Community collection of ocean current data: An example from Northern Aceh Province, Indonesia

Syamsul Rizal,[1] Haekal A. Haridhi,[1] Crispen R. Wilson,[2] Akhyar Hasan[3] and Ichsan Setiawan[1]

Abstract

As part of a recovery assistance package following the Indian Ocean earthquake and tsunami that occurred in December 2004, some fishing boats were equipped with global positioning system sounders with a data-logging device. Using this equipment, we conducted research that tried to promote a mutually beneficial framework between researcher and fishermen, based on ocean current data collection carried out by fishermen. One of the beneficiaries was the purse-seine fisher. Data from the purse-seine fisher's activities — date, time, position, speed, and water depth — are recorded by this equipment. These records enable us to distinguish where they drop their nets. This research and data collection was done between 25 November 2007 and 31 December 2008. The current was measured according to the sea level rise, and these levels are divided into four categories: rising, high, falling and low tide. Observation and model results were compared, and found to agree well.

Introduction

The devastating Indian Ocean earthquake and tsunami that occurred in December 2004 ranks among the worst natural disasters ever recorded. In Indonesia's Aceh Province alone more than 186,000 people died, including an estimated 15–20% of fishers (~ 10,000 individuals). In addition, the tsunami damaged or destroyed over 10,000 small-scale fishing boats, countless items of fishing gear, and associated fisheries-related infrastructure (Garces et al. 2010; Stobutzki and Hall 2005).

Besides the fishermen's lives that were lost, another incalculable loss that resulted from the tsunami was the practical professional information possessed by the dead or missing fishermen. Prior to the tsunami, no scientific observations had been made in the surrounding waters where the fishermen operated, hence there was no documentation regarding local fishing grounds. Likewise, the local knowledge of the fishermen had not been recorded.

In order to augment and complement the knowledge of fishermen, scientific research and survey is required in this region. However, most conventional research methodologies are expensive, take a long time to accomplish, and require the services of experts (Garces et al. 2010), whereas what is required is that: 1) research be inexpensive, 2) information be easily gathered, 3) data collection involve fishermen, and 4) all stages of the research process and its outcomes be applied to develop the skills and incomes of fishermen.

To accomplish that we used a community-based survey as a research activity, in which fishermen were involved in collecting the data. The research system was set up so that the fishermen could collect oceanographic data at the same time as they were engaged in their regular fishing activities. As part of the post-tsunami rehabilitation and reconstruction process in Aceh, fishing boats, gear and equipment formed part of the assistance provided to fishermen by the Body of Rehabilitation and Reconstruction (BRR) in Indonesia. Some fishermen were given global positioning system (GPS) sounders with data-logging devices as part of fishing equipment installed on their boat. They used the equipment to collect and record oceanographic data while fishing. Fishermen were trained in using a GPS (Fig. 1) and reading the maps produced by the data they gathered (Fig. 2). Potential trainers were chosen both from among the fishermen and university students, and were shown how to train for approximately one week. These people then trained the fishermen to use GPS. The data obtained by the fishermen were collected by the trainer who used the information to produce a map. On the boat, the

[1] Jurusan Ilmu Kelautan, Universitas Syiah Kuala, Darussalam, Banda Aceh, Indonesia
[2] Asian Development Bank
[3] Jurusan Teknik Mesin, Universitas Syiah Kuala, Darussalam, Banda Aceh, Indonesia
* Corresponding author: Syamsul Rizal, syamsul.rizal@unsyiah.net

Figure 1. Fishermen being trained to: a) use a GPS and data-logging instrument, and b) read a map produced from the raw data they gather.

fishermen and trainer discussed daily sea-related activities. In the *Panglima Laot*[4] office, the fishermen also provided information on the underwater hazards (e.g. coral reefs) they had encountered, so that these could be added to the maps.

The methodology we applied is not new. A few surface currents were recorded in these waters using a ship drift method (Cutler and Swallow 1984), which is still used as a main reference source (Shankar et al. 1996), as well as for model and observation comparison (Schott and McCreary 2001; Shankar et al. 2002), and model validation (Durand et al. 2009; Song et al. 2003). However, none of those observation surveys used fishermen as data collectors; rather, a scientific research vessel was used.

The waters around Aceh are bounded by the Indian Ocean and the Strait of Malacca, with myriads of small islands along the coast of Sumatra (Fig. 2). Few oceanographic data have been collected from the Malacca Strait and the waters near Aceh. Thus, the recording and collection of oceanographic data by fishermen is a very useful activity not only for fishermen, but also for universities, research institutions and governmental agencies.

For fishermen the collection of oceanographic data is of direct importance to their livelihood because the purse seine they use can easily be damaged by coral reefs. This research provides fishermen with detailed information about currents, which enables them to avoid coral heads. Mapping ocean currents can be done by fishermen themselves at very low cost, and because they can use the maps produced by the data, the benefits of the research are immediately obvious. This immediate and obvious feedback reinforces the value of participation in the research.

To validate the data, we compared the collected data with the results of numerical modelling (Rizal et al. 2012). The goals of this research were to 1) establish interaction between the university and the fishermen, and 2) increase the fishing community's knowledge of its environment.

Materials and methodology

Participation of fishermen. Data were collected daily for 36 days, using 45 purse-seine boats. Theoretically, data should have amounted to 1,620 units; but because some boats did not operate on all 36 days, the actual amount of data collected is 856 units. Most fishermen who participated in this research have their fishing ground in the northern waters of Banda Aceh. As a result, the ocean current data described here are for the northern waters only.

The data collection requires no special or extra effort by the fishermen. They deploy their net when they spot a school of fish, and later haul the net back into the boat (as they normally do). It is during this regular fishing activity that we identify and measure the ocean current by analyzing the boat track.

Boat and fishing gear. The size of the purse-seine boats involved in this data collection is

[4] In Aceh Province the *Panglima Laot* institution dates back to the 17th century (Nurasa et al. 1987). The term refers to both the institution and those elder men elected from among the senior boat captains to lead the fishermen in the immediate area. The duties of the *Panglima Laot* include enforcement of traditional fishing regulations, control of access to key areas, resolving disputes between fishermen, and organizing sea rescues for vessels in distress (Wilson and Linkie 2012).

about 27–30 gross tons. The boats are wooden, with a round bottom, and powered by a 150–230 horsepower diesel engine. Twenty-two fishermen (including a skipper) were onboard for each fishing trip. Figure 3 shows the activity when the bottom of the net is closed.

Most purse seines used by these local fishermen are about 1,200 m long and 80 m deep. This gear acts as a giant drifter that starts with the closing of the bottom of the net and ends when the net is hauled as shown in Figure 3. The net is hauled manually, which takes approximately 30–40 minutes.

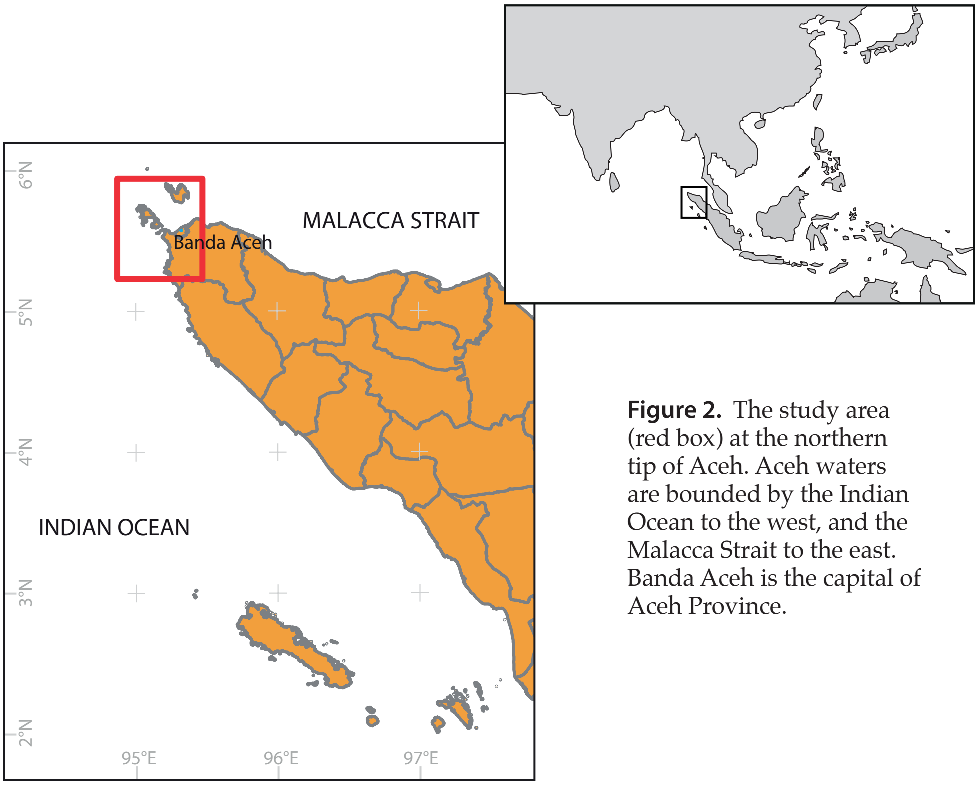

Figure 2. The study area (red box) at the northern tip of Aceh. Aceh waters are bounded by the Indian Ocean to the west, and the Malacca Strait to the east. Banda Aceh is the capital of Aceh Province.

Figure 3. A purse-seine boat closing the bottom of the net.

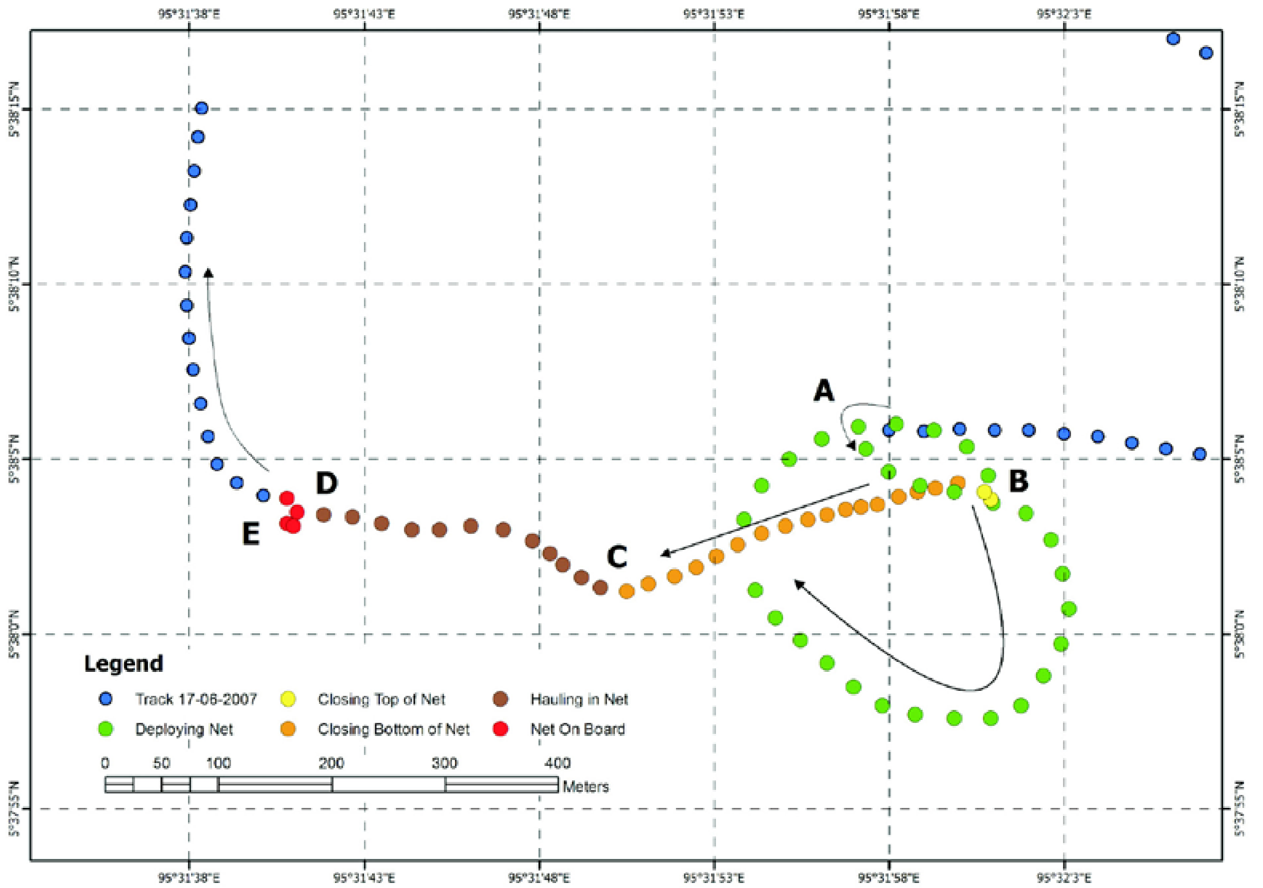

Figure 4. Tracking of a purse-seine fishing operation. In this example the data used to estimate the current velocity and direction were collected from point B to C and to D, as the boat drifted.

Track analysis. To collect raw data, the standard operational procedure is as follows:

a. The boat goes to point A, and to point B.
b. From point B, the boat follows a circular course (only once) that ends at point B again. At point B, the propeller must be stopped
c. From point B to point C, and until reaching point D, the boat starts drifting, and is moved by the ocean current only.
d. At point E, the work is finished and the net is hauled into the boat.

Figure 4 shows the steps of the standard operating procedure. From Figure 4, we measured the distance B–C–D ($z_{B\text{-}C\text{-}D}$). From this information, using the following formulas, we determined the current velocity ($|v|$) and its direction (α), with time being the time needed by the boat to go from B to C to D; y the distance of B–D projected on the longitudinal axis, and x the distance of B–D projected on the latitudinal axis.

$$|v| = z_{\text{B-C-D}}/\text{time} \qquad (1)$$

$$\alpha = \tan^{-1}(y/x) \qquad (2)$$

Analyzing tides. Figure 5 shows the location of two tide stations — Ulee Lheue, by the Malacca Strait and Pulau Rusa, by the Indian Ocean — used to categorize the data. For each station the exact timing of the four tide categories was determined as shown in Figure 6: (a) rising, (b) high (local maximum sea level is reached), (c) falling, and (d) low (local minimum sea level is reached).

In the example shown in Figure 5, data from Ulee Lheue station was used, as it was the closest station to the recorded boat's track (in green).

Results and discussion

Figure 7 summarizes the ocean current direction and velocity calculated from data provided by fishermen. Figures 8, 9, 10 and 11 show the ocean currents observed during the period 25 November 2007–31 December 2008 for locations 1, 2, 3 and 4.

In order to validate the data, all observed and analyzed current velocities (in the u component, the east–west vector component) were plotted on model figures obtained and derived from numerical model results (see Rizal 2000, 2002; Rizal et al. 2012).

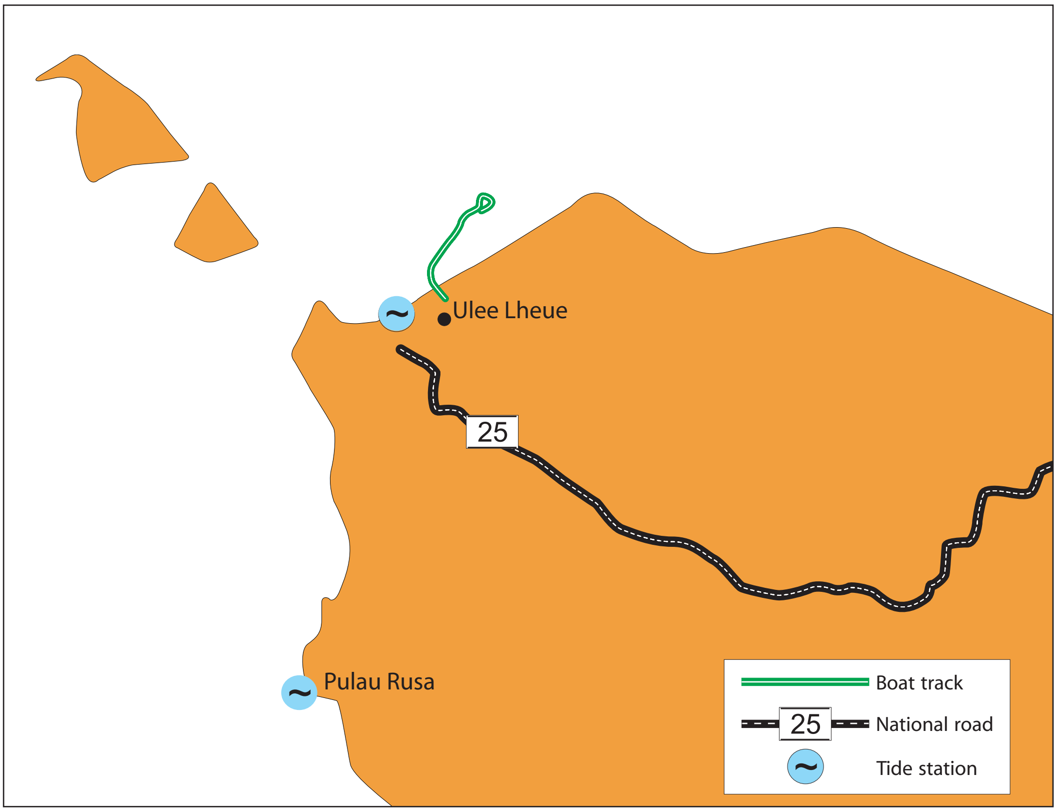

Figure 5. Tide station selection. In this example, Ulee Lheue station was chosen as it was the nearest one to the boat's track.

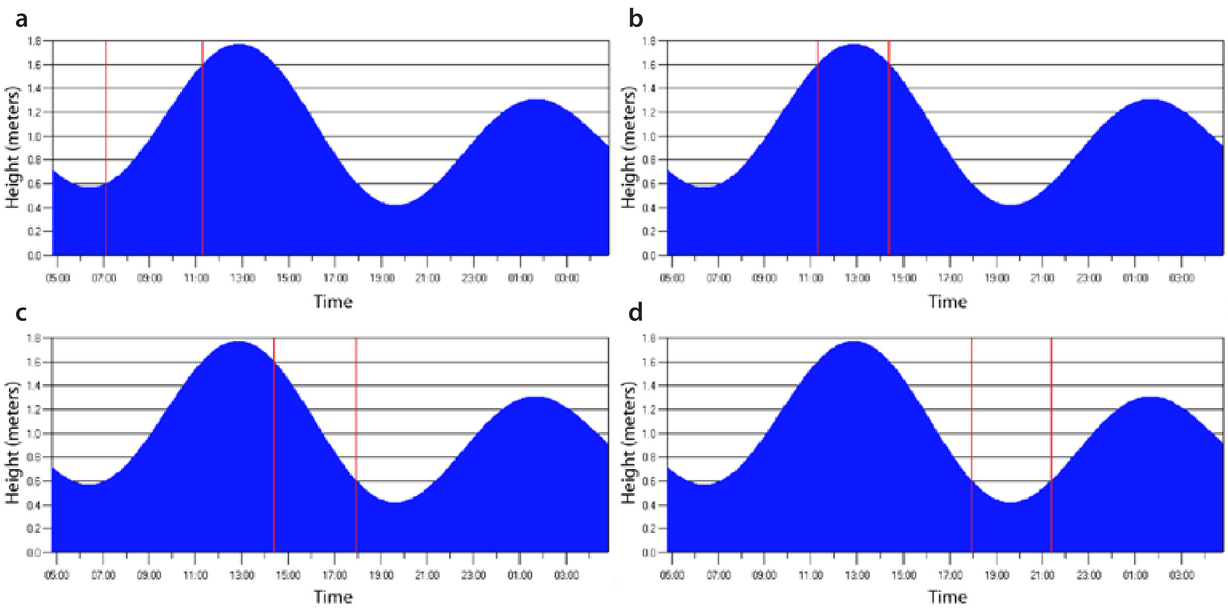

Figure 6. Tide type categorized using a day's worth of data. The red lines in each figure correspond to the start and the end of each tide type: (a) rising, (b) high (local maximum sea level reached), (c) falling, and (d) low (local minimum sea level reached).

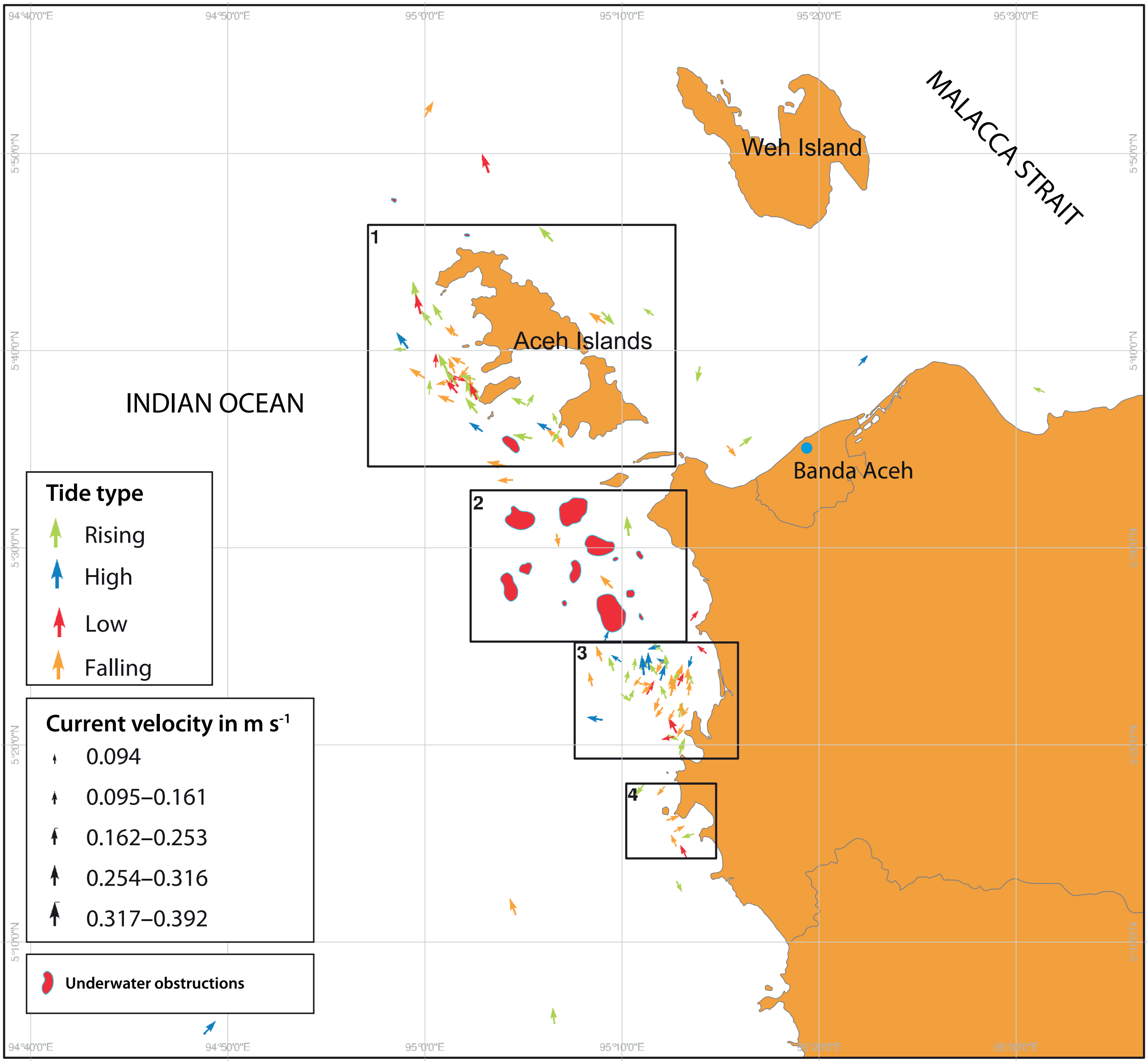

Figure 7. Ocean current direction and velocity calculated from data provided by fishermen. Location 1 is the Aceh Islands and surrounding waters; location 2 is offshore of Lhok Nga; location 3 is offshore of Leupung; and location 4 is offshore of Glee Bruek. Most observations were recorded within the waters of the Aceh Islands and offshore of Leupung; few observations were made offshore from Lhok Nga and Glee Bruek.

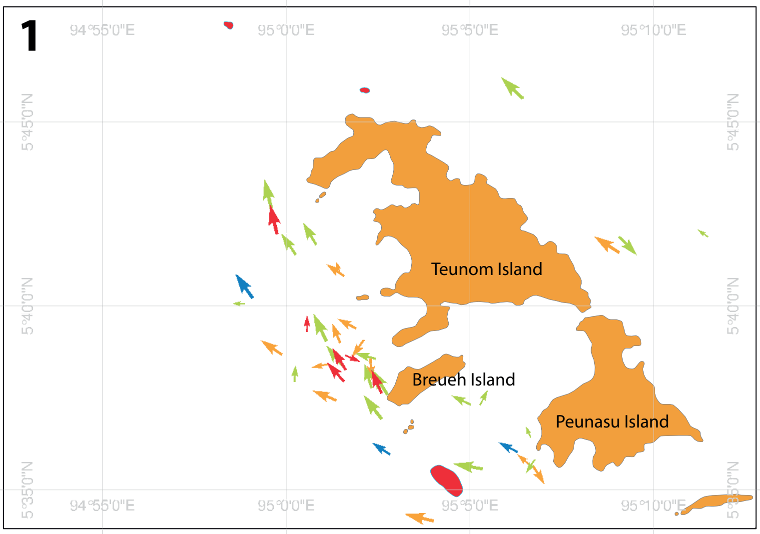

Figure 8. Ocean currents observed around the Aceh Islands by fishermen (see corresponding location and legends in Fig. 7).

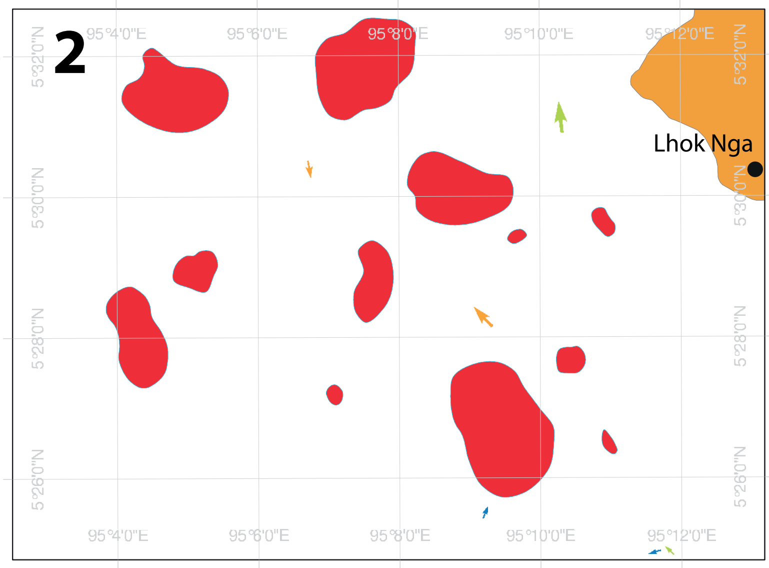

Figure 9. Ocean currents observed offshore of Lhok Nga by fishermen (see corresponding location and legends in Fig. 7).

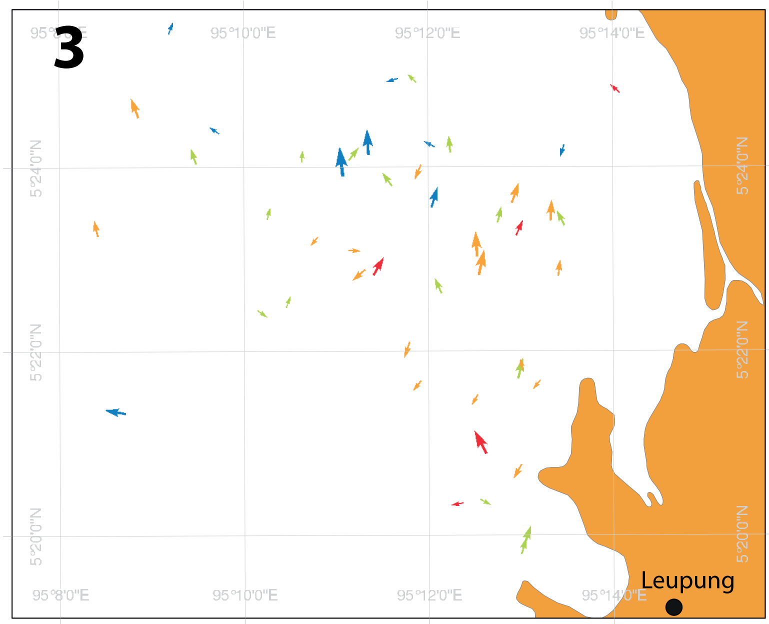

Figure 10. Ocean currents observed offshore of Leupung by fishermen (see corresponding location and legends in Fig. 7).

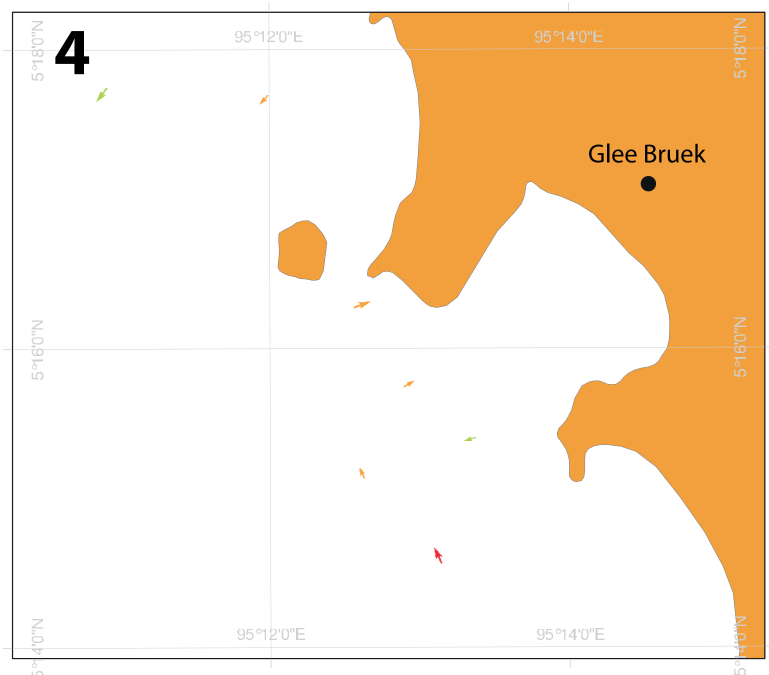

Figure 11. Ocean currents observed offshore of Glee Bruek by fishermen (see corresponding location and legends in Fig. 7).

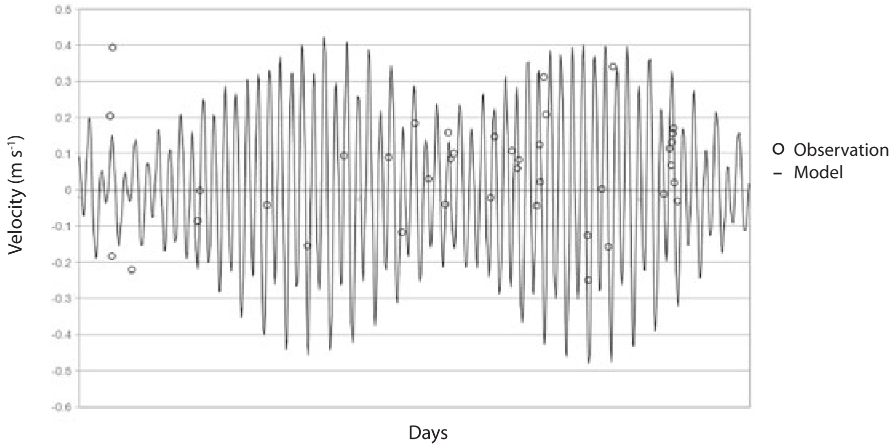

Figure 12.

Comparison between fishermen's observations of currents around the Aceh Islands (Fig. 8) and model results during December 2007. Solid black line indicates values extracted from the model; circles correspond to values extracted from observations.

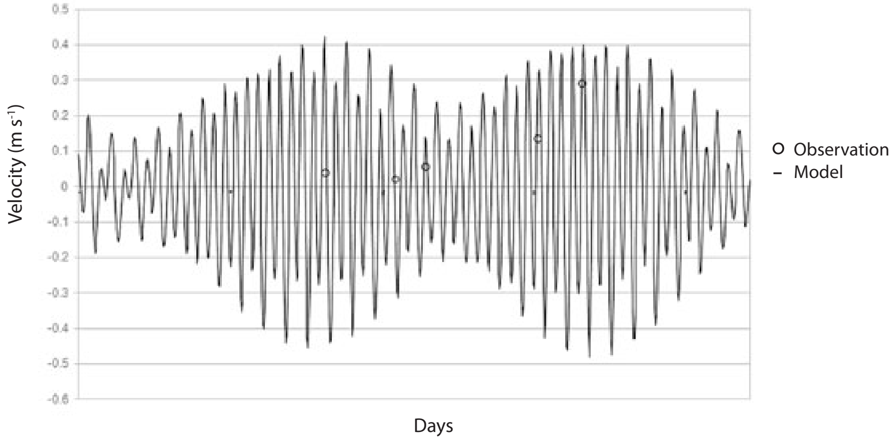

Figure 13.

Comparison between fishermen's observations of currents offshore of Lhok Nga (Fig. 9) and model results during December 2007. Solid black line indicates values extracted from the model; circles correspond to values extracted from observations.

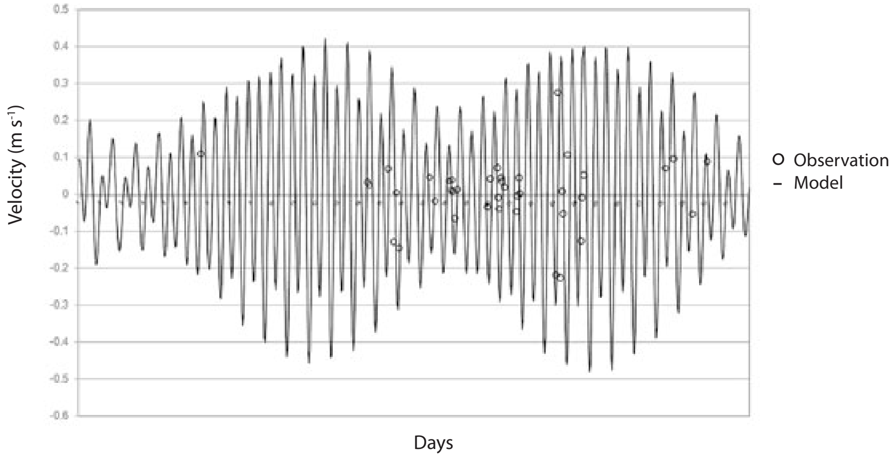

Figure 14.

Comparison between fishermen's observations of currents offshore of Leupung (Fig. 10) and model results during December 2007. Solid black line indicates values extracted from the model; circles correspond to values extracted from observations.

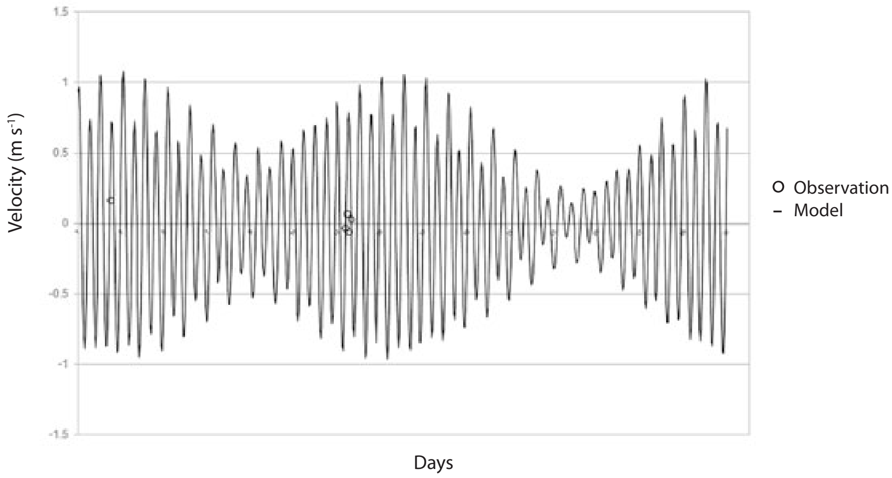

Figure 15.

Comparison between fishermen's observations of currents offshore of Glee Brueh (Fig. 11) and model results during December 2007. Solid black line indicates values extracted from the model; circles correspond to values extracted from observations.

As can be seen in Figures 12, 13, 14 and 15, most velocity values extracted from data collected by the fishermen agree well with the model results.

Conclusions

The involvement of fishermen was highly successful, and they willingly shared their data, which they regard as being of importance to both them and the researchers. Because daily data collection was done by the researcher on each boat returning from a fishing trip, fishermen and the researcher were able to interact and transfer their knowledge about using the GPS sounders with data-logging device, and share data results and other experiences. The fishermen were interested to know the results of the data that they collected.

From the results described above, it can be concluded that the observation and collection of data by fishermen is an effective and low-cost way to gather abundant observations, and can be used to facilitate knowledge transfer between researcher and fishermen.

The observations and model results of current velocity agree well for this region. This collaboration demonstrates the importance of observation by fishermen, in collaboration with a researcher can yield fruitful results, both for observation and for validation with the model. These experiments achieved successful results despite the limited budget.

Acknowledgements

This research was funded by the Asian Development Bank, through the Community-Based Bathymetry Survey project. This writing and publication were funded by the Directorate General of Higher Education, Ministry of Education and Culture, Republic of Indonesia, International Research Collaboration and Scientific Publication, with SP2H Number: 188/SP2H/PL/Dit. Litabmas/IV/2012, April 30, 2012.

References

Cutler A.N. and Swallow J.C. 1984. Surface currents of the Indian Ocean (to 25°S, 100°E): Compiled from historical data archived by the Meteorological Office, Bracknell, UK, Institute of Oceanographic Sciences, Report, No. 187, 8 p. & 36 charts.

Durand F., Shankar D., Birol F. and Shenoi S.S.C. 2009 Spatiotemporal structure of the East India coastal current from satellite altimetry. Journal of Geophysical Research 114 C02013.

Garces L.R., Pido M.D., Pomeroy R.S., Koeshendrajana S., Prisantoso B.I., Fatan N.A., Adhuri D., Raiful T., Rizal S., Tewfik A. and Dey M. 2010. Rapid assessment of community needs and fisheries status in tsunami-affected communities in Aceh Province, Indonesia. Ocean and Coastal Management 53(2):69–79.

Nurasa T., Naamin N. and Basuki R. 1987. The role of Panglima Laot “Sea Commander” system in coastal fisheries management in Aceh, Indonesia. Twenty-Second Indo-Pacific Fisheries Commission Symposium, Darwin, Australia.

Rizal S. 2000. The role of non-linear terms in the shallow water equation with the application in three-dimensional tidal model of the Malacca Strait and Taylor’s Problem in low geographical latitude. Continental Shelf Research 20:1965–1991.

Rizal S. 2002. Taylor’s problem — influences on the spatial distribution of real and virtual amphidromes. Continental Shelf Research 22:2147–2158.

Rizal S., Damm P., Wahid M.A., Sündermann J., Ilhamsyah Y., Iskandar T. and Muhammad. 2012. General circulation in the Malacca Strait and Andaman Sea: A numerical model study. American Journal of Environmental Science 5:479–488.

Schott F.A. and McCreary J.P. 2001. The monsoon circulation of the Indian Ocean. Progress in Oceanography 51:1–123.

Shankar D., Vinayachandran P.N. and Unnikrishnan A.S. 2002. The monsoon currents in the north Indian Ocean. Progress in Oceanography 52:63–120.

Shankar D., McCreary J.P., Han W. and Shetye S.R. 1996. Dynamics of the East India coastal current: 1. Analytic solution forced by interior Ekman pumping and local alongshore winds. Journal of Geophysical Research 101(C6):13,975–13,991.

Song Q., Gordon A.L. and Visbeck M. 2003. Spreading of the Indonesian throughflow in the Indian Ocean. Journal of Physical Oceanography 34:772–792.

Stobutzki I.C. and Hall S.J. 2005. Rebuilding coastal fisheries livelihoods after the Tsunami: Key lessons from past experience. Naga, WorldFish Center Newsletter 28(1 and 2):6–12.

Wilson C. and Linkie M. 2012. The *Panglima Laot* of Aceh: A case study in marine management after the 2004 Indian Ocean tsunami. Oryx 46:495–500.