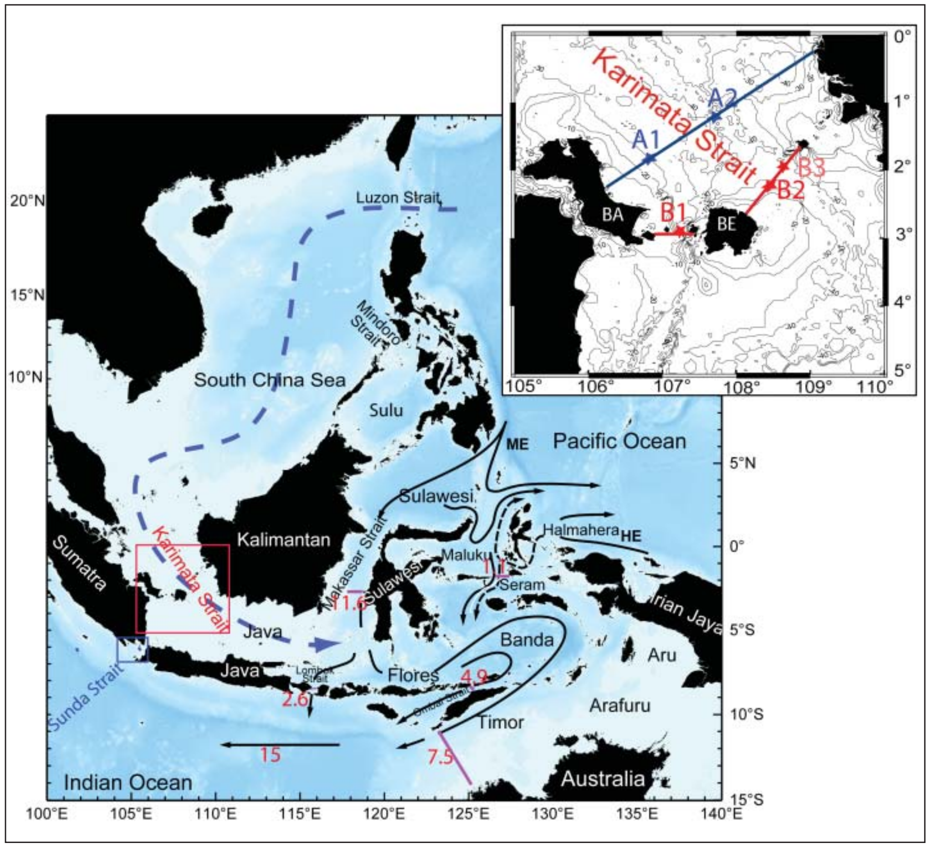

*Fig. 1. Path of the Indonesian Throughflow (ITF) through the Indonesian seas. The ITF branch through Karimata Strait is denoted by the dashed blue curve. Red numbers represent volume transport in sverdrups (1 sverdrup = 1 million cubic meters per second) of the ITF in major straits based on measurements collected in 2003–2007 by the International Nusantara Stratification and Transport (INSTANT) program [*Gordon et al., *2010]. Islands are labeled in white, and seas are labeled in black. HE is the Halmahera eddy, and ME is the Mindanao eddy. The inset shows the Karimata Strait with mooring locations for the South China Sea (SCS)–Indonesian Seas Transport/Exchange (SITE) program at A1 and A2 (old) and B1, B2, and B3 (new). BA is the island of Bangka, and BE is the island of Belitung.*

SITE Fieldwork

The Karimata Strait is characterized by heavy fishing grounds, a high biofouling rate that can serve to cover moored instruments in accumulated animal and plant matter, busy shipping lanes, underwater cables, and a soft bottom. Thus, the use of the right instruments to measure currents and other properties is essential.

SITE involves repeatedly deploying three moorings, designed to lie stationary at a given depth in the Karimata Strait. All moorings have upward looking acoustic Doppler current profilers (ADCPs) and pressure-temperature sensors; two moorings have conductivity-temperature-depth (CTD) sensors for determining heat and freshwater fluxes. Both CTD sensors and shipboard ADCPs help to capture the vertical structure of the water profile and velocity.

In December 2007, two trawl-resistant bottom-mounted ADCPs were deployed at A1 at 37 meters below sea level and at A2 at 48 meters below sea level (see Figure 1 inset). Unfortunately, A1's ADCP did not activate; a supplementary mooring was deployed in January 2008. In May 2008, data were successfully uploaded via modem, but the instruments themselves could not be recovered due to submergence in the mud. Thus, an additional mooring at B1 was deployed. In November 2008, all moorings were recovered by divers. Their data were archived and the instruments were cleaned and redeployed at new locations, B1, B2, and B3. In October 2009, a new cycle of recovery and redeployment of these three moorings was successfully conducted. Such fieldwork will continue until the end of 2010.

It is hoped that the collected data will help decipher key processes in the ITF that are important to global ocean circulation and climate change research. SITE data would also benefit fishery and marine pollution management, search and rescue efforts within Indonesia, and the accuracy of high-resolution ocean predictive models. Hence, the SITE program may be viewed as an umbrella for larger multidisciplinary programs.

Acknowledgments

The SITE program is supported by the U.S. National Science Foundation, the U.S. Office of Naval Research, the International Cooperative Program of China's Ministry of Science and Technology, China's National Science Foundation, and Indonesia's Agency for Marine and Fisheries Research.

References

Fang, G., Y. Wang, Z. Wei, Y. Fang, F. Qiao, and X. Hu (2009), Interocean circulation and heat and freshwater budgets of the South China Sea based on a numerical model, *Dyn. Atmos. Oceans, 47*(1-3), 55–72, doi:10.1016/j.dynatmoce.2008.09.003.

Gordon, A. L., R. D. Susanto, and K. Vranes (2003), Cool Indonesian throughflow as a consequence

of restricted surface layer flow, *Nature, 425*(6960), 824–828, doi:10.1038/nature02038.
Gordon, A. L., J. Sprintall, H. van Aken, R. D. Susanto, S. Wijffels, R. Molcard, A. Ffield, W. Pranowo, and S. Wirasantosa (2010), The Indonesian throughflow during 2004–2006 as observed by the INSTANT program, *Dyn. Atmos. Oceans, 50*(2), 115–128, doi:10.1016/j.dynatmoce.2009.12.002.
Sprintall, J., S. Wijffels, A. L. Gordon, A Ffield, R. Molcard, R. D. Susanto, I. Soesilo, J. Sopaheluwakan, Y. Surachman, and H. M. van Aken (2004), INSTANT: A new international array to measure the Indonesian Throughflow, *Eos Trans. AGU, 85*(39), 369, 376.
Tozuka, T., T. Qu, and T. Yamagata (2007), Dramatic impact of the South China Sea on the Indonesian Throughflow, *Geophys. Res. Lett., 34,* L12612, doi:10.1029/2007GL030420.

—R. Dwi Susanto, Lamont-Doherty Earth Observatory of Columbia University, Palisades, N. Y.; E-mail: dwi@ldeo.columbia.edu; Guohong Fang, First Institute of Oceanography, State Oceanic Administration, Qingdao, China; Indroyono Soesilo, Agency for Marine and Fisheries Research, Jakarta, Indonesia; Quanan Zheng, University of Maryland, College Park; Fangli Qiao and Zexun Wei, First Institute of Oceanography, State Oceanic Administration; and Budi Sulistyo, Agency for Marine and Fisheries Research

NEWS

New Earth Science Research Opportunities: Committee Seeks Input

PAGE 263

In 2001, the National Academy of Sciences (NAS) published *Basic Research Opportunities in the Earth Sciences*, which helped define the priorities for the National Science Foundation's (NSF) Division of Earth Sciences (EAR) over the past decade. Motivated by this report, EAR funded key components of the EarthScope initiative, established a network of Critical Zone Observatories, and expanded its postdoctoral fellowship programs.

Ten years later, again at the behest of NSF, NAS has assembled the Committee on New Research Opportunities in the Earth Sciences at the National Science Foundation. The committee will, among other things, identify high-priority new and emerging research opportunities in the Earth sciences over the next decade, including surface and deep Earth processes and interdisciplinary research with fields such as ocean and atmospheric sciences, biology, engineering, computer science, and social and behavioral sciences. The committee also will identify key instrumentation and facilities needed to support these new and emerging research opportunities.

The committee, chaired by Thorne Lay, University of California, Santa Cruz, is querying the Earth science community and related disciplines using an online questionnaire to gain a wide range of perspectives to help inform its recommendations.

The committee is asking community members to consider and respond to the following questions:

What is one compelling and emergent question that Earth science can address in the next 10 years?

Within your area of expertise, what is one compelling and emergent question that your subdiscipline can address in the next 10 years?

What facilities and infrastructure are needed to conduct the research to answer these questions?

Responses received by 8 September 2010 will be considered at the committee's next meeting on 13–14 September 2010. However, the committee welcomes any ideas throughout the course of its study.

For more information and to complete the questionnaire, visit http://thenationalacad.nroes.sgizmo.com.

—Mark Lange, National Research Council, Washington, D. C.; E-mail: mlange@nas.edu

Roundtable Explores Remote Sensing for Disaster Relief

PAGE 263

Against a backdrop of recent natural disasters—including the 2004 Indian Ocean tsunami, Hurricane Katrina in 2005, and the 2010 Haiti earthquake—an 8 July roundtable at the U.S. National Academies explored ways to improve the use of remote sensing data before, during, and after disasters.

At the "From Reality 2010 to Vision 2020" roundtable in Washington, D. C., speakers from U.S. federal government agencies and the private sector generally agreed that there would likely be continued improvements in remote sensing instrumentation, including reduced size and weight and the capability for more rapid dissemination of remote sensing data. However, they also stressed the need for closer collaboration among agencies and settling political and turf battles, overcoming security and other restrictions such as with sharing high-resolution data, and responding better to user needs.

Keynote speaker Ray Williamson, executive director of the Secure World Foundation, envisioned that by 2020 the use of space and air remote sensing would be "a routine and cost-effective means of support to disaster response and recovery." In addition to discussing various satellite and airborne resources, Williamson noted that smart phones and other devices could help to deliver information from the field. He said that could help close the gap between space and aircraft sensing data and response and recovery personnel on the ground, could quickly update the ground situation, and could help with the safety of affected populations and recovery teams.

Williamson and others also stressed the need for community remote sensing, a bottom-up approach where individuals who are often nonexperts collect and provide data from the field. Mary Lou Zoback, vice president of Risk Management Solutions in Newark, Calif., said on-the-ground information can be very useful. Zoback, formerly with the U.S. Geological Survey (USGS), noted the value of USGS's "Did You Feel It" earthquake hazards Web site that encourages input from individuals.

Vince Ambrosia, a researcher at the NASA Ames Research Center, Moffett Field, Calif., noted the need to ensure that remotely sensed data reach people in need of the information in a timely manner. He said getting data through the "last mile" from technologists to users can be "the valley of death" and that in a fast moving disaster (such as a wildfire), receiving information several hours late is not as useful.

While many speakers focused on remote sensing, USGS scientist Roger Clark noted the need to focus more on chemistry. Noting the chemicals that were released when the World Trade Center towers were destroyed on 9/11 and those that can be released during major earthquakes and other disasters, Clark said that understanding chemistry is key to disaster recovery.

Williamson added that "the bang for the buck [in remote sensing] is largely there. If we can help communities understand the risk they face and why it might be a good idea not to build on that hillside and so forth, that would be useful."

For more information, visit http://dels-old.nas.edu/dr/remotesensing.shtml.

—Randy Showstack, Staff Writer

Supplementary material to “New Surveys of a Branch of the Indonesian Throughflow”

27 July 2010

R. Dwi Susanto, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York

Guohong Fang, First Institute of Oceanography, State Oceanic Administration, Qingdao, China

Indroyono Soesilo, Agency for Marine and Fisheries Research, Jakarta, Indonesia

Quanan Zheng, University of Maryland, College Park

Fangli Qiao and *Zexun Wei*, First Institute of Oceanography, State Oceanic Administration, Qingdao, China

Budi Sulistyo, Agency for Marine and Fisheries Research, Jakarta, Indonesia

Citation:

Susanto, R. D., G. Fang, I. Soesilo, Q. Zheng, F. Qiao, Z. Wei, and B. Sulistyo (2010), New surveys of a branch of the Indonesian Throughflow, *Eos Trans. AGU, 91*(30), 261–263. [**Full Article (pdf)**]

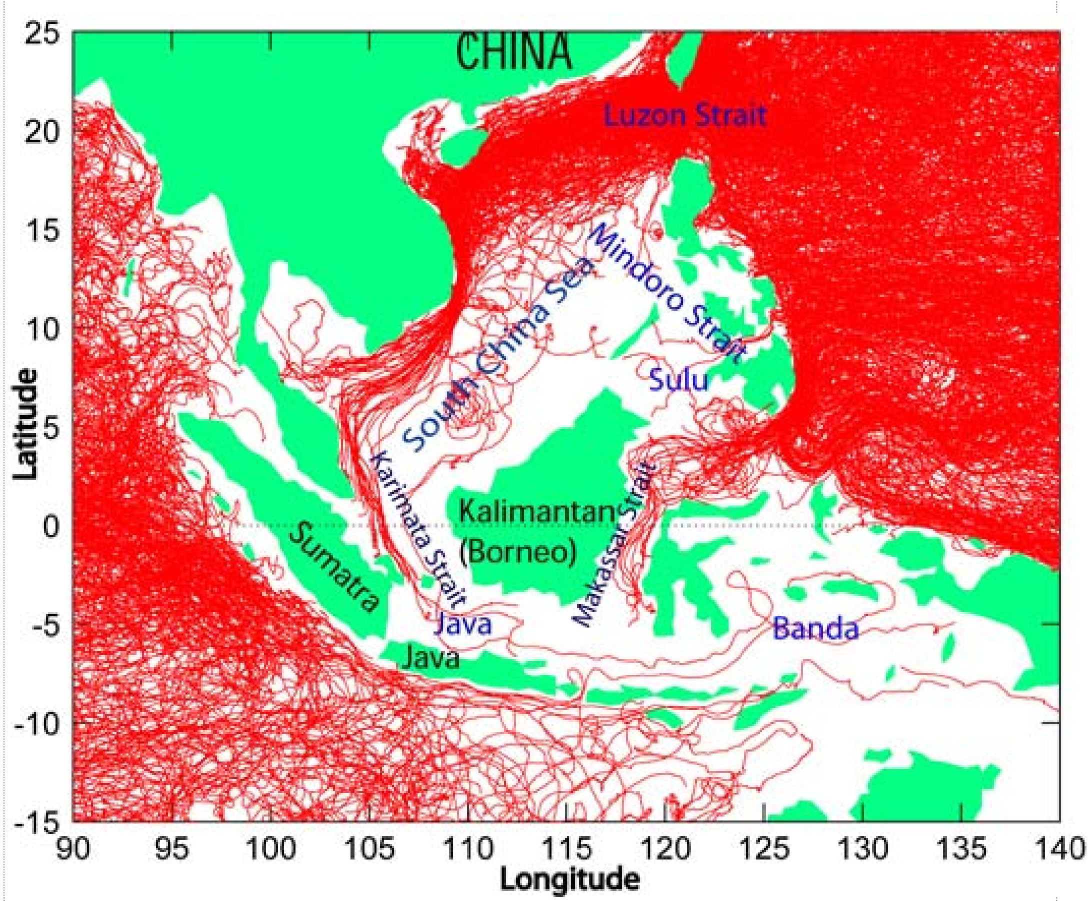

Fig. S1. Trajectories of sea surface drifters of the Global Drifter Program from August 1988 to June 2007. The trajectories clearly show that a current intrudes into the South China Sea through the Luzon Strait and forms a throughflow branch through Karimata Strait (between Sumatra and Kalimantan/Borneo) toward Java Sea and Banda Sea. In fact, the total number of drifters that pass through the Karimata Strait is higher than those that pass via the main throughflow pathway of Makassar Strait. The drifter data is a courtesy of Mayra Pazos, NOAA-AOML.