PROPOSED MANAGEMENT GUIDELINES FOR OFFSHORE SAND MINING ACTIVITIES IN SOUTH JOHORE, MALAYSIA

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ABSTRACT

Sand deposits in the form of beach ridges, alluvium and, more recently, subaqueous accumulations, found along the eastern coast of Johore Strait have been extensively extracted for use in construction and, to a lesser extent, for glass manufacturing. Often, the conditions imposed on the approval for offshore sand mining activities are expressed in administrative terms, without technical consideration of their potential impact on the stability of the affected coastline.

The removal of offshore sand can reduce the amount of sediment available to replenish the beach. If the sand deposits occur as subaqueous sandbars/banks, thereby protecting the coast from direct wave action, their removal could also lead to shoreline instability. Offshore dredging not only destroys marine habitats; it also imposes stresses on marine communities. By considering the physiographic adjustments and biological impact of offshore dredging, this paper proposes a management plan for offshore sand mining that allows the harmony between economic resources use and the maintenance of environmental quality.

INTRODUCTION

The projected economic recovery and the attendant buoyant construction market in the local scene will increase the demand for sand aggregates. There is also a huge demand for sand as fill material for reclamation work in Singapore since it is near Johore. Thus, local entrepreneurs view sand mining as a viable venture. With the availability of these ready markets for sand, both locally and in Singapore, applications for sand mining concessions will increase.

According to one sand mining application, the southern coast and the eastern section of Johore Strait have 100 million m^3 of sand deposits that can be extracted for export. This lucrative venture is further borne out by the numerous overlapping applications received by the Land Offices. To illustrate, the projected revenue accruing to the State Government, which levies royalties ranging from M\$0.70[a] (seabed) to M\$1.20[a] (river sand) per m^3 on export sand can be substantial.

Applications for concession areas are concentrated along the Johore River estuary, the Johore Strait and the seabed off the southeastern corner of Johore (Fig. 1). Along these coasts are many fishing villages and a major tourism and recreational center. At present, the only road link to the Customs Complex and the Ferry Service Centre at Tg. Pengelih also skirts along the coast. Some stretches of the coast have been identified as Category 1: erosion areas (EPU-PMDM 1985). Therefore, sand mining in the aforementioned coastal/offshore areas, if not carefully planned and controlled, can initiate new erosion and/or aggravate existing erosion (Fig. 2).

Often, the conditions imposed on the approval for offshore sand mining activities are expressed in administrative terms, without technical consideration of their impact on the biological environment and the physical stability of the affected coastline. To arrive at a harmony between economic pursuits and environmental quality in the case of offshore sand mining, the likely impact of dredging activities should be considered.

This paper gives an overview of the different dredging operations and their relative ability to generate adverse environmental impact. It also discusses the various potential environmental stresses that can result from offshore dredging, with emphasis on the physical and biological environments. The paper then outlines the prevailing

[a]28 December 1988: M\$2.70 = US\$1.00

management practices in other countries to minimize the adverse impact of offshore sand mining. Based on the proven management strategy employed in these countries and in light of the peculiarities of local conditions, the paper then presents a set of tentative management guidelines as a first step toward formulating a comprehensive management plan for offshore sand mining that balances economic development and environmental quality off the southeastern coast of Johore.

DREDGING TECHNOLOGY

Despite its technically demanding process and the associated risks in operating under potentially adverse weather conditions, dredging is the most popular method employed for offshore sand extraction. Two types of dredging systems are commonly used: the hydraulic and the mechanical types (Fig. 3).

Hydraulic dredges

The two most frequently used hydraulic dredges in coastal waters are the cutter suction and the trailing suction hopper dredges. The former uses a rotating spiral-shaped cutterhead to break the consolidated materials and then pumps the slurry to the disposal point via a flexible floating pipeline or into a transporting barge. The dredging operation is restricted to moderate sea conditions, especially if a floating pipeline to a shore spoil area is adopted. In contrast, the trailing suction hopper dredge is a self-propelled seagoing vessel fitted with a suction pipe dragged across the bottom. Materials collected in the form of slurry are pumped into a hopper, which is also located on the same vessel, and periodically transported to and dumped at the designated disposal point. Not only does it dispense with the need for a transporting barge, the dredge can also operate in more exposed and heavier sea conditions due to the flexible linkage between the trailing suction pipe and the vessel.

Mechanical dredges

The most common mechanical dredges are the dipper and bucket types. The former is basically a barge-mounted power shovel that is equipped with a scooplike bucket attached to a power-driven ladder structure. The bucket is forcibly thrust into the seabed for material extraction. This type of dredge can work in water depths of up to 15 m. In contrast, the bucket dredge consists of a barge-mounted crane. A drop bucket fitted to the end of the wire is used to excavate bottom materials. The clamshell and the dragline types are the most common dredges under this category. The material excavated by these mechanical dredges is placed in hopper barges, which are then towed to the disposal area. The effective working depth for a bucket dredge is limited to about 30 m.

The dredge to be used in offshore sand mining should be selected properly. Different dredges employ different working systems; thus, they have differing degrees of environmental impact. Mechanical dredges, such as the clamshell, bucket or dipper types, cause a resuspension of material at the bottom of the water column and also spew the fine sediment from the bucket during the hoisting operation. To a lesser degree, hydraulic dredges also release, under wave action, some sediment from the leaking joints of the floating discharge pipeline while they are pumping the slurry ashore.

ENVIRONMENTAL IMPACT OF OFFSHORE DREDGING

Biological environment

The environmental impact due to offshore dredging stem from the suspension of sediment themselves and the release of pollutants from the disturbed sediment. Thus, dredging-induced suspensions can perturb water quality and affect local biota (Dubois and Towle 1985). Dubois and Towle cite operational design, scale and duration of activity as significant factors since each material handling phase--extraction, transport and emplacement--can generate undesirable effects. While the direct environmental impacts associated with offshore dredging are due to the massive displacement of the substrate and the subsequent destruction of nonmotile benthic communities, the resulting indirect impacts are more subtle and can escape recognition by an untrained person. They include (Price et al. 1978):

a. restriction of feeding and respiratory efficiencies and induced mortalities in bottom-dwelling biota, such as bivalve mollusks, as a result of the smothering effect of sedimentation;
b. reduction of the primary productivity (photosynthesis) due to turbidity in the water column;

c. introduction of abnormal volumes of organic material and nutrients, thus increasing the biological oxygen demand (BOD), which in turn reduces oxygen levels and productivity;
d. reintroduction of toxic substances uncovered by mining activities;
e. inadvertent destruction of the adjacent habitat critical to the life cycles of certain organisms; and
f. disruption of migratory routes of motile marine organisms.

A concentration of resuspended sediments and their subsequent distribution and deposition are the primary agents causing the biological stresses mentioned above. Survival under these stressful conditions depends largely on the specific requirements of the marine communities affected and a host of extraneous factors such as depth of sediment, length of time under burial, time of year, sediment grain size and sediment quality.

Another consequence of concern is the physical reduction in habitat area, which is a function of the rate of repopulation of the dredged area. Sea bottom borrow pits remain intact for long periods of time unless infilling occurs from current-induced sediment movement. If the sediments are organic-laden, the subsequent decomposition can lead to anaerobic conditions and the deterioration of the quality of the ambient water. Hence, the reestablishment of marine habitats at the dredged area is again dependent on the magnitude of the dredging operation, new sediment interface and water quality.

Physical environment

Offshore mining activity normally incurs a risk of altering the beach dynamics, wave and swell pattern, and coastal current circulation, which can invoke an undesirable morphological response from the coastline such as erosion or sedimentation. Dredging can influence the coastal physical processes through:

a. beach drawdown due to infilling of the dredged pit during calm periods;
b. interception of sediment movement by the dredged pit, which results in sand depletion onshore/downdrift;
c. removal of protection afforded by offshore banks, which leads to bigger waves impinging on the coast; and
d. changes in the wave refraction pattern, which concentrates wave energy at a particular place.

All the above modifications in the coastal response lead to coastal erosion. It will be seen in later sections that the concerns enumerated above also constitute the primary criteria applied to offshore dredging in other countries.

OVERSEAS PRACTICE

In the United Kingdom, the licensing system for offshore dredging has evolved to a stage where a license is granted only after comprehensive consultations with many authorities. Whereas the Crown Estate Commissioners are entrusted with the issuance of sand mining licenses on a first-come, first-served basis, the governmental review on applications for sand mining is coordinated by the Department of Environment.

The Hydraulics Research Limited (HRL) plays a central role in vetting the application for an offshore sand mining license. Its opinion is often the first to be sought by the Crown Estate Commissioners, who are empowered to issue licenses for gravel extraction. If HRL's opinion on the application is unfavorable from the standpoint of the stability of the adjacent coastline, the license application is unlikely to proceed further (Price et al. 1978).

The following factors must be addressed when processing dredging applications for sand mining in the United Kingdom (Brampton 1987):

a. whether beach slumping or drawdown into the deepened area will occur;
b. whether dredging will affect the natural movement of seabed material by intercepting onshore sediment movement, thereby interrupting sediment supply to the shore;
c. whether the dredging areas include bars and sand banks that might provide protection to the coast from wave action; and
d. whether wave refraction over the dredged area will cause significant changes in the pattern of waves at the coast, such as wave energy concentration or the alongshore transport of bed material.

Based on HRL's detailed investigation of material movement and comprehensive research, which are premised on the answers to the factors addressed above, the following guidelines have been adopted in assessing the effects of dredging on the coastline:

1. *Beach drawdown*. There are two criteria based on the seasonal sequence of beach

recession during storms and beach building during calmer weather: (a) a minimum water depth of 10 m and (b) a minimum offshore distance of 600 m. It will be seen that these are seldom invoked as they are overridden by stringent requirements under other considerations, except for small scale or short-term operations for beach nourishment or land reclamation purposes.

2. *Interception of sediment*. This criterion is based on field investigation of the incipient motion of waves and tidal currents with the 18-m water depth limit at present. More recent studies have revealed that induced shingle movement occurs at depths as great as 22 m. This has been attributed to the stronger tidal current experienced at the test site. Further studies are still ongoing.
3. *Protection by offshore banks*. The ability of offshore banks to dissipate incident waves through premature breaking, bottom friction and reflection, hence, providing protection to the coast, is well acknowledged. At present, however, uncertainty inherent in modeling the wave transmission characteristics of these submarine features still exists. Therefore, the dredging of sandbanks adjacent to the coastline is generally not permitted, unless the rate of sand accretion there is very high and well documented. Even under the latter circumstances, dredging is only for the short term and strictly controlled.
4. *Change in wave refraction*. Waves refract when they enter shallow water since those waves in deeper water travel faster than those in shallow water. Thus, the wave crest tends to wheel around in an effort to parallel the bottom contours/coastline. Thus, waves traversing through a dredged pit can change direction and consequently, concentrate on certain parts of the coastline previously unaffected. In general, the effects of wave refraction are insignificant in water depths greater than 14 m.

The above criteria indicate that the controlling factor is the water depth over the area to be dredged. Hence, in British coastal waters, dredging is not allowed shoreward of the 18-m bottom contours on sediment supply consideration. Although the wave climates and textural properties of sand between the United Kingdom and Malaysia differ, the criteria adopted in the former do serve as a good starting point for formulating a sand mining management plan for the South Johore area, which will be dealt with in later sections.

On the other hand, the potentially deleterious impact of offshore dredging on fisheries and coastal ecology are obviated through the implementation of a Code of Practice for the extraction of marine aggregates. This is usually attained by conducting a baseline study to delineate sensitive resource areas that are to be avoided. Often, site precautionary measures such as erecting a screen around sensitive benthic and other nonmotile communities are specified. Thus, the requirements are very site specific and are seldom depth-dependent as in the case of evaluating the impact of offshore dredging on the physical environment.

OFFSHORE SAND MINING IN SOUTHEAST JOHORE

Present practice on sand mining control

Applications for offshore sand mining concessions are concentrated in the offshore areas between Tg. Siang to Tg. Sepang and off the southeast coast in the South China Sea, along the eastern side of Johore Strait and the Johore-Lebam estuarine system (Fig. 1). However, there are also applications for offshore sand mining off Kukup Island on the western coast of Johore, which is fronted by mangrove-fringed mudflats. There the mechanics of sediment transport are likely to be different since sand is evidently not the primary littoral material for shore building. Nevertheless, the considerations relating to the potential effects of offshore dredging on wave refraction and attenuation by offshore sandbanks, as enumerated in the earlier sections, are still valid.

Having conducted a prospecting survey, a prospective company applies for the mining concession area with the District Land Office, which in turn will consult the various concerned agencies. If there is no objection from any government agency, the application is approved contingent upon adherence to the technical comments, which are listed as preconditions, received from the respective government agencies.

In the past, if the area of interest to the company is within the jurisdiction of the State Government, which is within 3 nautical miles (nm) from the coastline, the State Authority will not have to consult the Federal Government. However, with the implementation of the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment Order 1987) and General Circular No. 5/1987, which is described in the following section, it becomes mandatory for the State Authority to inform the Department of Environment and the Coastal Engineering Technical Centre of the Drainage and Irrigation Department of any application for offshore sand mining and seek their technical comments.

The present legal/administrative machinery

The Environmental Quality (Prescribed Activities) (Environmental Impact Assessment Order 1987) was gazetted pursuant to the Environmental Quality Act of 1974 and enforced in April 1988. Under this order, anybody who intends to engage in any of the prescribed activities is required to carry out an Environmental Impact Assessment (EIA). Under the subject of mining, the order requires an EIA study to be conducted for sand mining that involves an area of 50 ha or more.

In an effort to reduce the need for future coastal protection work, the Federal Government has issued General Circular No. 5/1987 pertaining to the approval of development plans in the coastal area. Under this circular, any development activity, including sand mining, in coastal areas has to be referred to the Coastal Engineering Technical Centre of the Drainage and Irrigation Department for comment.

While the EIA study under EIA Order 1987 covers both the biological and physical environments, the circular is concerned only with the physical environment. For mining activities involving areas larger than 50 ha, the order precedes Circular 5/1987, and the Coastal Engineering Technical Centre then functions as a member of the panel that will evaluate the EIA report collectively.

Coastal Engineering Technical Centre's criteria

At present, the Coastal Engineering Technical Centre bases its recommendation for approving sand mining applications on the seaward limit of sediment movement within which it significantly influences shoreline change. This seaward limit is related fundamentally to sediment and wave characteristics and is site-specific. For most Malaysian conditions, this depth is taken to be the 10-m depth. For a typical east coast offshore profile, it is located about 2 km offshore. Sand mining seaward of the seaward limit of effective sediment transport should not have a significant impact on the shoreline insofar as erosion and accretion are concerned.

This criterion will be examined in greater detail under the ongoing South Johore Coastal Resources Management Project by subjecting it to more rigorous analyses such as refraction using radioactive tracers techniques as has been employed in the United Kingdom. As a comparison, the recommended water depths seaward where dredging is permitted are 18 m, in the case of the United Kingdom (Price et al. 1978), as mentioned earlier, and 35 m, in the case of Genkai Sea, Kyushu, Japan (Kojima et al. 1986). On the other hand, the Shore Protection Manual (US ACEWES 1984) cites a depth limit between 5 and 20 m for offshore sand mining, depending on site conditions, while Dubois and Towle (1985) recommend that "any nearshore marine mining adjacent to a beach should take place outside the 10 meter depth contour. . . ."

Although the depth limit for offshore dredging recommended for the case of Southeast Johore is much less stringent than for those in the United Kingdom and Japan, one must consider that the wave climate in Malaysian waters is much less energetic than those experienced in the countries mentioned above. Another additional consideration is the difference in shoreline geometry, which will be explained below.

Physically, the eastern seaboard of Johore consists of a series of crenulate (or hook-shaped) bays, which can be mathematically analyzed using the log-spiral. Under the constant beating of waves emanating from a predominant direction, the bay will tend toward an equilibrium. Once the equilibrium is attained, the bay can be considered as a closed system with a minimal exchange of sediment with the outside environment. Unfortunately, this stage is almost never reached due to human interference. Sharifah Mastura (1987) has analyzed the physical stability of these hook-shaped bays and found them still in the process of adjusting toward the equilibrium platform. Such a shoreline geometry is less likely to be influenced by the onshore-offshore sediment movement compared to that in British waters, which has more linear features. The direct transposition of the guideline in this case will be untenable.

Therefore, the concept of active profile closure depth and its methods of determination as outlined in the Shore Protection Manual (US ACEWES 1984) are employed to determine the depth limit for dredging operations.

As for the seabed off the western coast of Johore, the prospect of economic offshore sand mining is still uncertain. Nevertheless, the same depth limit has been imposed in the interim.

MANAGEMENT OBJECTIVES AND GUIDELINES

A review of the potential impact of dredging operations on the biological and physical environments and the prevailing dredging practice in other countries elicited these elements for an effective management plan for offshore sand mining:

1. proper inventory of the available resources through a sand resources survey;
2. identification of alternative sources such as land-based river sand;
3. zoning of areas where dredging is permitted;
4. a predredging baseline survey and dredging and postdredging monitoring;
5. precise positioning of dredge to avoid sensitive areas;
6. use of dredging equipment that minimize sedimentation and turbidity; and
7. public education on the adverse impact of offshore sand mining.

To date, the Geological Survey Department of Malaysia has conducted a field geophysical survey with its German counterpart in the South China Sea. Although the spatial coverage is large and sand resources may not have featured strongly in the survey, useful information on the thickness of sand deposits off the southeastern coast of Johore can be gleaned from the report. In addition, a private dredging company has commissioned a sand resources study off the eastern coast of Johore but, unfortunately, the information it obtained is deemed proprietary.

Guided by the above-mentioned elements toward an effective management plan, the proposed management guidelines follow:

1. Offshore sand mining will not be allowed shoreward of the 10-m bottom contours measured from the Lowest Astronomical Tide.
2. Suction dredges are preferred over mechanical dredges and, if feasible, plain suction dredges are preferred over cutter suction dredges.
3. An Environmental Impact Assessment (EIA), which includes a preproject baseline survey of marine biota at the proposed sand mining area, should identify and delineate the natural resources (i.e., corals, commercial clam beds, sea turtle-nesting beaches, fish-spawning areas and seagrass beds) to avoid potential damage to these resources.
4. If dredging is to be carried out near sensitive resource areas, a barrier should be erected to separate them from the dredging site.
5. The dredge should be positioned accurately in the designated area and the anchors/cables/discharge pipes should be placed in the sand or other nonsensitive habitats.
6. Shallow dredging over a large area is preferred over deep dredging to avoid the formation of a stagnant borrow pit that requires a long time to recover. Additionally, dredging should proceed from layer to layer.
7. All leaking joints in delivery pipelines should be repaired immediately to prevent the release of sediment in large quantities to the water column.
8. Dragging of anchors/cables on the seabed is prohibited.
9. Dredging is to be conducted during periods of lowest biological activity.
10. A monitoring program should conduct periodic seabed and marine biota surveys during and after the dredging operation.

These guidelines imply that the removal of sand from the beach itself is to be prohibited. Beach sand mining is not only a direct attack on the very resources to be protected; it also leaves behind a visually cogent evidence of the deleterious impact of such an activity in the form of gaping holes or run-down dunes with resulting wave overwash. The erosion that follows is also likely to be imminent. Available published literature is replete with examples of such human oversight/indiscretion, which invariably lead to disastrous implications. Thus, mobilizing public support for such a prohibition is easy. Only under very rare circumstances, such as a well-documented shoreward accreting beach at the terminus of a littoral cell or landward dunes of a relict beach ridge system, should the above prohibition be relaxed but still strictly controlled in terms of the rate of extraction.

On the other hand, the physiographic adjustment that results after offshore dredging is a gradual process--its main bulk is likely to be subaqueous initially--and may not be apparent within a few years. The associated hazards can surface long after the cessation of sand mining activities. Hence, close and documented monitoring is imperative to reveal early signs of unanticipated stressful conditions and to provide enough information to fully understand this complex coastal phenomenon.

Other potential issues relate to the impact of offshore dredging on navigation and the socioeconomic aspects of the local residents. These impacts are of secondary importance as far as the southeastern coast of Johore is concerned since a major shipping route lies to the south (except within Johore Strait), and dredging operations are highly capital- and equipment-intensive; hence, the local population's involvement in offshore sand mining is likely to be minimal.

The above guidelines represent, at best, a preliminary attempt to enumerate the salient features of a proposed management plan for offshore sand mining. Only the coastal engineering aspects have been dealt with in detail; the biological aspects, which are just as important, have been skimmed over. The cursory treatment of the latter is explained by the professional limitations of the writers, thus underscoring the need for a multidisciplinary approach in formulating a comprehensive management plan for offshore sand mining.

CONCLUSION

Sand mining physically removes sand and alters bathymetry. It also disturbs marine habitats and exerts stresses on marine communities. The physical effect manifests itself in shoreline change as a result of the imbalance in sediment transport while the biological impact transforms into lower productivity and even direct loss of living aquatic resources. Thus, the need to regulate offshore mining activities is obvious.

Prevailing practice in other countries indicates that the physical impact on the shoreline can be obviated by disallowing dredging shoreward of a specified or agreed-upon water depth limit. Various methods are available to ascertain this depth limit as outlined in the Shore Protection Manual (US ACEWES 1984) and employed by Hydraulics Research Limited of the United Kingdom. None of these has been conclusively proven or is universally applicable. Nevertheless, on the basis of wave statistics prevailing along the southeastern coast of Johore and on the practice in other countries, it is recommended that 10 m be considered the minimum depth for the shoreward limit, where offshore dredging should be prohibited. Future work through the use of radioactive tracers techniques or other suitable field methods to study the incipient motion of seabed sediment under various depths is strongly recommended. Such work will strengthen further the practical basis for the depth limit adopted vis-à-vis the anticipated mounting pressure for its relaxation because land-based alternatives for sand resources are depleted.

On the other hand, the impact of offshore dredging on the biological environment is best evaluated through preproject biotic and postproject recovery surveys. These surveys should be included as standard features in the mandatory EIA. Administratively, the complementary Environmental Quality (Prescribed Activities) (Environmental Impact Assessment Order 1987) and General Circular No. 5/1987 are adequate regulatory controls to effect the harmony between economic resources use and the maintenance of environmental quality in the case of offshore sand mining.

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REFERENCES

Brampton, A.H. 1987. Effects of dredging on the coast. Rep. No. IT 306. Hydraulics Research, Wallingford. 11 p.

Dubois, R. and E.L. Towle. 1985. Coral harvesting and sand mining management practices, p. 203-289. *In* J.R. Clark

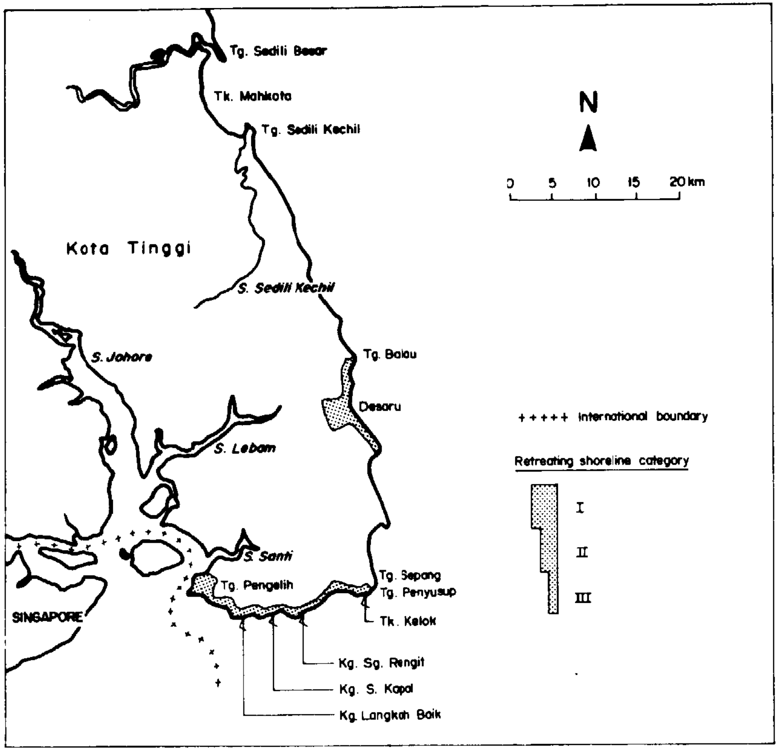

Fig. 2. Coastal erosion areas along the coast of Southeast Johore.

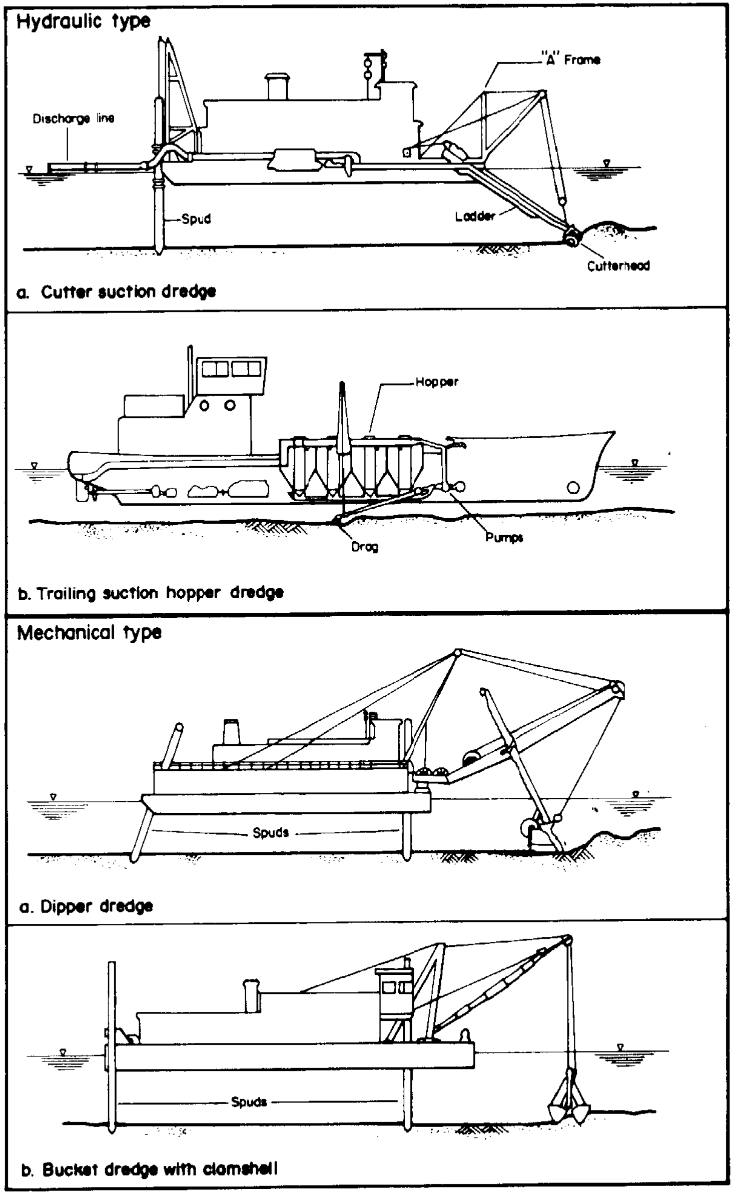

Fig. 3. Common types of dredges.