SPECIAL ARTICLE

J. Sci. Soc. Thailand, **2** (1976), 127-138

CURRENT AND INFERRED MOVEMENT OF PARTICULATE MATTERS IN THE UPPER GULF OF THAILAND

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(Received 8 July 1976)

Summary

Expecting the movement of oil spill, pollutants and sediments to be dominantly controlled by characteristics of currents is speculative but fairly reasonable. Operating currents in the upper Gulf of Thailand are virtually unknown for appraising problems associated with the rapid growth of industries along the upper Gulf. This paper presents orders of magnitude of currents considered important to the transport processes. Inferred movements of sediment and of oil spill are discussed. It is aimed at raising some interest in making quantitative determination of currents.

The whole Gulf of Thailand is shown in Fig. 1. Particular attention will be paid to the upper Gulf where its surface area is 100×100 km^2, with an average depth of 15 m. From the shallow-northern coast, the bottom slopes gradually downward to a mean depth of 25 m at its mouth between Sattahip and Hua Hin. The eastern part, with its rocky offshore islands, is slightly deeper than the western half. There are four major rivers draining into the upper Gulf of Thailand, namely the Mae Klong, Tha Chin, Chao Phya and Bang Pa Kong, as included in Fig. 1. The average depth of the Gulf over its total area of about 320,000 km^2 is 45 m. Maximum depths in the central part are in the range between 70 and 85 m.

River and Tidal Currents

One of the components of the current system in the Gulf is derived from the river flows, especially in the neighborhood of the river mouths. Upon interacting with the ocean tide, and together with the sediment carried from upstream, the

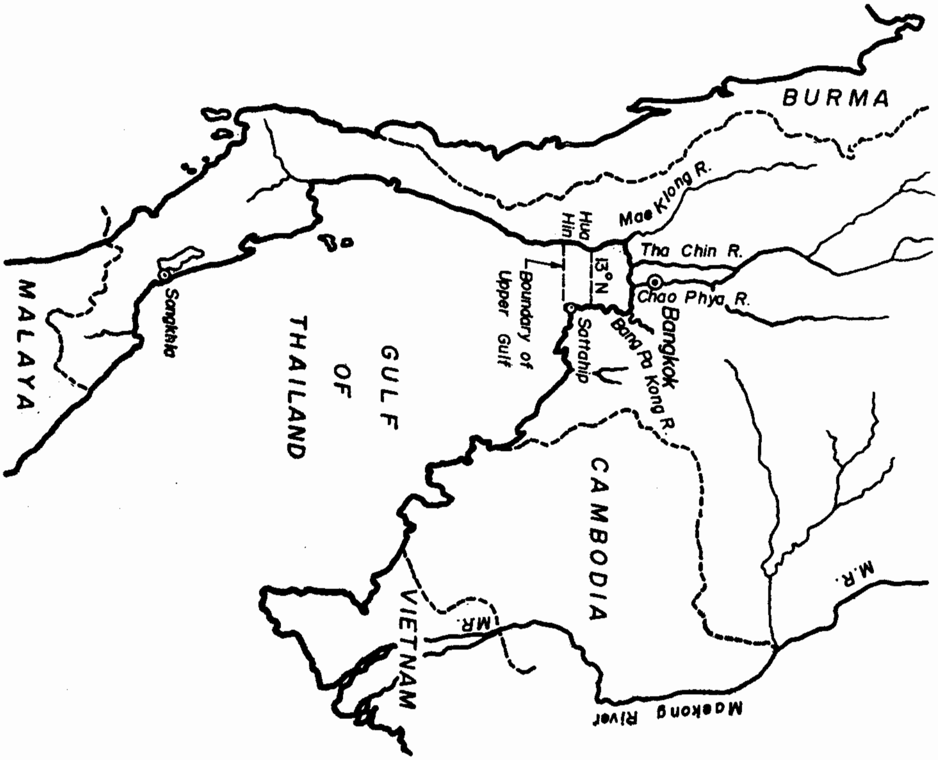
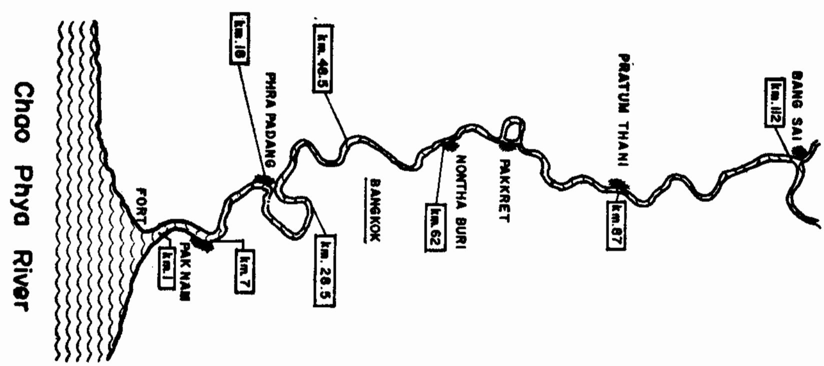


Fig. 1 - Location Map



resulting current is irregularly distributed: and the flow in the lower reach is thus modified considerably.

The monthly river-flows and suspended sediment loads of the four rivers measured by the Royal Irrigation Department have been plotted in Fig. 2. The approximate ratio of fresh water flow and suspended load of the Tha Chin, Bang Pa Kong, Chao Phya and Mae Klong are 1:3:8:8 respectively. In the spate period, a huge amount of river flow and suspended load from the rivers drains into the Gulf. These water-borne suspended loads cause shoaling of navigation channels, while the fresh water flow itself reduces the salinity of the Gulf water. However, the inflow volume of fresh water is rather small, as compared with the volume of the water of the upper Gulf above latitude 13°N, as shown in Fig. 3.

Influences of tides on the flows of the Chao Phya river have been studied by Amnat Apichatvullop[1], whose results are shown in Fig. 4. Such influences on the river flow, and thus on transport processes, are shown as far as 90 km upstream. The tidal range at 100 km upstream from the river mouth is nearly 2m in height and at that same time is 3 m at the mouth. Under such condition salt water intrudes as far as Bangkok. The amplitude of the tidal flow at the mouth is 2,800 m^3/s, while that of the fresh water flow is only 60 m^3/s. Due to the dominant influence of the ocean tide, the direction of the flow in the vicinity of the mouth is upstream during the rising tide and downstream during the falling tide. The daily resultant drift downstream of any water particle is thus only a few kilometers (less than 3 km, Fig. 4). In the upper Gulf, the influence of the fresh water flow becomes less as the whole mass of water motion is under the influence of the tide. Usually, the fresh water volumes from the four rivers are accumulated in the upper Gulf from January to September (See Fig. 3). This is not only due to the fact that the fresh water volume from the four rivers during this nine month period is only 25 percent of the whole volume of water in this region, but also because the tidal current along the coastline from Samut Songkhram to Chon Buri is rather weak, as the coastline prevents the current from flowing past it. Exceptions are at the river mouths where the tidal current can flow into the rivers. Any pollutant flowing through the Mae Klong and Bang Pa Kong rivers, is expected to be accumulated near their mouths for a longer period. Thus great care must be exercised in the areas around the mouths of these two rivers, where many shrimp and shellfish farms are located.

Chart of tidal currents in the Gulf of Thailand has not been available. A detailed mathematical model is needed. As an order of magnitude, the tidal range in the upper Gulf is about 3 m, resulting in an oscillating tidal current of 1 knot (0.515 m/s) at about 10 m depth. In the shallower area the current is weaker due to bottom friction. In one tidal cycle of ebb and flood, the water particle motion induced by this current will flow back to almost its original position. The drift of the water particle depends more on other types of current, such as river flow, wind driven current and slope current.

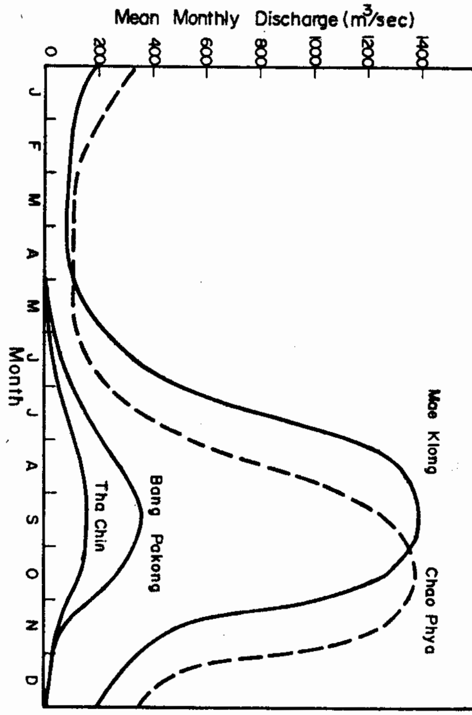


Fig. 2a –Mean Monthly Discharges of the Four Rivers

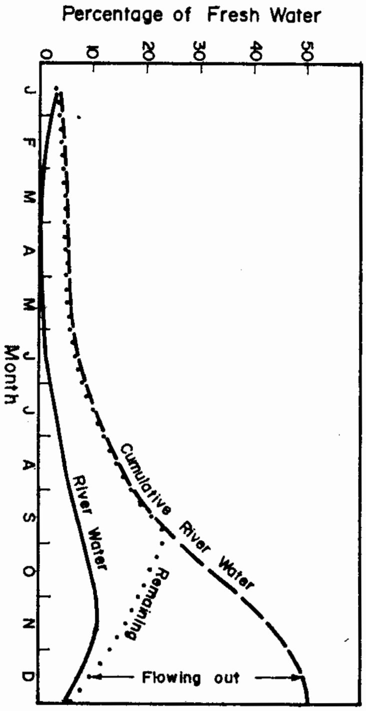


Fig.3 –Percentage of Fresh Water from Four Rivers, Its Cumulative Value, and Remaining Part in the Upper Gulf above 13°N Latitude

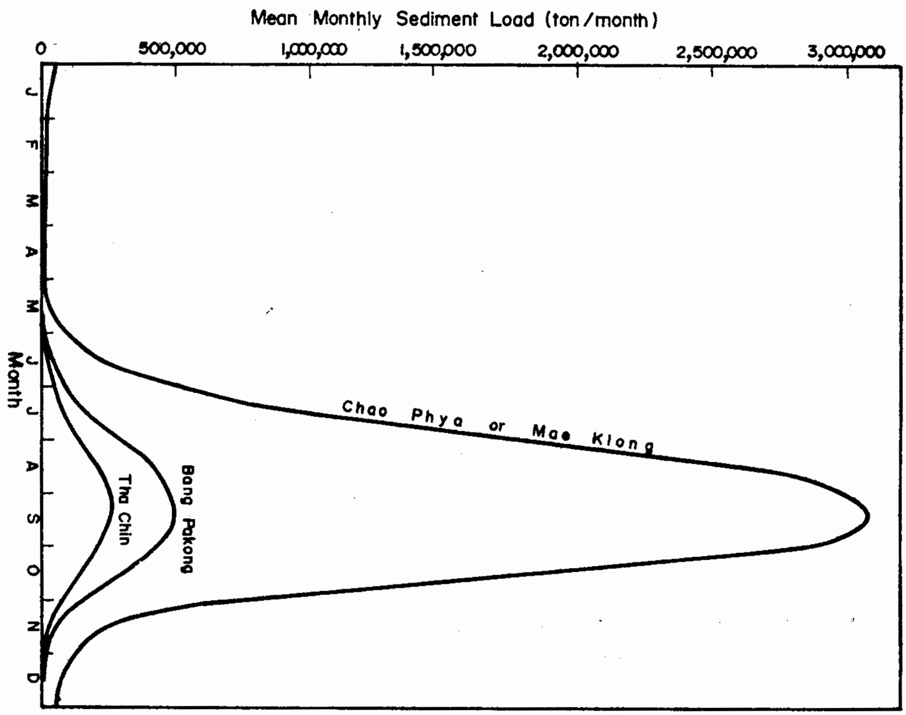


Fig. 2b –Mean Monthly Sediment Load of the Four Rivers

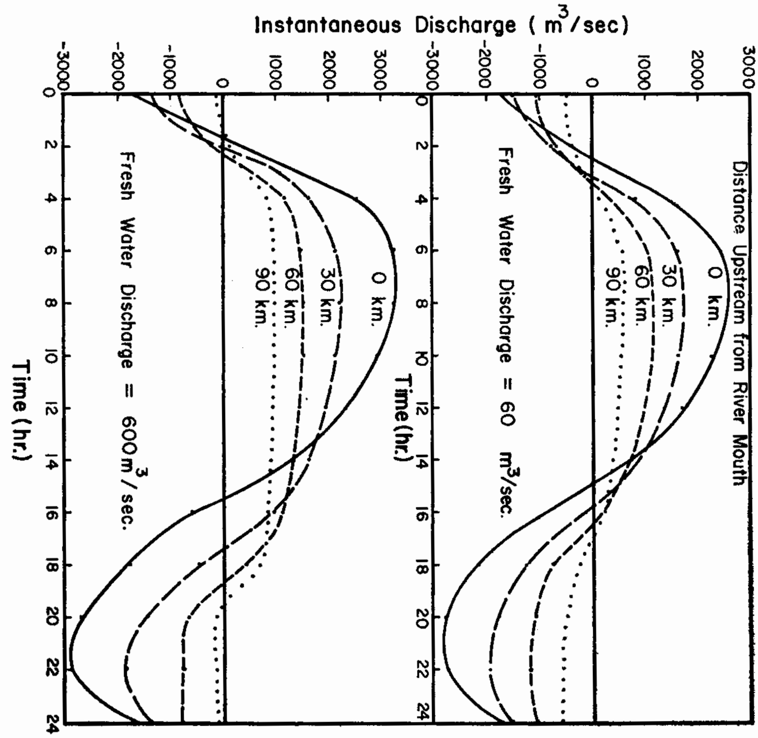


Fig.4a- Variations of Instantaneous Discharge in One Tidal Cycle at Various Locations along Chao Phya River during Low and Mean Fresh Water Discharges.

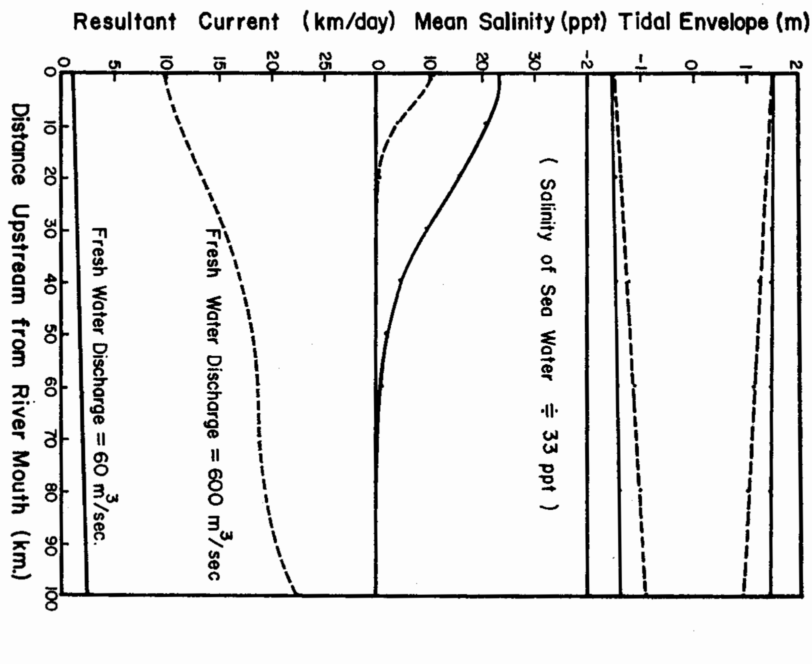


Fig.4b–Variations of Tidal Envelope, Mean Salinity and Resultant Current along Chao Phya River during Low and Mean Fresh Water Discharges.

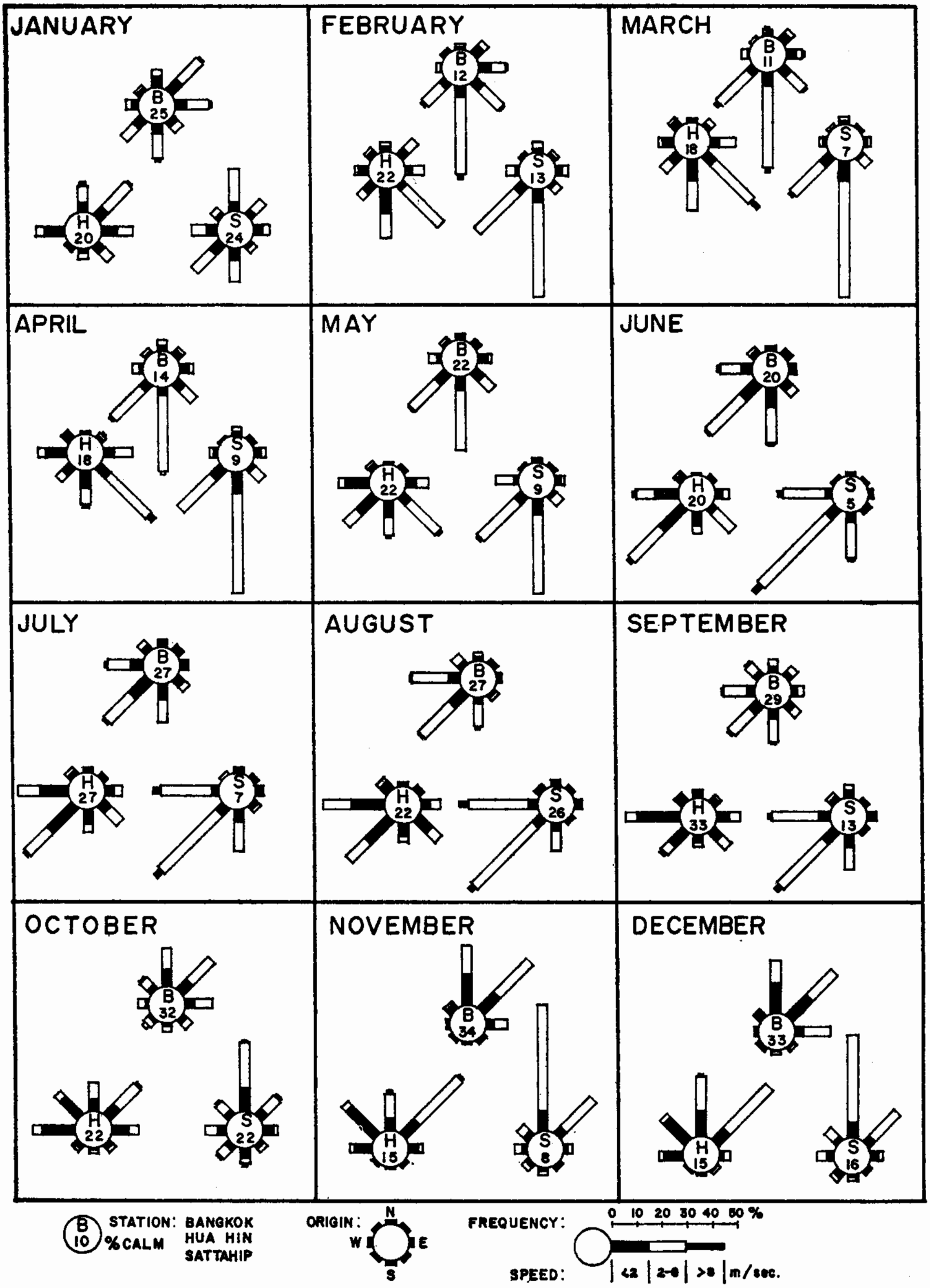


Fig. 5 - Frequencies of direction and the velocity of the wind at Bangkok, Hua Hin and Sattahip from 5 years observations (Reference 6)

Wind Driven and Slope Currents

Thailand is under the influences of the prevailing Northeast and Southwest monsoons. The Northeast monsoon flows from land to sea in winter from November to February, while the Southwest monsoon blows from sea to land from May to September. Frequencies of direction and velocity of the monthly wind at Bangkok, Hua Hin and Sattahip, as measured by the Meteorological Department, are presented in Fig. 5.

The wind generates a wind driven current at a thin layer of water at the surface and its magnitude is about 3 percent of the wind velocity[2]. The whole Gulf is located in the zone of weak wind, with a typical wind of 2 to 8 m/s (i.e. 4 to 15 knots) resulting in a weak wind driven current of 5 to 20 cm/s. As this current is limited to a thin layer of water surface, it only has strong influence on such floating material as a thin film layer of oil.

Unlike the open sea, the upper layer of water in the upper Gulf is also under the influence of slope current, caused by such external forces as the wind effect and atmospheric pressure difference. The slope current in the upper Gulf of Thailand caused by the slope of the sea surface generally drifts in a loop, i.e., clockwise from October to March when the wind blows from the Northeast and counter clockwise during the rest of the year[3]. The magnitude of the current is stronger at the outer portion of the loop than nearer to its center of circulation.

Wave Induced Current

Wind blowing over a water surface can generate waves. Stronger winds with longer duration will generate bigger waves. Another factor governing the size of the generated wave is the fetch or the available water surface. For a limited fetch of a canal or lake, the generated wave is accordingly limited to a size that will not grow bigger–even though the wind is strong and keeps on blowing[4]. Hence for a wind from the northeast blowing with a constant velocity over the whole Gulf of Thailand, waves on the east coast will be smaller due to a smaller fetch. When the wind stops blowing, the waves also stop their growth but keep propagating further as 'swell'. Hence, in Northeast monsoon the waves are bigger on the west coast in the Gulf, while they are smaller on the east coast in the Gulf and on the west coast of the peninsula. In this situation fishermen would find areas favorable for fishing to be along the west coast of the peninsula in the Indian ocean. In the northeast monsoon season waves south of Songkla are bigger than those to the north since the bigger waves here originate in the South China Sea with a larger fetch and stronger wind magnitude. Wave characteristics in the Gulf of Thailand and South China Sea, as reported from ships sailing in these areas[5], are summarized in Fig. 6.

The fluid drift induced by waves will oscillate back and forth in the same manner as the tidal current but with much smaller amplitude and period. The velocity of water particle motion basically depends upon wave height, period and water depth. Waves exert a strong influence on the bottom sediment in the shallow area along the coast. Wind in the Gulf of Thailand is so weak that there is no generation of big waves with high steepness which result in severe erosion problems. An exception is when an infrequent tropical cyclone passes over Thailand. As a result of small erosion, the problem being faced is the deposition of huge quantities of sediment from rivers, as made evident by the gradual advance towards the sea of the water lines along the coast, especially at the river mouths.

An Incident of Oil Spill Spreading In The Gulf

Accidental oil spill spreadings frequently occur. Immediate efforts must be taken to identify the probable area in which spray boats should operate, in an attempt to re-collect the spills or prevent potential shore pollution.

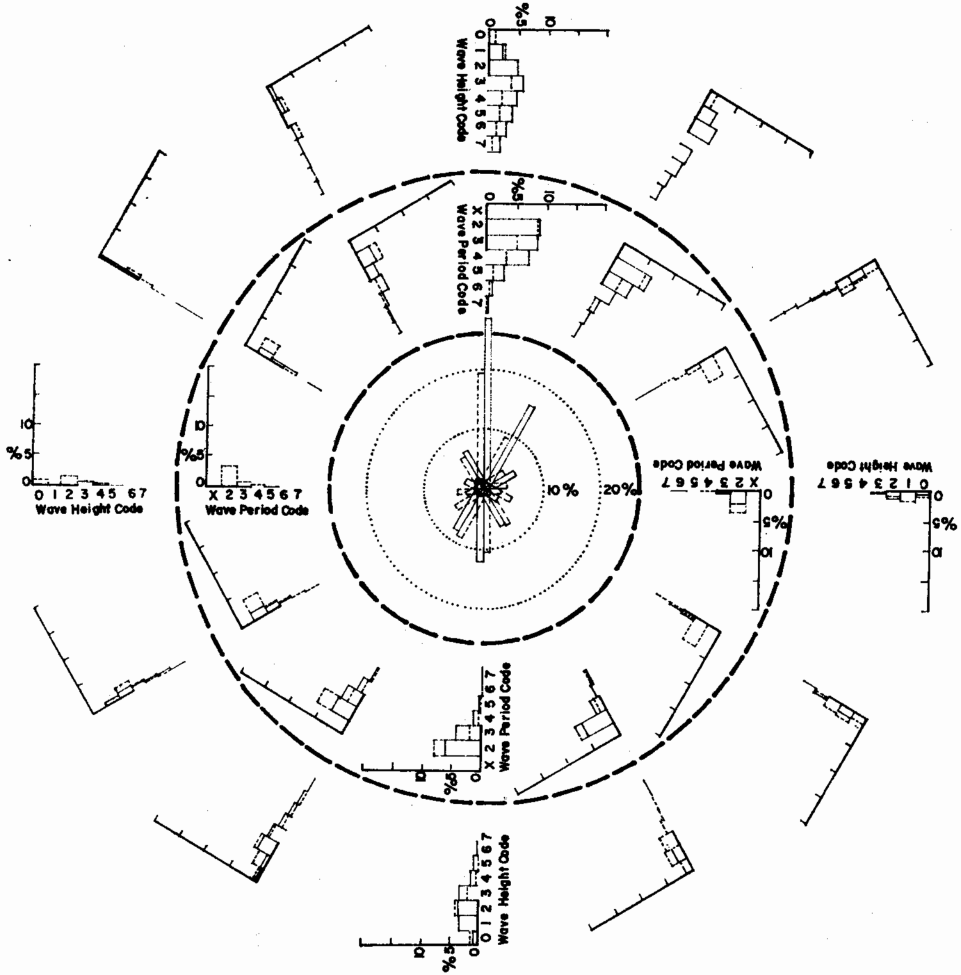
At 5:30 a.m., April 10, 1974, the 5000 ton coastal vessel 'Visahakit' was struck amidships by the 'Toluca' about 8 kilometers from the mouth of the Chao Phya river, as illustrated in Fig. 7. A quantity equivalent to 9,000 barrels of oil was reported to have discharged into the sea at the time of collision. In addition another 5,000 barrels were later found to have discharged over the next two days, with 2,000 barrel discharged in the afternoon of the second day. On the fifth day after the spill an aerial survey was conducted, and the slick was finally found to be transported in two directions. One came ashore to the north of the collision paint and the other was moving across the sea surface in a westerly direction towards the Ban Rang Chan village (see Fig. 7).

Quantitative knowledge of the current system would have been of direct use in giving some ideas of where the general areas of the spills were bound to be. Qualitative information and some knowledge of magnitude order of the current can at least form a plausible explanation for what occurred.

As described in the previous section, the predominant directions of tidal current are north during the flood tide and south during the ebb tide. Knowledge of the tide there indicates that the incident occurred at the time of high water slack semi-diurnal tide. The huge amount of the spill, 9,000 barrels, was therefore transported seawards by the ebb current for another quarter of a day (6 h.). With a current amplitude of about 1 knot (0.515 m/s) the spill is estimated to have been transported seawards for a distance of about 7 km. As the oil kept leaking continuously in small amounts for two days, a portion of the leakage during the flood tide was transported shorewards also for a distance of about 7 km which was near to shore (collision side is 8 km away from the shore).

The rather sudden leakage of 2,000 barrels of oil in the afternoon of the second day during flood tide was however believed to be the one which reached the shoreline in large quantities since the tidal current in the neighborhood of the river mouth was stronger than one knot assigned.

Note that the opposing river current from the Chao Phya river and the topographic pattern modified the tidal current to yield net drift in a direction slightlyaway from north to N-N-W. The spills were thus seen to be deposited on the tidal flat shown near the mangrove swamp in Fig. 7. At the same time the wind



Area 25 ——— South Chaina Sea
Area 31 - - - - - Gulf of Thailand

Wave Height

Code	Meters
0	0.25
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5

Wave Period

Code	Seconds
X	Calm
2	5
3	6-7
4	8-9
5	10-11
6	12-13
7	14-15

Fig.6a —Wave Roses in the Gulf of Thailand and South China Sea

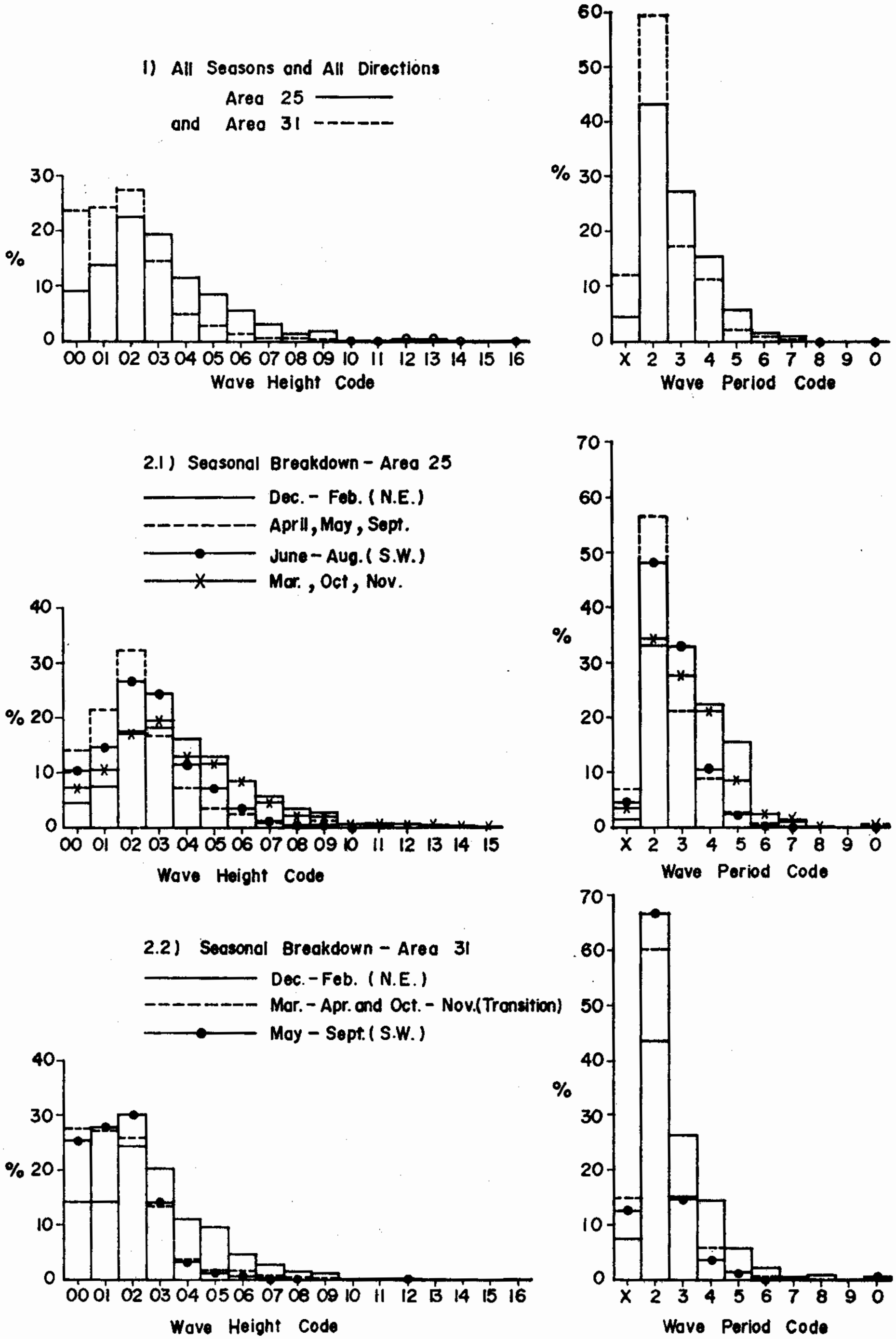


Fig. 6b - Seasonal Wave Climate in the Gulf of Thailand and South China Sea

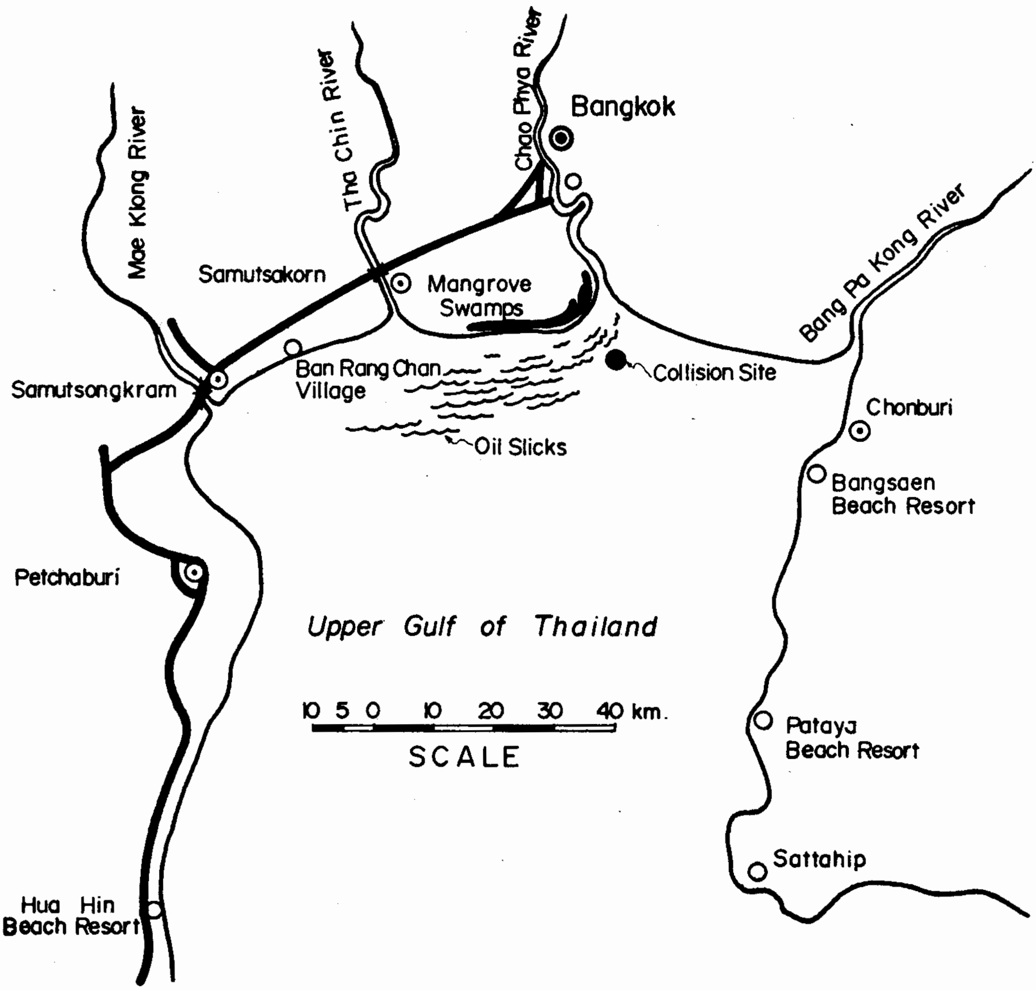


Fig.7 Spreading of Oil Spill , April 1974-Incident

driven current and the slope currents were considered responsible for moving the oil in the westerly direction to reach Ban Rang Chan village on the sixth day after the accident. This is seen from the fact that in April when the incident occurred, the slope current had its counter-clockwise circulation and that for the normal order of magnitude of wind over the Gulf, of 2 to 8 m/s, to give a wind driven current of 5 to 20 cm/s the slicks would have been transported for a duration of 3 to 12 days to a distance of 50 km; this is the location of Ban Rang Chan.

General Discussion

Expecting the spreading and movement of oil spill or pollutant to be primarily governed by the influence of various currents is speculative but fairly reasonable. However, the current components in the Gulf of Thailand as outlined are only crudely estimated. Further research in obtaining the accurate current system in the Gulf of Thailand should be initiated. A joint effort is necessary in future quantitative accomplishment. Wind and pressure fields along the coast are inadequate for analysing wind driven and slope currents. The Meteorological Department may take responsibility in setting up more stations along the coast and at lighthouses. The Hydrographic Department can assist in providing data of tide and measured current to be substantial enough for calibrating mathematical model of the current. To make the kind of predictive current model, simultaneous data of the river flows are needed; and the Royal Irrigation Department may take this responsibility. Development models in predicting the current system, as a whole using the data suggested above, is next to be undertaken. The current system is not only needed for the problem of transport of particulate matter but also for that of navigation.

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บทคัดย่อ

การคาดคะเนว่า การเคลื่อนที่ของน้ำมันรั่ว มลพิษ และตะกอนในทะเลนั้น ขึ้นอยู่กับลักษณะของกระแสน้ำนั้น เป็นการคาดคะเนที่มีเหตุผลดีพอ ปัจจุบันนี้อุตสาหกรรมรอบอ่าวไทยตอนบนกำลังขยายตัวมากยิ่งขึ้น แต่ความรู้เกี่ยวกับกระแสน้ำในอ่าวไทยตอนบนนี้ยังไม่เพียงพอที่จะประเมินปัญหาสิ่งแวดล้อมเป็นพิษในย่านนี้ได้ บทความนี้จะเสนอแนะให้เห็นขนาดของกระแสน้ำที่คาดว่า มีความสำคัญต่อกระบวนการไหลนำพามลพิษ และยังจะได้พิจารณาถึงการเคลื่อนที่ของตะกอนและน้ำมันที่รั่วลงสู่ผิวทะเลด้วย บทความนี้คงจะก่อให้เกิดความสนใจที่จะศึกษากระแสน้ำอย่างละเอียดต่อไป.