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## The Supply of Marine Fish Species for Fermentation in Southeast Asia

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## The Supply of Marine Fish Species for Fermentation in Southeast Asia<sup>1)</sup>

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### INTRODUCTION

The principal ecological driving force of Southeast Asia is the seasonal pattern of the monsoon. In the physical environment this is readily apparent in the alternation of dry and wet seasons in the terrestrial and freshwater biomes of the great hydrological basins of the mainland, and in the alternating constraints on and opportunities for resource procurement that this regime produces. Since most of the population of Southeast Asia remains highly dependent on primary industry, climate is of major importance in daily life and in the seasonal round of activities. This is clearly demonstrated in annual agricultural and related cycles and village ritual life.

That this monsoonal regime is of equal magnitude and socioeconomic importance in the marine environments of the region has been less than thoroughly appreciated, apart from a superficial interpretation of its impact on fishing schedules and the like. As in the terrestrial habitats of Southeast Asia so in their aquatic counterparts seasons of abundance and scarcity of potential food resources follow each other, according to the stage of the monsoonal circulation. To balance such extreme fluctuations in food availability methods were devised centuries ago to store at least the rice and fish staples, that with vegetables constitute the basis of most diets of the region. The fermentation of fish and other aquatic organisms is one of the enduring techniques applied in this region to ensure the availability of an animal protein and a savory side dish and condimental complement to rice in the seasons when fresh fish is either scarce or unobtainable.

With few exceptions, fermented fish products are cheap and are regarded as inferior to other fish products. As such, they must be made from inexpensive raw materials. This, in turn, means that such raw materials must have no or few more valuable, alternative economic uses; that they must be readily available in large quantities to permit bulk, low cost fermentation; that they must be caught easily and in safe locations, to reduce labor costs and hazard, respectively; and that their capture must require little highly specialized or expensive fishing gear. Further, the species used must meet certain physical criteria to ensure an easy and even bulk fermentation.

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1) Contribution No. 3 to the "Project on Fermented Fish".

Thus most of the marine species routinely preserved by fermentation share certain dominant characteristics that make them pre-eminently suitable for processing by this technique. Principal among these is that all the species utilized are small, of low economic value and seasonally abundant in inshore marine and brackish waters in large shoals that are easily captured with relatively simple gear. In contrast, at other times of the year they are scarce or absent in the same locations.

The fish fermentation industry based on the use of marine organisms utilizes mainly various species of finfish and planktonic shrimp<sup>2)</sup>. Since, with few exceptions, the finfish utilized are juveniles, they are of low economic value and, apart from conversion into animal feed, have few alternative economic uses<sup>3)</sup>. The fermentation industry also utilizes the smaller fish of the by-catch taken in the hauls of other targetted fisheries.

To obtain the juvenile finfish and planktonic shrimp required for fermenting, the small-scale fisheries that supply the raw materials for fish fermentation demonstrate a detailed empirical knowledge of the seasonal biological rhythms of fish behavior, since in all cases the species utilized and at the size needed are abundant at particular coastal locations only during certain times of the year. For finfish I hypothesize that the fundamental biological rhythm exploited by this fishery is the feeding and recruitment migration of juvenile planktivores, as well as the feeding aggregations of the piscivores that predate on them. Thus the fishery depends on the seasonal location of coastal upwellings induced by the prevailing offshore monsoon winds, which gives rise to phytoplankton blooms. The biological causes of the seasonal behavioral rhythms of planktonic shrimp remain to be elucidated.

Thus the seasonal and diel behavioral characteristic exploited by the fisheries that supply the fermentation industry is the tendency of the juveniles of the finfish species utilized to aggregate in vast shoals in shallow inshore marine and brackish estuarine waters for feeding<sup>4)</sup>. In addition, many of these species are photosensitive and thus can be forced to aggregate further by the use of lights during night fishing. This facilitates the capture of large shoals (*vide infra*). The inshore, seasonal swarming of planktonic shrimp seems to have multiple causes, however [OMORI 1975]. In all cases, these behavioral characteristics permit the fish and shrimp to be captured in vast numbers, using relatively simple fishing gear, and in relatively shallow, sheltered and safe inshore waters.

It is occasionally mentioned in the scant literature on fermented fish products that although certain species are preferred any fish can be fermented. This was verified by informants in the field. Thus to understand the characteristics that

2) Since shellfish are of minor importance they are not discussed in this article.

3) However, larger specimens of many of the species used in fermentation are more valuable when either sold fresh, sun-dried, smoked or salted. Generally, if caught, they are assiduously removed from the catch of juveniles and treated separately.

4) Diel refers to a 24-hour cycle that includes a daylight and a night period.

cause certain species to be preferred, these fish and shrimp are examined here in terms of the monsoon seasonality in Southeast Asia, physical oceanographic factors associated with the monsoons that cause local upwelling and therefore increase primary productivity in marine waters, the seasonality of their biological rhythms, and the techniques used to capture them.

Certain constraints limit a study of this kind. Principal among them is that most hypotheses on the seasonal aspects of fish behavior have been developed and tested in the temperate waters of the Northern Hemisphere. Although a link has been postulated between monsoon winds and the seasonal patterns of spawning and recruitment of Indo-Pacific fishes [QASIM 1973; WEBER 1976; JOHANNES 1978], and tested with inconclusive results [NAVALUNA & PAULY 1986], in contrast, apart from the fishes of coral reefs, mangroves and seagrass communities, relatively little comparable work has been conducted in the tropics<sup>5</sup>). The dearth of research and literature on fish behavior is particularly acute for sandy or muddy continental shelves in the seasonally extremely different marine environments of the monsoon belt. This severely constrains discussion of the relationships between biological rhythms and the supply of raw materials for fermentation, since most such materials are derived from muddy or sandy shelf areas. Perforce, much of the section on monsoon seasonality and the biological rhythms of fishes represents a series of assumptions that in large part remain to be tested.

Severe problems of field identification are imposed by the classification of these species by local nomenclature. Many terms, such as *silinyasi* or *bolinau*, used in the Philippines, for example, are used to describe miscellaneous small fish of the same family but of several different species (and possibly genera, too) taken either in a single haul or fermented in a single batch. For example, in the Tagalog language of the Philippines the term *silinyasi* refers to the undifferentiated fry of *Sardinella* spp., as well as to *S. fimbriata*, which is also referred to as *tunsoy*. As in many countries, one of the problems with local names applied to Philippine fish is that terms for the same fish vary by growth stage [HERRE & UMALI 1948]. Further difficulties also arise from the large number of languages/dialects, as in Indonesia [SCHUSTER & DJAJADIREJA 1952] or in the Philippines [HERRE & UMALI 1948; RAU & RAU 1980; SCHROEDER 1980], in particular.

This article is one of a series of reports on a comprehensive study of fermented fish products in Asia conducted jointly by the author and Dr. N. Ishige of the National Museum of Ethnology, Osaka. Earlier publications in this series have examined the history of fermented fish products in Northeast Asia [石毛 (ISHIGE) 1986a] and *narezushi* (fish fermented with rice or another cereal, or another vegetable item) [石毛 (ISHIGE) 1986b]. This article is based on fieldwork and library research conducted from November, 1982 to August, 1985 in Burma,

5) Recruitment means an increase in the natural population resulting from the addition of juveniles.

Indonesia, Malaysia, the Philippines, Thailand and Vietnam.

## THE PATTERN OF MONSOON SEASONALITY

The biologically and physically complex region that constitutes Southeast Asia is composed of topographically and climatically dissimilar mainland and insular units. The climate of the entire region is dominated by the large-scale circulation patterns of the monsoons: the northeast monsoon, the southwest monsoon, and the two inter-monsoonal periods.

### (1) THE NORTHEAST MONSOON

Although varying somewhat according to specific location, the northeast monsoon lasts from about mid-October until March. During the Northern Hemisphere winter the pressure gradient from the high pressure over the Asian landmass slopes southward across Southeast Asia, toward the low pressure zone over the heated Australian continent. This creates a basically north to south flow of air across Southeast Asia that causes the northeast monsoon (Fig 1).

In the Northern Hemisphere winds blow from the northeast, become northerly near the Equator, and, under the influence of Coriolis Force, are deflected as westerlies in the Southern Hemisphere, over Java and Eastern Indonesia. The northeasterly winds that affect the western part of Southeast Asia are composed partly of the monsoon airstream that emanates from the Asian landmass and partly from the Trade Winds blowing from the Western Pacific high pressure system. The winds blowing over the Philippines during this season are derived mainly from the latter.

At this time of the year strong onshore winds and heavy precipitation are experienced along the coasts of Vietnam, and the eastern coasts of Thailand and Peninsular Malaysia. But over the remainder of mainland Southeast Asia this is the dry season, with predominantly offshore winds and an associated upwelling in coastal waters (*vide infra*) (Fig. 1).

In insular Southeast Asia, however, the northeast monsoon is the wet season, since this part of the region lies within the Inter-Tropical Convergence Zone. Thus winds are onshore over eastern Sumatra, Java and Eastern Indonesia, northern and western Borneo, and the western coasts of Sulawesi. Winds are onshore on the eastern coasts of the Philippines. In those locations coastal upwelling is therefore mostly suppressed.

### (2) THE SOUTHWEST MONSOON

In Southeast Asia the southwest monsoon season lasts from mid-May until September. During this season the wind patterns are essentially the reverse of those prevailing during the northeast monsoon.

The low pressure over the Asian landmass resulting from heating during the Northern Hemisphere summer causes the southwest monsoon to sweep eastwards from the Indian Ocean over Southeast Asia, as far north as the Philip-

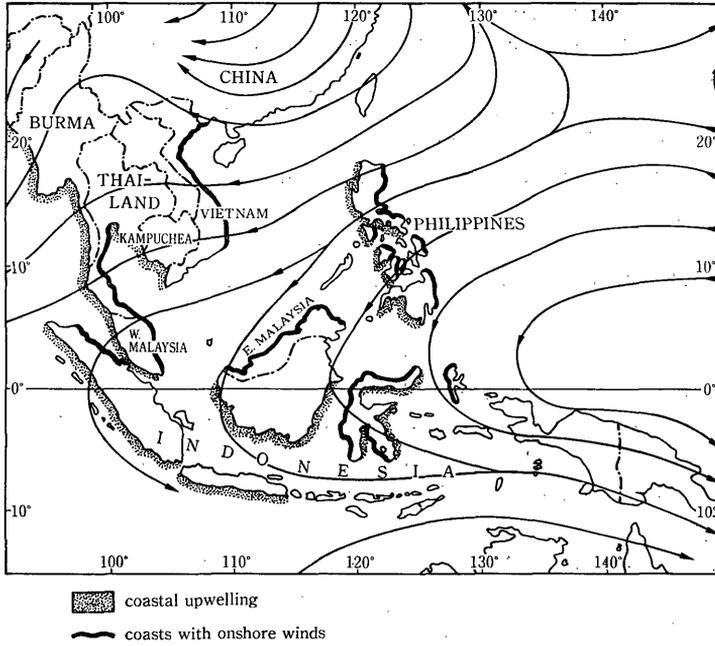


Figure 1. Predominant Wind Streamlines and Main Areas of Wind-Induced Upwelling in Southeast Asia during the Northeast Monsoon

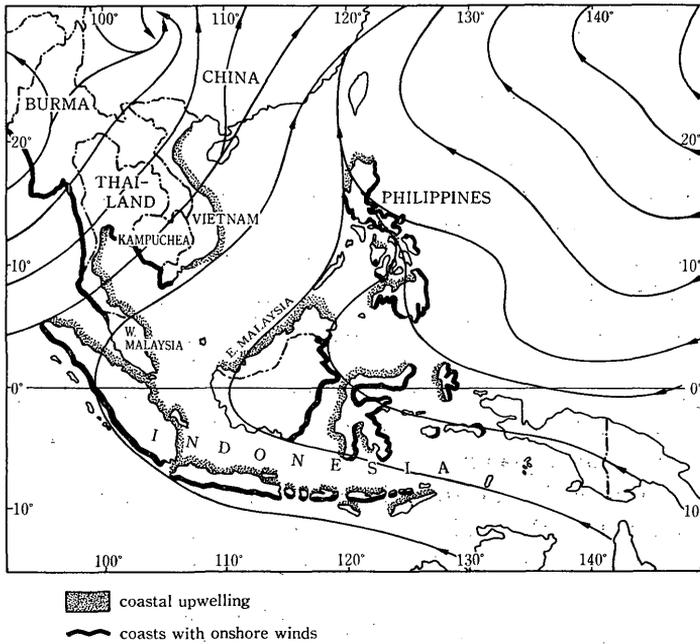


Figure 2. Predominant Wind Streamlines and Main Areas of Wind-Induced Upwelling in Southeast Asia during the Southwest Monsoon

pinus. This airstream is joined by southeasterly winds flowing from the winter high pressure over the Australian continent, which spread across Indonesia as easterlies, become southerly as they near the Equator, and eventually merge with the southwest monsoon main stream over insular Southeast Asia (Fig. 2).

Over mainland Southeast Asia the southwest monsoon is the season of onshore winds, heavy rain, and suppression of coastal upwelling. Prevailing winds are onshore along the coast of Burma, the Andaman Sea coast of Thailand, Kampuchea, the west coast of Sumatra, the eastern coasts of Java and Eastern Indonesia, Sulawesi and Kalimantan, and the southern and southwestern coasts of the Philippines.

### (3) THE INTER-MONSOONAL PERIODS

The two inter-monsoonal periods mark the transition seasons between the two monsoons. One such period occurs from late-March through May, when the southwest monsoon advances and the northeast monsoon retreats, and the other occurs from late-September through November, when the northeast monsoon advances again. Since they are transitional seasons, the inter-monsoonals are characterized by frequent changes in the direction of the prevailing winds, as retreating monsoons make a temporary resurgence of 1-2 weeks before the new monsoon has become fully established.

The length of these inter-monsoonals varies. In some years they may last but three weeks, whereas in others they may extend for up to two months. That from September to November is generally of shorter duration than the March-May transition period.

## OCEANOGRAPHIC AND BIOLOGICAL FACTORS

The fish production of any sea area depends on the fertility of the water therein<sup>6</sup>). Thus ultimately production depends on the level of primary production of phytoplankton, which constitutes the base of the marine food web. Since the weak fluctuations of solar radiation means that tropical marine waters are continuously well-illuminated and well-heated throughout the year, photosynthesis of phytoplankton is limited only by the depth of light penetration. It usually occurs within the upper 200 m of the water column in tropical seas. As a consequence, the primary production of an area is therefore limited by the supply of nutrient salts, particularly nitrates and phosphates, required for the protein synthesis of phytoplankton.

However, *ceteris paribus* in tropical seas a strong thermocline usually persists year-round and inhibits the mixing of waters<sup>7</sup>). This limits primary production because dead organisms and excreta, which provide the nutrients for phytoplank-

6) Here, "fish production" means "biological production" as opposed to the "yield of a fishery". The latter obviously depends also on a variety of cultural, economic and technical factors.

7) A thermocline is a layer of water in a thermally stratified area that separates an upper, warmer, lighter and oxygen-rich zone from a lower, colder and oxygen-poor zone.

ton growth, sink out of the euphotic zone into the deeper waters beneath the thermocline, where they are not used for primary production<sup>8)</sup>. As a result, nutrients are gradually depleted in the euphotic zone, the fertility, and therefore the fish production, of which gradually declines.

Thus upwelling or vertical water movements that seasonally disrupt the thermocline and restore the temporarily lost nutrients to the productive cycle in the euphotic zone are of fundamental importance to the fertility of the sea and to fish production. When nutrient-laden waters are thus restored to the surface a "burst" of phytoplankton growth occurs, followed by a growth in the zooplankton population, and in turn, an increase in the population of both planktivorous fish and those piscivores that predate on them. The spawning and feeding patterns of fish are adapted to this seasonal sequence of the loss and restoration of nutrient levels (*vide infra*). Thus the occurrence of upwelling, which is caused by a variety of physical factors, is of fundamental importance to both the fish production of an area and the fishery based on it (Fig. 3a)<sup>9)</sup>.

In Southeast Asia coastal upwelling is caused mainly by the prevailing offshore monsoonal wind flow. Thus the location of areas of coastal upwelling, and therefore of fishing activities, changes seasonally according to the prevailing direction of the monsoonal winds. During the season of the northeast monsoon upwelling occurs on western, southwestern and eastern coasts, and *vice versa*, during the southwest monsoon it occurs on eastern, northeastern and northern coasts (Figs. 1 and 2).

Conversely, during the monsoon season with prevailing onshore winds the reverse process operates. At this time of the year nutrient-rich waters are kept below the thermocline by the piling-up of surface water against the coast under the pressure of the prevailing wind. Thus without replenishment from below the thermocline, the euphotic zone undergoes a decline in nutrients and a concomitant decline in populations of phytoplankton and fish.

Local upwelling is also caused by obstructions such as islands or submerged raised areas of the seabed, which obstruct the surface current flow induced by the prevailing wind (Fig. 3b). Local upwelling in the lee of islands is a particularly important phenomenon that reinforces that induced by monsoon winds in the Indonesian and Philippine archipelagos.

Localised, temporary upwelling also occurs at night as a consequence of convection cells. During the night the sea surface loses heat by radiation, evaporation and conduction. Thus surface waters become denser and sink, forcing underlying waters to compensate by rising toward the surface (Fig. 3c). Such convection cells are some 100–200 m in diameter and about 100 m deep. The

8) A euphotic zone refers to the upper layers of a body of water into which enough sunlight penetrates to permit the growth of green plants.

9) These vertical water movements in the marine environment are extremely complex. The discussion here has been greatly simplified for the purposes of this paper.

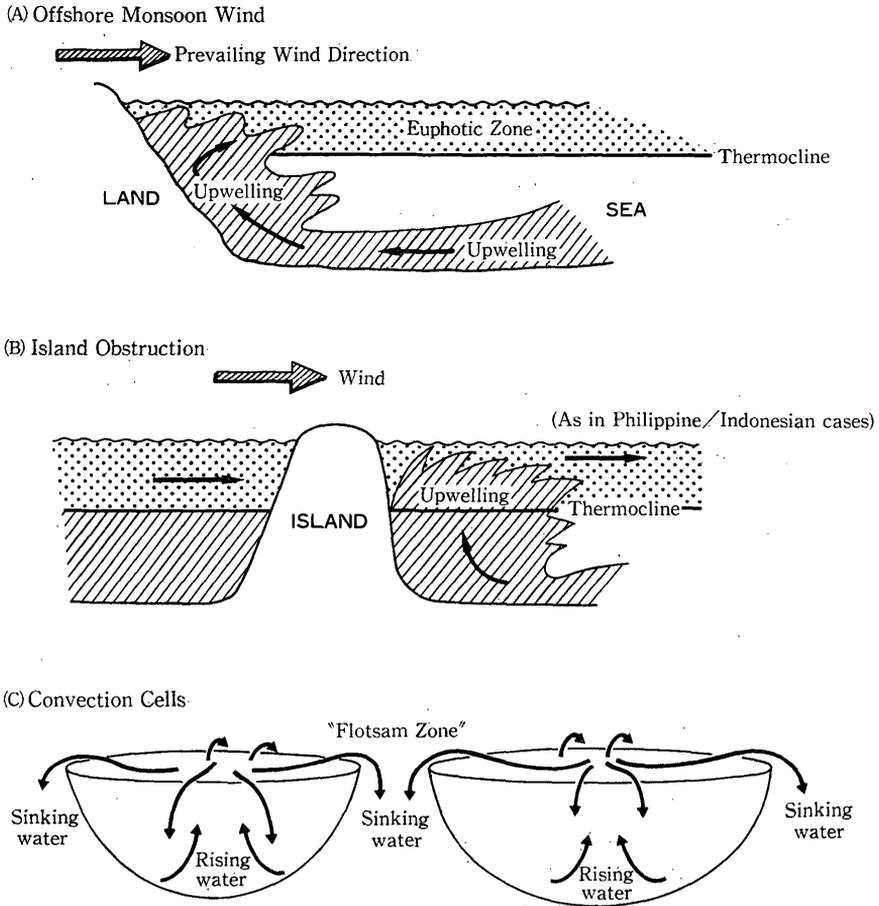


Figure 3. Principal Causes of Upwelling in Southeast Asian Coastal Waters

boundary between two such cells, where the waters are sinking, is a “flotsam zone” that is usually rich in plankton. These flotsam zones therefore provide rich sites for night fishing, when schools of planktivores can be further aggregated by using lights as lures (*vide infra*).

But these broad patterns of coastal upwelling induced by the prevailing wind are locally distorted by a range of other complex and often interacting physical factors. Local distortions may result from the impact of “global” and local currents, a major influx of nutrients contained in the discharge of rivers swollen by monsoon rains, as well as being input directly from the rain itself, and by the interruption of winds and currents caused by highly indented coastlines. Although it may be the prevailing physical factor, particularly in localities with long and uninterrupted stretches of coastline that trend at a constant angle toward the prevailing wind, in many places monsoon-induced upwelling may be

reinforced, masked, or totally negated by such local factors.

## I. FINFISHES

### THE SPECIES USED FOR FERMENTATION

Although any species of fish can be fermented to produce fish sauces and pastes, by preference, because of the inherent chemical characteristics of certain species, as well as biological rhythms that favor uniform harvesting in bulk, in Southeast Asia only relatively few species are utilized (Table 1). The use of other marine species is highly localized and is therefore not discussed here.

In terms of both the quantity harvested and the number of species utilized, most of the fish fermented are clupeoids (herrings and herring-like fishes, and engraulid anchovies). Adults of the smaller species of these families are fermented and juveniles of the larger species are used, since adults generally command a good market price as table fish. Adults of the atherinids are used. Juveniles of *Decapterus* spp., *Rastrelliger* spp. and *Therapon* spp., as well as Exocoetidae, Eleotridae

Table 1. The Principal Marine Finfish used for Fermentation in Southeast Asia

SCIENTIFIC NAME	ENGLISH COMMON NAME	B	I	M	P	T	V
<i>Dussumieria</i> spp.	Round herring				X	X	
<i>Spratelloides</i> spp.	Round herring				X		X
<i>Escualosa</i> spp.	Sardine				X		
<i>Sardinella</i> spp.	Sardine				X		X
<i>Corica soborna</i>	Shad					X	
<i>Anodontostoma chacunda</i>	Gizzard shad				X		X
<i>Nematolosa nasus</i>	Gizzard shad				X		X
<i>Colia</i> spp.	Anchovy						X
<i>Setipinna</i> spp.	Anchovy						X
<i>Stolephorus</i> spp.	Anchovy	X	X	X	X	X	X
Exocoetidae	Flying fish				X		
Atherinidae	Silversides				X		
<i>Therapon</i> spp.	Therapons				X		
<i>Decapterus</i> spp.	Round scads				X		X
Leiognathidae	Slipmouths		X		X		
Eleotridae	Sleepers				X		
Gobiidae	Gobies				X		
<i>Auxis</i> spp.	Frigate mackerel				X		
<i>Katsuwonus</i> sp.	Skipjack				X		
<i>Rastrelliger</i> sp.	Indo-Pacific mackerel		X			X	X

Table Note: B=Burma, I=Indonesia, M=Malaysia, P=Philippines, T=Thailand, V=Vietnam. "X" denotes used.

and Gobiidae are fermented. In general, only the viscera of the scombrids *Auxis* spp. and *Katsuwonus* spp. are used to prepare fermented products, as a by-product of the main use of these species.

Adult and juvenile anchovies (*Stolephorus* spp.) are the marine fish most widely utilized for fermenting in Southeast Asia. They are used in every country of the region (Table 1). In Southeast Asia the widest range (80 percent) of the species shown in Table 1 is used in the Philippines. There, however, the most frequently used fish is anchovy, followed by a mixture of clupeoids, juvenile round scads and slipmouths. The other species used in the Philippines are of minor, local importance and do not constitute a major source of raw material for the fish fermentation industry overall.

In Vietnam 45 percent of the species listed in Table 1 is used. There, apart from *Rastrelliger* spp. and *Decapterus* spp., the fish used are all clupeoids. Vietnamese fish sauce makers first separate pelagic from demersal species [LU'ONG 1981] and then carefully segregate the latter by species, to ensure a superior level of processing [NGO 1953]. This also occurs in the Philippines [MONTALBAN 1932].

In the Philippines and Vietnam marine species supply most of the raw materials for fermentation. The relative importance of marine species in the Philippines compared to other parts of Southeast Asia reflects the greater role in other countries of freshwater species [RUDDLE 1987].

In Thailand most fermented fish products are made from freshwater species. Apart from juveniles of the genus *Rastrelliger* only clupeoids are used to produce marine fish sauce. In Malaysia and Burma only *Stolephorus* spp. is used; in Malaysia because, apart from the manufacture of shrimp-based fermented products, only *budu*, a minor, localised product, is based on finfish, and in Burma because fermented products are based mostly on planktonic shrimp and freshwater species. Similarly, in Indonesia only stolephorid anchovies, slipmouths and juvenile mackerel are used, because the better grades of *terasi*, the principal fermented marine product, are based primarily on planktonic shrimp.

Thus the finfishes used by the fermentation industry are mostly planktivores that depend on the phyto- and zooplankton blooms generated by the upwelling induced by the offshore monsoon, and, to a lesser extent, on piscivores that predate on those planktivores.

#### (1) PLANKTIVORES

##### **Engraulidae (Anchovies)**

These small pelagic planktivores occur in immense shoals in coastal and estuarine waters, are important in the marine food chain, and are subject to heavy predation. In Southeast Asian waters only the genus *Stolephorus* of this large family is of appreciable economic importance [TIEWS *et al.* 1968]. It is used in all the countries under consideration here to make fermented fish products,

and is the main species used in the Philippines. Most stolephorids are caught within a few kilometers of the coast, where they aggregate in large shoals, as in the Singapore Strait and off the east coast of Peninsular Malaysia [THAM 1974]. In the former area there is an apparent close relationship among precipitation, salinity, phosphate content, the abundance of phytoplankton and zooplankton, and the abundance of stolephorids. Whereas excessive freshwater influx lessens the quality of the coastal marine environment for these fish and causes them to move to deeper waters, it contributes to nutrient loading, particularly of inorganic phosphorus, which then promotes phytoplankton blooms that in turn sustain zooplankton. With the increase in the population of the latter stolephorids aggregate for feeding, since zooplankton, particularly copepods, is their principal food [THAM 1953, 1955].

Eggs and different growth stages of the fish occupy different habitats [THAM 1974]. Thus spawning may occur offshore and aggregations in coastal waters may be for feeding. Further, different species of stolephorids exhibit different physical and chemical environmental preferences, as well as those for different types of plankters [HARDENBERG 1934; THAM 1953, 1955]. Wind force may also play a part in the distribution of some species.

### **Clupeidae (Sardines and Herrings)**

These are mostly moderately small, schooling pelagic planktivores. Clupeids form a large family, the species of which are often difficult to distinguish in the field. Following anchovies, they are the preferred fish for use in fermentation.

Clupeids usually swim near the surface of coastal waters and enter brackish water estuarine areas and occasionally freshwaters. They are important in the marine food chain and are preyed on by large marine predators. The diet of juveniles consists mainly of phytoplankton but later switches mainly to zooplankton.

Among the clupeids used for fermentation in the Philippines is the *Sardinella longiceps*, the Indian oil sardine, often admixed in schools with the *S. fimbriata*. The seasonal migrations and possible seasonal variations in feeds of *Sardinella* seem to be heavily dependent on seasonal variations in the location of plankton. For example, from November through February, during the wet Northeast Monsoon, which blows from the west in the Bali Strait, *S. longiceps* schools occur on the shallow shelf areas, where zooplankton are most abundant. They do not normally occur in other areas, where concentrations of zooplankton are lower. But the onset of the Southeast Monsoon leads to a periodic upwelling along the coast of south Java, and especially in the Bali Strait, which causes high primary productivity. At this season *S. longiceps* may alter its feeding habits to utilize phytoplankton blooms. Further, it appears that spawning occurs during the Southeast Monsoon, of May through October, with a peak in June or July.

Thus if the hypothesis is correct this phenomenon, too, would represent an adaptation to utilize the rich food supply occasioned by the high primary productivity during periods of upwelling [RITTERBUSH 1975]<sup>10)</sup>. Along the Bali Strait of Indonesia *S. longiceps* tend to remain at a depth of 50–60 m on shallow shelf areas during daylight hours and migrate in the early evening to near the surface or to the surface, where they spend the night.

Gizzard shads (*Anodontostoma chacunda* and *Nematolosa nasus*) are fermented in the Philippines [UYENCO *et al.* 1953; ARROYO 1973; ANON 1981] and Vietnam [NGO 1953]. These small fish occur in shallow waters, estuaries and tidal rivers and are detritus feeders that feed on muddy bottoms. Since the gizzard shad has numerous bones it is little appreciated as a table fish or for other uses, and is thus of low economic value. Hence these fish are ideally suited for fermenting. The transparent herring (*Clupeoides lele*) is also fermented in the Philippines [UYENCO *et al.* 1953].

#### **Decapterus sp. (Round Scads)**

Round scads inhabit coastal pelagic waters, swim in schools, and are presumed to feed on small invertebrates [TIEWS *et al.* 1968]. Most caught in Southeast Asia are immature. Only two species are of commercial importance in Philippine waters, *D. russelli* and *D. macrosoma* [MAGNUSSON 1970]. Round scad is a low priced, small fish, with a TBL of 13–20 cm. It has a good flavor, and is not bony.

#### **Atherinidae (Silversides)**

These small, zooplanktivorous pelagics commonly occur in large schools in coastal waters and sometimes also in brackish and freshwaters. Although useful as tuna bait they have no other commercial value. As a consequence they are used in the Philippines for fermenting [ARROYO 1973; ANON 1981].

#### **Leiognathidae (Ponyfishes or Slipmouths)**

These are small, demersal schooling carnivores that occur over sandy or muddy bottoms in coastal waters. They feed on small, bottom-dwelling animals and zooplankton. Slipmouths are less widely used for fermentation than are small pelagics. They are used for this purpose in Indonesia [IPFC 1967] and the Philippines [ARROYO 1973; ANON 1981].

### (2) PISCIVORES

Drawn by the vast shoals of planktivores attracted by the plankton blooms, schools of juvenile and older piscivores predate on the former. These are mostly of minor local importance, and include juvenile barracuda (*Sphyraena* spp.), used in Hong Kong [IPFC 1967], juvenile *Therapon* spp., in the Philippines [ARROYO 1973; ANON 1981], and skipjack (*Katsuwonus* spp.), used in Mindanao

10) This supports evidence from India that the spawning of *S. longiceps* coincides with and varies according to the appearance of the diatom bloom [NAIR 1960].

[MACALINGAG-LAGUA & PAYOFELIN 1982].

(3) CATADROMOUS FISH

**Eleotridae (Sleepers) and Gobidae (Gobies)**

The most expensive fish paste in the Philippines is made from the fry of these two families of fish, and is closely dependent on their seasonal migration. In northern Luzon the Ilocano generic term *ipon* is applied to the two genera of eleotrids (*Eleotris melanosoma* and *Ophiocara aporos*) and three of gobies (*Chonophorus melanocephalus*, *Glossogobius celebius* and *G. giurus*, and *Sicyopterus lacrymosus*) that are exploited for fermentation [HERRE 1958, 1965].

These fish are of major commercial importance among the Ilocano people of northern Luzon. They are also fermented in Southern Mindanao [MACALINGAG-LAGUA & PAYOFELIN 1982]. Although fishes of this family inhabit a wide variety of marine, brackish and freshwater habitats, those of concern here are catadromous species that as juveniles and adults occupy riparian habitats and descend to the sea for spawning. The fry then return upstream to freshwater habitats during a precisely limited season from mid-September until mid-March (*i.e.*, during the Northeast monsoon and the inter-monsoonal that precedes it), and most abundantly for the three days following full moon, when the tides are highest. It is these fry that provide the raw materials for a special fish paste, and an important source of income to the Ilocano people of the northern coast of Luzon, and especially those living at the mouths of the Abra, Abulug and Cagayan rivers, where the fry occur in enormous quantities.

**THE RELATIONSHIP BETWEEN FISHING SEASON AND MONSOON SEASONALITY**

For the physical and biological reasons discussed above, most coastal fishing for finfish in Southeast Asian waters is conducted during the monsoon when the prevailing winds are offshore, and when coastal upwelling therefore occurs, and during the inter-monsoonals. Thus at Rayong, Samut Songkhram and Chonburi, along the Inner Gulf of Thailand, the species used for fermenting are caught between September and December, *i.e.*, from the end of the southwest monsoon, when upwelling induced by the prevailing offshore winds occurs in this region, through the inter-monsoonal and into the early part of the northeast monsoon, before the prevailing onshore winds of the latter have developed with full force and depressed the upwelling (Fig. 4).

At Songkhla, on the southern Thai coast, and at Kota Bharu, on the east coast of Peninsular Malaysia, the anchovy (*Stolephorus* spp.) fishing season lasts from March until October. That is, through both calm, inter-monsoonal periods and through the entire southwest monsoon, when prevailing winds are offshore

In Burma the main fishing season lasts from December, near the beginning of

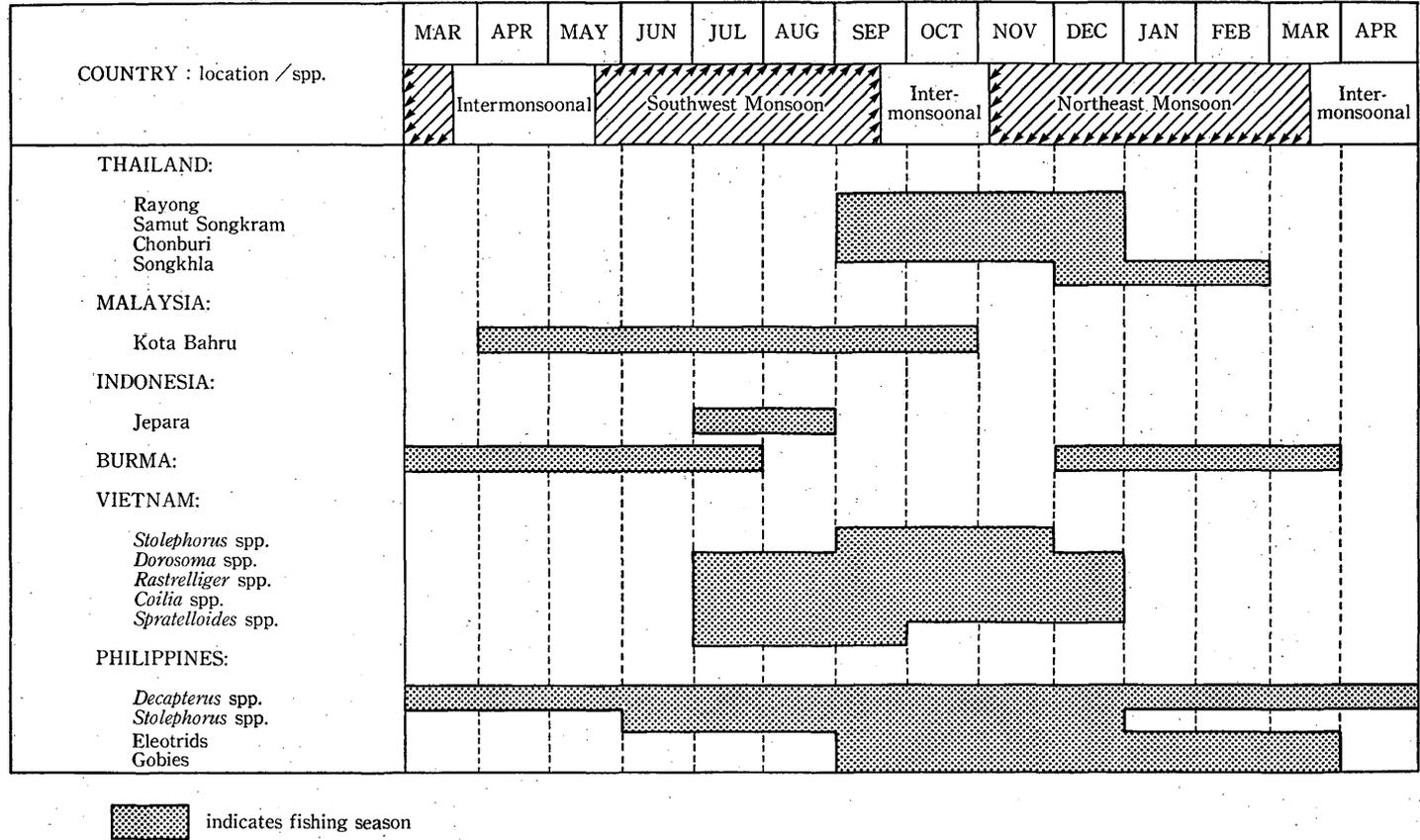


Figure 4. Relationship between Selected Sites, Fish Species and Monsoon Seasonality

the prevailing offshore winds of the northeast monsoon, through the inter-monsoonal, until July, mid-way through the southwest monsoon season of prevailing onshore winds. The extended fishing season in Burmese coastal waters is probably attributable to the highly indented and island festooned coastline, particularly in the south of the country, which affords ample scope for local areas of upwelling and sheltered fishing grounds during the different monsoons.

In the coastal waters of Vietnam, anchovies (*Stolephorus* spp.) are taken from September until November, *i.e.*, from the end of the offshore southwest monsoon, through the inter-monsoonal, and into the beginning of the onshore northeast monsoon. *Dorosoma* spp., *Coilia* spp., and *Rastrelliger* spp. are caught for a somewhat longer period, from July to December. Anchovies of the genera *Setiplinna* and *Engraulis* are caught only from July to September, *i.e.*, only after the prevailing offshore winds of the southwest monsoon and the coastal upwelling that it induces are firmly established.

Because of the archipelagic nature of the Philippines, which affords alternate and nearby leeward and windward coasts during both monsoons, the fishing season extends year-round, although the target species vary according to the biological rhythm of the fishes. *Decapterus* spp. is taken throughout the year, but in different waters at different seasons, whereas *Stolephorus* spp. can be caught from June until December, and sleepers and gobies are caught from September to March, in northern Luzon.

### SPAWNING SEASON, GROWTH RATES AND HARVESTING TIMES

Although in the waters in and around west-facing Manila Bay, Philippines, *S. heterolobus* spawns throughout the year, peak spawning occurs from October to March, *i.e.*, during the northeast monsoon, when upwelling is greatest. Conversely, there is little or no spawning from April to July, during the southwest monsoon, when upwelling is minimal on this western coast. Most young fishes are recruited into the fishery during the period February-April, and thus are able to take advantage of the maximum phytoplankton population caused by the upwelling induced by the northeast monsoon, and into the following inter-monsoonal period. Some recruitment also occurs in August and September, the end of the southwest monsoon [TIEWS *et al.* 1968].

A similar pattern is exhibited by *S. punctifer*, for which the main recruitment takes place in the northeast monsoon, peaking between December and February, with a secondary recruitment period at the end of the southwest monsoon, in August-September. The pattern of *Leiognathus blochii* shows that recruitment extends from September until April (*i.e.*, from the beginning of the inter-monsoonal until the end of the northeast monsoon), and peaking at the beginning (November) and end (March) of the monsoon [NAVALUNA & PAULY 1986].

Along the east-facing coast of the west of the Gulf of Thailand phytoplankton is abundant during the period March-July, with peaks in March and July.

This coincides with the inter-monsoonal and the upwelling caused by the predominantly offshore winds of the southwest monsoon. *Rastrelliger brachysoma* and *R. neglectus* were found to spawn 16–60 km offshore from February to September, with spawning peaks in February–March and July–September. The spawning rhythm of *Decapterus* spp. was also found to be the same. Similarly, on the western coast of Peninsular Malaysia, *R. brachysoma* and *R. neglectus* were found to spawn mainly from August to December, which would permit juveniles to utilize the phytoplankton blooms during the inter-monsoonal [SCS 1978].

Although miscellaneous small fish which often constitute a “by-catch” are commonly utilized for fermenting, fish of a fairly uniform size and growth stage and of the same species are preferred for producing fermented sauces and pastes, since they ferment at an even rate and yield a product of uniform quality. Thus fishing efforts to supply the larger factories are directed with certain gear at a particular species and in particular seasons, times and places. Smaller producers are usually supplied mainly from the by-catch of efforts directed at other species.

Most of the marine fish utilised to make fermented sauces and paste are either juveniles or young adults. This can be ascertained by comparing the size of this fish fermented with their total body length when mature. In the Gulf of Thailand, for example, the Indo-Pacific mackerel (*Rastrelliger neglectus*) grows to a size of about 13 cm in 6 months [DHEBTARANON & CHOTIYAPUTTA 1974]. This is close to the maximum size of that fish found in the fermentation tanks of fish sauce factories around the Inner Gulf. This means that the juveniles of fish spawned in the early to middle months of the period February–September are harvested for fermenting in the period September–December. The size of the fish harvested for making fermented fish sauce in Vietnam is shown in Table 2.

## HYPOTHESIS ON MONSOON SEASONALITY AND THE BIOLOGICAL RHYTHMS OF FISHES

Most of the finfish used to make fermented products are small, pelagic, schooling planktivores (Table 1). Thus their feeding behavior depends on spatio-temporal variations in the location of plankton, which, in turn, depends on monsoonal seasonality. Further, since these fish are subject to high predation pressures it can be supposed that in their reproductive strategy they migrate away from inshore zones, where predation rates are extremely high, to spawn in offshore areas where the pressure is less intense [DALZELL & RUDDLE n.d.].

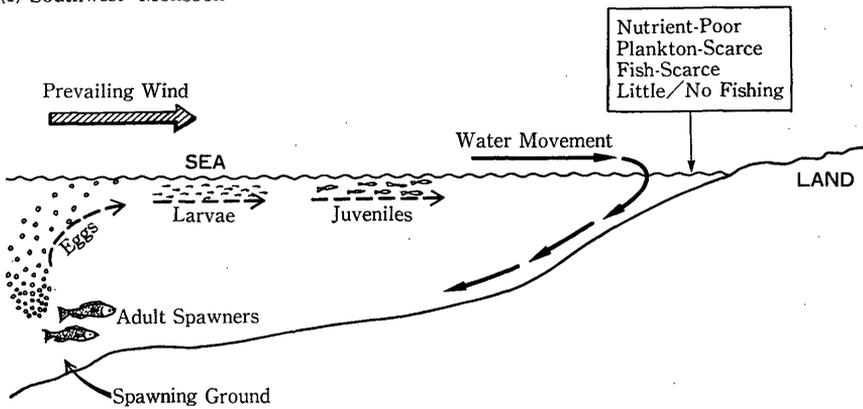
The larger and less-mobile finfishes of the coral reef, mangrove and seagrass habitats studied by Johannes [1978] have adapted to intense inshore predation by ensuring that the eggs are spawned inshore, drift offshore, and then are returned inshore during the season when prevailing winds would not sweep them further out to sea. With the small pelagic finfishes of concern in this paper, however, I hypothesize that intense predation inshore leads to offshore spawning

**Table 2.** Sizes of Fish Harvested for Fermentation in Vietnam

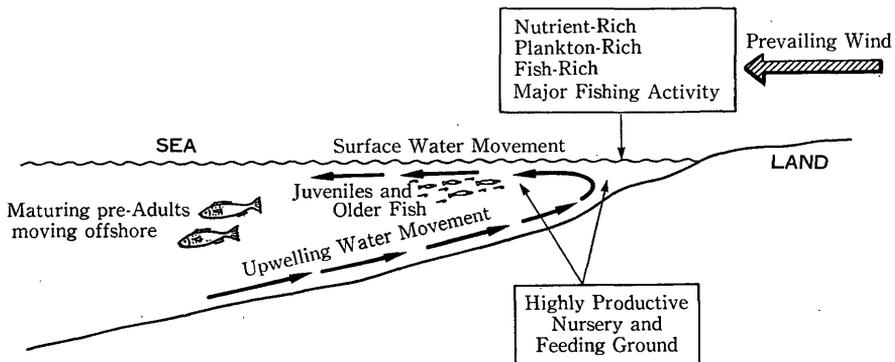
SCIENTIFIC NAME	TBL MATURE (cm)	SIZE HARVESTED (cm)
<i>Spratelloides</i> spp.	6-10	5-6
<i>Sardinella</i> spp.	8-25	16-20
<i>Anodontostoma chacunda</i>	14-20	10-12
<i>Setipinna</i> spp.	10-15	7-8
<i>Stolephorus</i> spp.	10-14	5-7
<i>Engraulis</i> spp.	10-15	5-7
<i>Decapterus</i> spp.	25-30	9-12

Sources: TBL compiled from various sources; size harvested abstracted from Ngo [1953].

(1) Southwest Monsoon



(2) Northeast Monsoon



**Figure 5.** Hypothesis on Fish Behavior and the Monsoons (for a western coast)

migrations at times and in places where the eggs and larvae are assured of being swept coastwards. They should also spawn at times and in locations where their eggs would not be flushed further offshore, and, on the contrary, when winds, currents and gyres would ensure a steady coastwards drift of eggs, larvae, and post-larval forms. Thus at an early juvenile stage they would arrive at their plankton-rich inshore feeding grounds (Fig. 5).

Thus, depending on the distance offshore of the spawning grounds, spawning of the migratory species should occur toward the latter part of the onshore monsoon. This would ensure that the post-larval forms reach inshore waters, where phytoplankton blooms are rich as a consequence of the upwelling induced by the offshore monsoon, either before the winds of the offshore monsoon cause them to drift further out to sea, or just after they have developed the swimming ability as newly recruited juveniles. In the latter case they could swim against the wind-induced current and reach the inshore feeding grounds prior to the intense and persistent development of the monsoon.

Thus, for example, if the hypothesis is correct spawning on western coasts should occur at the end of the southwest monsoon so that juveniles can utilize the food supply at the inshore upwelling areas induced by the northeast monsoon, as is the case with the anchovies (*Stolephorus heterolobus* and *S. punctifer*) and slipmouths (*Leiognathus blochii*) in Manila Bay waters (*vide supra*) (Fig. 6)<sup>11)</sup>. The spawning of *Rastrelliger brachysoma* and *R. neglectus* off both the west coast of the Gulf of Thailand and the west coast of Peninsular Malaysia, together with *Decapterus* spp. off the latter, is also consistent with this hypothesis that seasonality in food availability influences reproductive seasonality.

## FISHING GEARS AND TECHNIQUES UTILIZED

A variety of gears is used to procure finfish raw materials for fermentation. These range from the large, industrial purse seine operations used in the Philippines and Vietnam to supply large-scale fermentation factories, to the simple filter bag nets used to satisfy cottage industry and household needs. The surrounding and bagging gears and techniques used in the industrial fisheries all exploit the shoaling behavior of planktivores, as well as that of fish with other feeding habits. They also exploit their photosensitivity by using lights as a lure. Most types of small-scale gear are targetted primarily at obtaining planktonic shrimp for fermentation, and their catch of finfish is usually incidental to this. They are therefore discussed below, in the section on gear for planktonic shrimp.

Throughout Southeast Asia the industrial fishery that supplies raw material to large-scale fermenting enterprises uses a variety of seine nets, such as the purse seine, or the *payang* of Indonesia, and bag nets, such as the *basnig* of the Philippines. Both operations are based on the shoaling behavior of the target species, especially

11) For a detailed exemplification of this rhythm see Ingles & Pauly [1984], in which data for 56 species of 112 commercially exploited teleost fish stocks are analyzed.

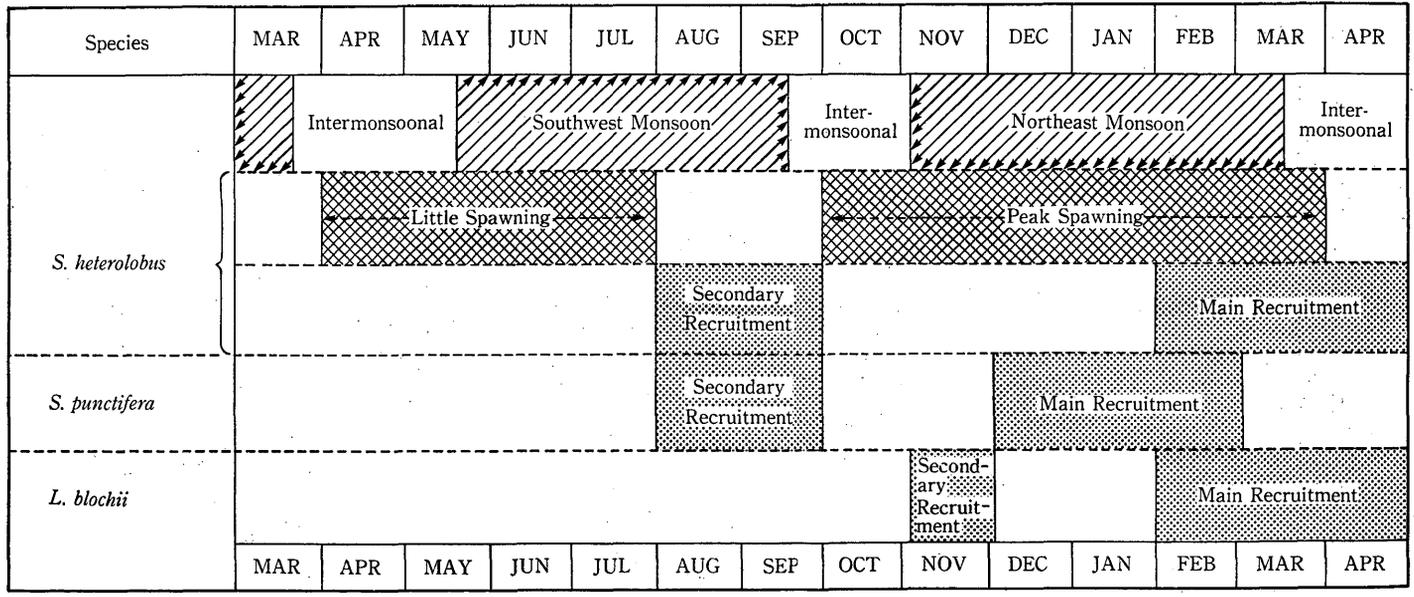


Figure 6. Fish Recruitment Patterns and Monsoon Seasonality in Manila Bay, Philippines

when they rise toward the surface at night for feeding. At this time, because of their photosensitivity, they can be forced to aggregate into tighter shoals to facilitate catching by luring them with lights. Thus in most places in Southeast Asia fishing for clupeoids is conducted at night. The *Sardinella* fishery of the Bali Strait, for example, is conducted thus during periods with little or no moon [RITTERBUSH 1975]. Since the purse-seine and other boat-operated seine technology is familiar it is not discussed further here.

In the Philippines bag net (*basnig*) operations are concentrated in sheltered

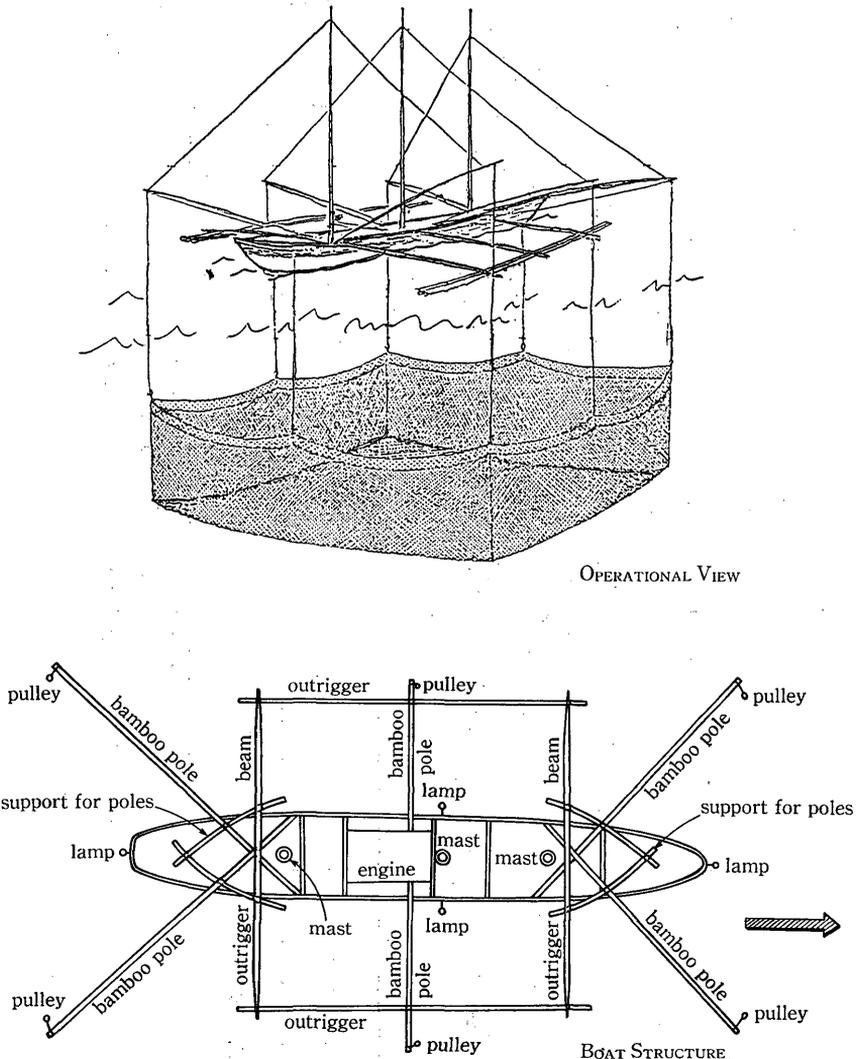


Figure 7. The *Basnig* Bag Net

bays in the shallow, inner seas of the archipelago. Over 25 species are caught in commercial quantities by this method. These are mainly roundscads, stolephorid anchovies, and mackerel, all of which are of primary importance to the fermented fish products industry.

The size of the *basnig* varies but is typically  $.19 \times 13 \times 8$  m [RASALAN & VILLADOLID 1955]. The gear has four parts (Fig: 7), the bunt (or bottom), the four sides, pull ropes, and weights that are attached to the foot of the ropes to minimize drifting. The mode of operation varies in different regions of the Philippines and according to boat size. Most commonly, however, a *basnig* is operated from a 2–20 t outrigger canoe, known as a *basnigan*. This net, operated during the dark phase of the moon, is spread under a shoal of fish, which are further aggregated using strong lamps, and then raised into a bag form to enclose the fish.

## II. PLANKTONIC SHRIMP

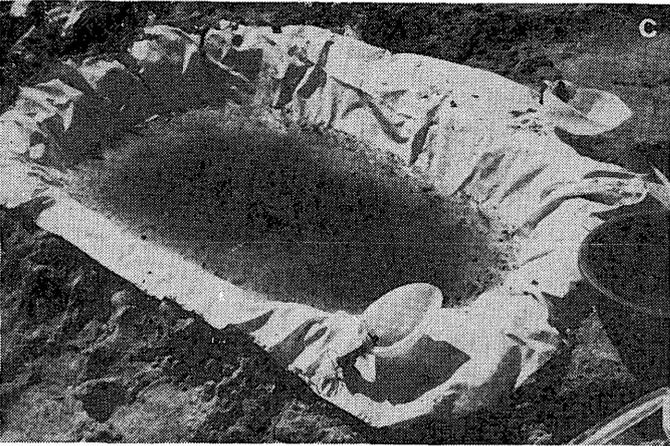
Fermented shrimp pastes and sauces are important components of many cuisines of Southeast Asia. Sergestid shrimps of the genera *Acetes*, *Mesopodopsis*, and *Lucifer*, as well as mysids, are of economic importance to both the commercial

**Table 3.** Species of *Acetes* Shrimp Utilized in Fermentation

COUNTRY	SPECIES
BURMA	<i>A. indicus</i>
INDONESIA	<i>A. intermedius</i>
	<i>A. vulgaris</i>
	<i>A. japonicus</i> (Pugar*)
	<i>A. sibogae sibogae</i> (Mancar*)
MALAYSIA	<i>A. japonicus</i> (West Malaysia)
	<i>A. erythraeus</i> (East Malaysia)
PHILIPPINES	<i>A. erythraeus</i> (Luzon)
	<i>A. sibogae sibogae</i> (Luzon, Visayas, Cebu*)
	<i>A. intermedius</i> (Iloilo*)
SINGAPORE	<i>A. erythraeus</i>
	<i>A. vulgaris</i>
THAILAND	<i>A. erythraeus</i> (Gulf coasts)
	<i>A. indicus</i> (Gulf coasts)
	<i>A. vulgaris</i> (Gulf coasts and Andaman Sea)
	<i>A. japonicus</i> (Andaman Sea)

Sources: Mostly compiled from Omori [1975].

Table Notes: An asterisk indicates samples collected by the author and identified by Omori.



**Photo 1 (a, b, c)** In addition to planktonic shrimp, used to prepare shrimp paste, the larvae of commercially valuable penaeid species are also caught in the push net. As at Bulu Village, Kapubaten Tuban, East Java, these are carefully sorted in makeshift plastic-lined tanks dug on the beach, and later sold to prawn farmers.

and household sectors of the fermentation industry throughout the region. Many are not well known scientifically<sup>12)</sup>. The bulk, however, are of the genus *Acetes* (Table 3).

Although in many instances, because of the dense swarming behavior of *Acetes* spp. (*vide infra*), the catch may consist entirely of this genus, because of the characteristics of the gears employed the larvae and juveniles of other genera of shrimp, especially penaeids, together with those of other crustaceans and finfish, are inevitably caught also. For the production of the best grades of shrimp paste the latter are removed and discarded, whereas for the lower grades they are processed together with the shrimp<sup>13)</sup>.

In Indonesia catches which consist mostly of planktonic shrimp some 3–20 mm in length are distinguished by the term *rebon* from a catch composed of a mixture of planktonic shrimp with larger size larvae of other genera, which is termed *jembret* [DJAJADIREJA & SACHLAN 1956]<sup>14)</sup>. Both *rebon* and *jembret* are processed into fermented shrimp paste. However, because the latter contains many larvae valuable as seed for stocking brackish water fish ponds, the catch is often sorted in a temporary "tank" dug in the beach, with the seed species being carefully placed into separate containers for sale (Photo 1).

Despite their local importance, however, little scientific information is available on the fisheries for *Acetes* spp. That which is available has been systematized by Omori [1975].

## SEASONALITY OF THE FISHERY

The fisheries for *Acetes* spp. are strongly seasonal, and their seasonality appears to vary from year to year. There is also considerable inter-annual variation in the size and density of the exploitable swarms.

The immense aggregations of planktonic shrimp exploited for fermentation result in part from spawning behavior. However, since, in addition to adults, post-larval and juvenile stages have been observed to swarm, this phenomenon probably cannot be ascribed to any single function. The swarming behavior of *Acetes* spp. has also been described in association with maturation, light intensity, and water temperature. Ho [1985] observed reduced swarming the higher the

12) So much so that a mysidacea of the genus *Gastrosaccus* collected by the author at Melemen, on the south coast of East Java, is a species new to science (Omori, pers. comm.).

13) It is claimed that in the estuarine areas in the Inner Gulf of Thailand the use of set bag nets for planktonic shrimp is causing the destruction of the larvae of various valuable species of finfish. Thus, as around Khlung, Chanthaburi Province, these nets are being gradually phased out [CHRISTENSEN 1982].

14) Although the term *rebon* is applied throughout Java, local terms are used more commonly in East Java. The term *reket* is used at Pugar and Melemen by both Madurese and Javanese villagers alike; *guragu* is used by the Madurese-speaking Lekok and Kalbut villagers; and in the Osing dialect *caluk* denotes fresh shrimp and *garung* sun-dried shrimp to be used for making shrimp paste [RUDDLE unpub. notes].

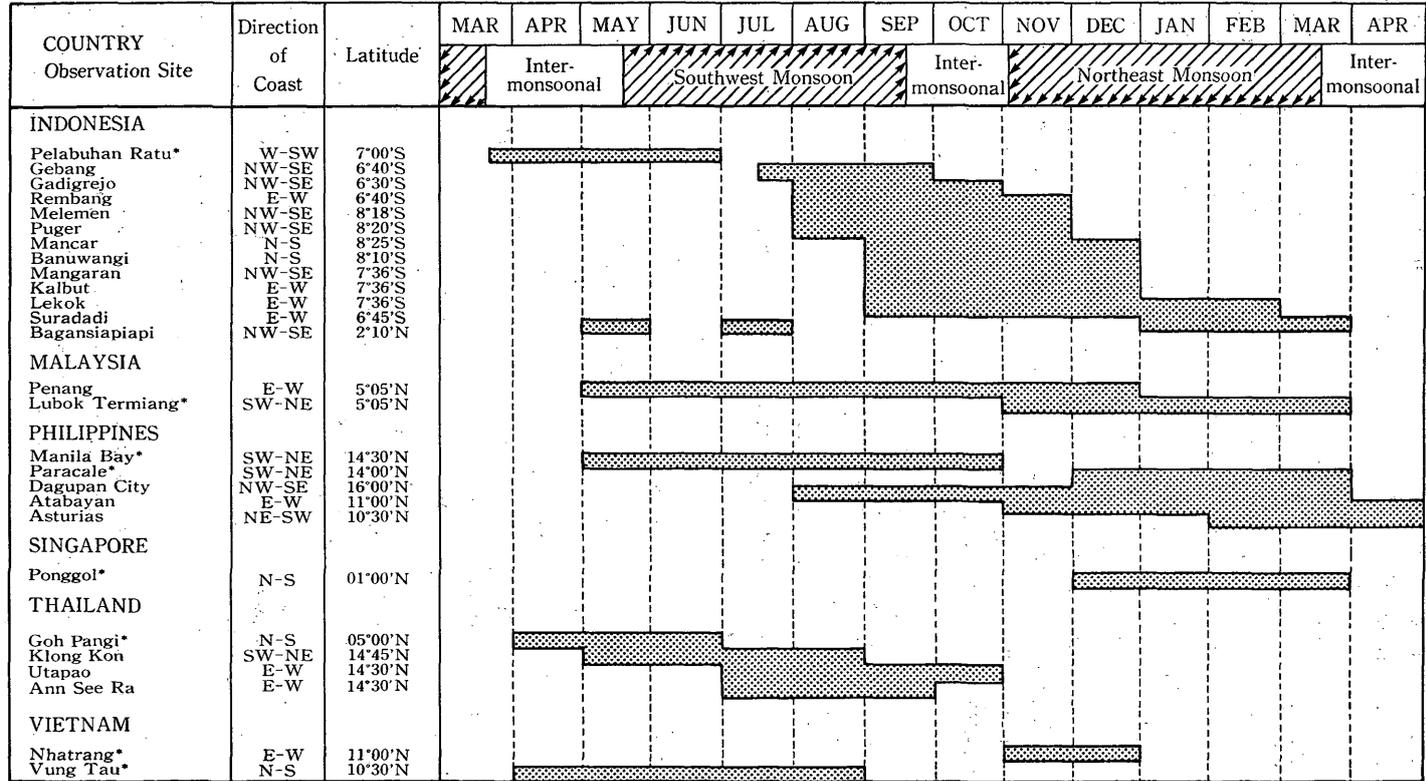


Table Note : \*after Omori [1975] ;  indicates fishing season

**Figure 8.** Fishing Seasons for Planktonic Shrimp in Southeast Asian Waters

annual mean values of air pressure, water temperature and specific gravity, but greater swarming with increases in total annual precipitation.

The nearshore and estuarine swarming behavior of *Acetes* spp. is the critical behavioral rhythm of importance to the fishery. In this, prevailing monsoonal wind direction and tide are fundamental causative factors. When the wind blows landwards surface water currents accumulate the shrimp in inshore waters, and perhaps stimulate them to swarm, although this latter is an assumption that remains to be tested. Spawning may follow this, since at such times larvae can remain in favorable nearshore habitats without being swept out to sea.

The fishing season for planktonic shrimp varies in Southeast Asia according to the predominant angle of the coastline toward the prevailing wind (Fig. 8). As observations from Java demonstrate (Gebang through Suradadi, in Fig. 8), the season extends from the end of the southwest monsoon, when the prevailing offshore winds are slackening, through the inter-monsoonal and into the onshore northeast monsoon. Interviews in fishing villages along the coasts of Central and Eastern Java repeatedly demonstrated that although some planktonic shrimp could be caught throughout the seasons indicated in Fig. 8, in most cases peak yields coincided with the later and wetter part of the inter-monsoonal and the beginning of the rains brought by the onshore northeast monsoon. In contrast, yields were generally small at the beginning and end of the season. It was also ascertained during these interviews that there is considerable inter-annual fluctuation in both the timing and the length of the season in the various locations, according to the onset of the rainy season, as well as in yields for each season. Similar relationships with monsoon seasonality can be derived for the other stations shown in Fig. 8.

## OTHER ENVIRONMENTAL FACTORS AND THE FISHERY

The *Acetes* spp. exploited to make fermented shrimp products attain a mature size of 10–40 mm. These shrimps are typically neritic and are common in estuarine and brackish water environments as well as in nearshore marine waters where the discharge of freshwaters from river systems greatly influences the marine environment<sup>15)</sup>. Shrimps of this genus have a characteristically high tolerance for great seasonal fluctuations in salinity levels.

Other characteristics of the environment inhabited by this genus are that the sea is shallow for a considerable distance offshore; that the habitat is protected from the ocean or sea by a peninsula, island or a submarine feature; that the tidal range is relatively large; and that the bottom is either sandy or muddy [OMORI 1975]. In general, *Acetes* spp. does not inhabit depths greater than 50 m, and the swarms sought by fishermen are usually found from the water surface to

15) A neritic environment is a belt of shallow, coastal waters that is generally regarded as extending seawards to a depth of about 800 m.

depths of 20 m. Most small-scale fishermen in Southeast Asia usually catch this shrimp in waters less than 5 m deep.

## FISHING GEARS AND TECHNIQUES UTILIZED

Throughout Southeast Asia *Acetes* spp. shrimp are caught using several simple types of gear. Principal among them are scoop nets, manual- and boat-mounted push nets, boat seines, lever nets, fry seines, and a wide range of fixed, filter bag nets. Less commonly used is a range of seine nets. All exploit the swarming behavior of these small shrimp.

Since there exists such a large number of detailed local variants of what are essentially the same types of gear and techniques, the analysis in this section is limited to representative examples of the major types used to secure the raw materials for fermentation. They are classified as either mobile (active), of which there are (a) manual and (b) boat-using subtypes, or fixed (passive).

### (1a) MANUAL MOBILE GEARS

#### (i) Scoop Nets

Simple, hand-held scoop nets are characterized by a wide variety of shapes, sizes and materials from which they are made. All, however, are used in the same way. A typical example is the simple *sesser* used at Bondo Village, Jepara, Central Java to catch swarming shrimp and small fish. This net is triangular and lacks a shaft. It is made of a fine mesh nylon attached to a thin bamboo frame. One person operates it either during the day or at night, by wading in shallow water and pushing it with one hand just beneath the surface along banks or the shore, to scoop up shrimp. Yields are estimated to range from 0.5–1.0 kg for 3–4 hours of work.

#### (ii) Push Nets

These are known locally as *waring* (Indonesia), *wa* (Inner Gulf of Thailand), *lun* (Southern Thailand), *hudhud* (Philippines), *suongkor* (Peninsular Malaysia), and *sondong* (Singapore)<sup>16</sup>. The example described here is based on field observation in various parts of Java, and particularly in August, 1985 at Gebang Village, Cirebon, West Java.

Planktonic shrimp are caught daily during the season with this type of net. One man works for 2–3 hours during the period 04.00–12.00 hrs, regardless of tidal conditions. The net is pushed slowly to and fro against the current and parallel to the shore or bank, at depths ranging from knee- to neck-height, in approximately 15 m sweeps about 10–20 cm above muddy and sandy bottoms.

16) In Indonesia the push net is properly denoted by the generic term *nonok*. Correctly, *waring* refers to the fine mesh net material alone. In many places this was formerly made of the fiber of the *Corypha* palm (*Corypha utan*), but nowadays is usually of nylon [Djajadiredja & Sachlan 1956]. However, since the term *waring* is most commonly used by fishermen, and the word *nonok* not heard, the former is employed here.

The catch is emptied periodically from the cod end into a container. On a good day up to 50 kg of shrimp can be taken during 2–3 hours of work (Fig. 9; Photo 2).

The push net is essentially an elaborate version of the scoop net. There are many local variations in minor detail. This net is triangular in shape. The two sides are attached to bamboo poles, which are connected by a peg or bolt so that they can be closed and opened like scissors (hence the alternate name, scissors net), by manipulating the proximate end. A bamboo or wooden strut is often fitted at the proximate end as a pushing bar. "Shoes", made of curved pieces of wood or coconut husks, are attached to the distal ends of the poles, to facilitate sliding over the bottom. Toward its apex the net curves into a long, tubular codend, which is tied with string so that it can be opened easily to empty the catch into a container.

Except for the scoop net this is the simplest and least expensive of the gears used to catch *Acetes* spp. Yields are also greater than those achieved with the scoop net. As such the manual push net is commonly owned by poorer fisheries households and by part-time fishermen.

### (iii) Fry Seines

Fry seine nets are used also to catch shrimp for fermentation. These range from the simple *ching* net, 3–6 m in length and 1 m in height, that is pulled through shallow waters off Southern Thailand by two wading fishermen, to the more complex encircling seines 10–15 m long, such as the *uan lom kung*, used in the same

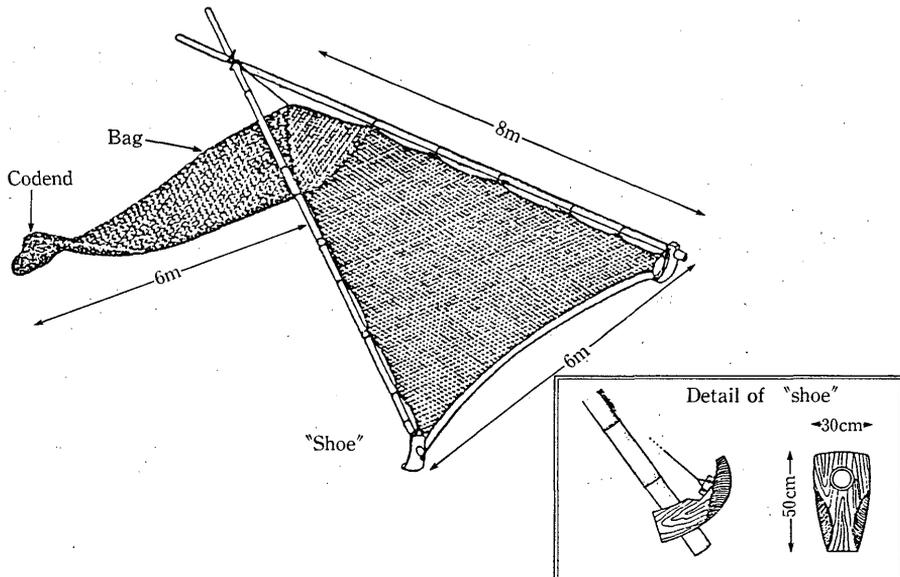
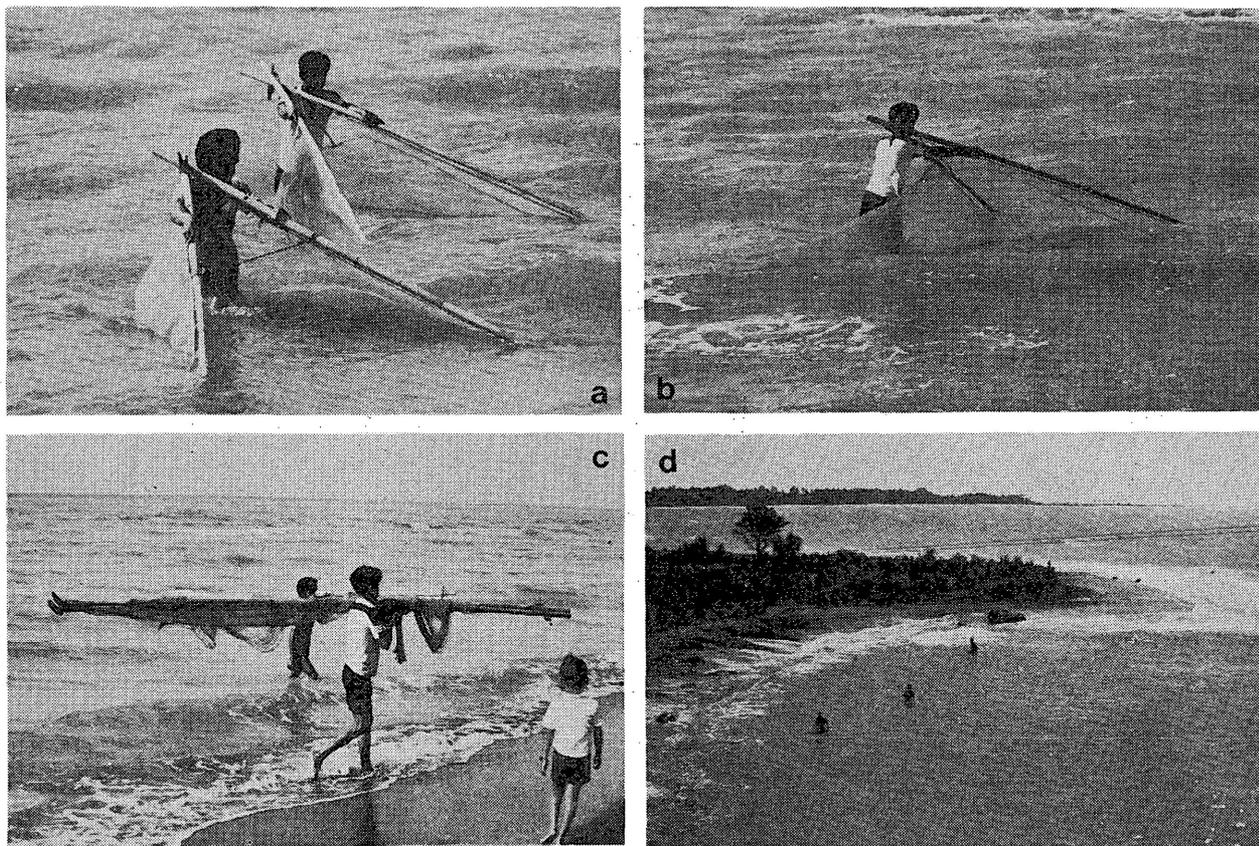


Figure 9. The Waring Push Net



**Photo 2 (a, b, c, d)** Using the *waring* push net at Suradadi Village, Kapupaten Tegal, Central Java. The codend trails behind the fisherman (b). The net is folded for transport (c). (d) shows a typical shallow, sheltered embayment, to which the push net is best suited (Seluke Village, Kapupaten Rembang, Central Java.)

region.

In the simplest type a bamboo stick is tied to each end of the net. Rubber, wooden or bamboo floats are fixed to the top, and lead or stone weights to the bottom. (Some nets have neither floats nor weights.) The net is pulled by two men parallel to the shore, in waist-deep waters.

(1b) BOAT-MOUNTED MOBILE GEAR

(1) Boat-mounted Push Net

When capital is available, push nets are often operated from small, motorized outrigger canoes. This is done at Bondo Village, where the technique is also known as *waring*, and where the manual push net is not used [RUDDLE, unpub. notes], at Barangay Atabayan, Tigbauan, on the Philippine island of Panay, where the technique is known as *hudhud* [RUDDLE unpub. notes], and in Hong Kong [OMORI 1975], among other places. Although sometimes described as a skimming net, this is essentially a manual push net mounted on a boat. It can be used at all levels in shallow inshore waters, but is generally used just to skim the surface.

In this night fishing technique the net is held to one side of the bow of the boat and a lamp, to lure the shrimp (and to aid navigation), is fixed above the bow. The boat runs at high speed to scoop the shrimp from the surface waters. At Bondo Village three persons man this operation; one works the net, another runs the boat and the third does general work. The same technique is used at Tigbauan, except that two men crew the boat; one operating the net and the other steering the boat from the bow using a rudder bar (Fig. 10).

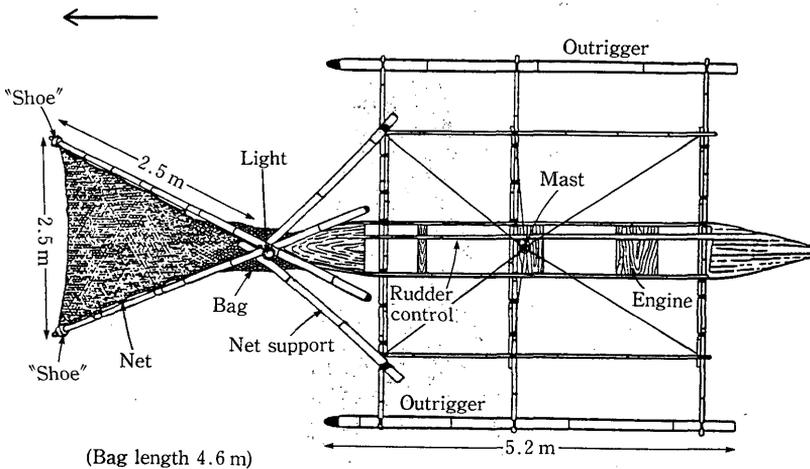


Figure 10. Plan View of a Boat-Operated Push Net

(2) FIXED GEARS

(i) Lever Nets

Lever nets (also known as the "Chinese lift net"), common throughout the Indo-Pacific, are widely used to catch shrimp and various small, schooling fish. All are of similar construction, although varying in detail, and operate on essentially the same principle. Those fitted with lights are operated both at night and during the day. Those without are worked during the daytime only. These nets are either mounted along the shore or river banks, or on rafts.

This is a square net that hangs on curved bamboo crossticks and which is lifted into a bag form by operating a bamboo lever. The net and its frame is lashed to the end of a boom made of two bamboo poles. These poles are set in a log that rotates between two pairs of stakes secured firmly in the ground. A counter boom, with stone weights, is fixed to the center of the log. The tops of the two booms are connected by a rope (Fig. 11). The net is lowered and raised by either releasing or pulling in the rope while carefully removing or adding stone counterweights.

Lever nets mounted on a raft are the same as those erected on land. Mounting on a raft, however, permits rapid relocation to different fishing grounds.

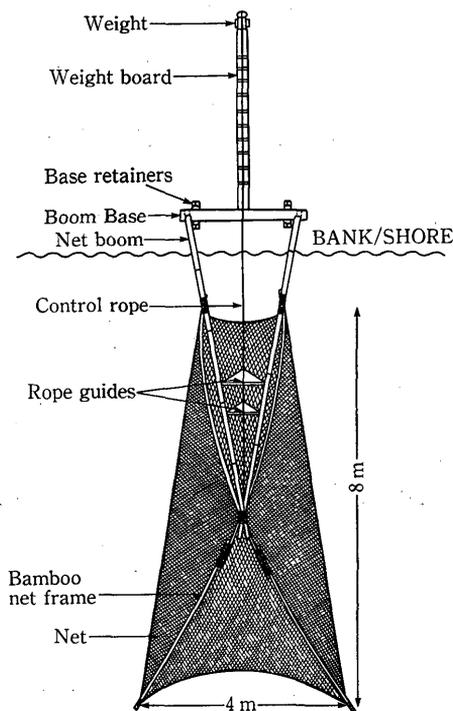
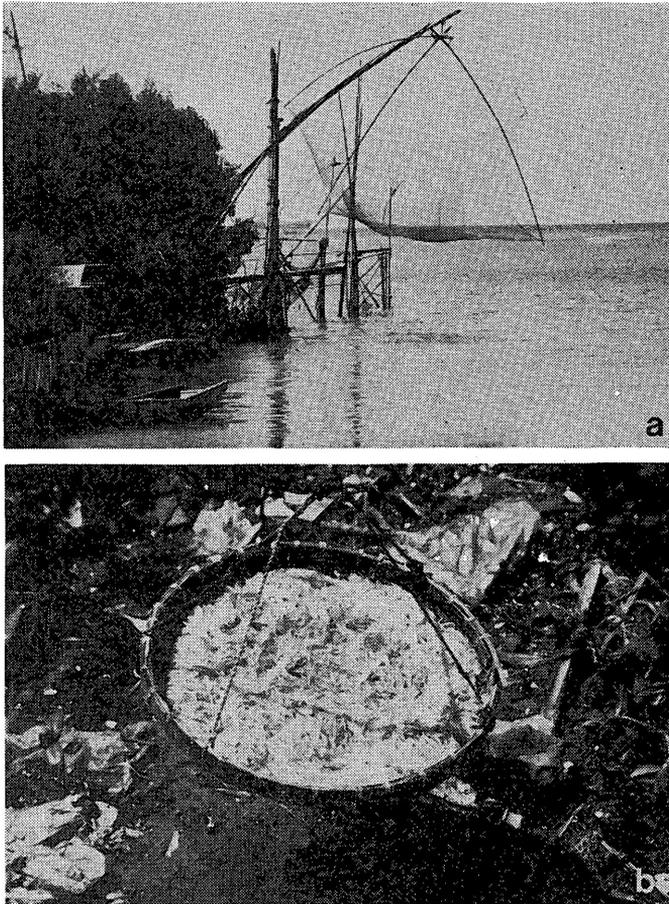


Figure 11. Plan View of a Lever Net



**Photo 3 (a, b)** (a) Lever nets for shrimp and small fish line the mangrove fringe of a small tidal creek near Cirebon, West Java. (b) planktonic shrimp caught in a lever net at the same location.

In Java, several or more lever nets of varying sizes commonly line the banks of small estuaries, the shores of open coasts, and tidal creeks in mangroves (Photo 3.) Along the north coast of Java these nets are known as *anco* (*antjo*). They are owned and operated by individual households. During one hour of daytime operation a medium-sized net ( $3 \times 3$  m) examined at a small estuary near Cirebon, West Java yielded 0.25 kg of shrimp (August, 1985).

(ii) **Lift Nets**

Lift net are commonly used throughout Southeast Asia. They are widespread in sheltered bays along the north coast of Java, where they are used to catch small shrimp and various species of small, shoaling finfish, especially anchovies. Known in Java as the *bagan*, lift nets are constructed in sheltered

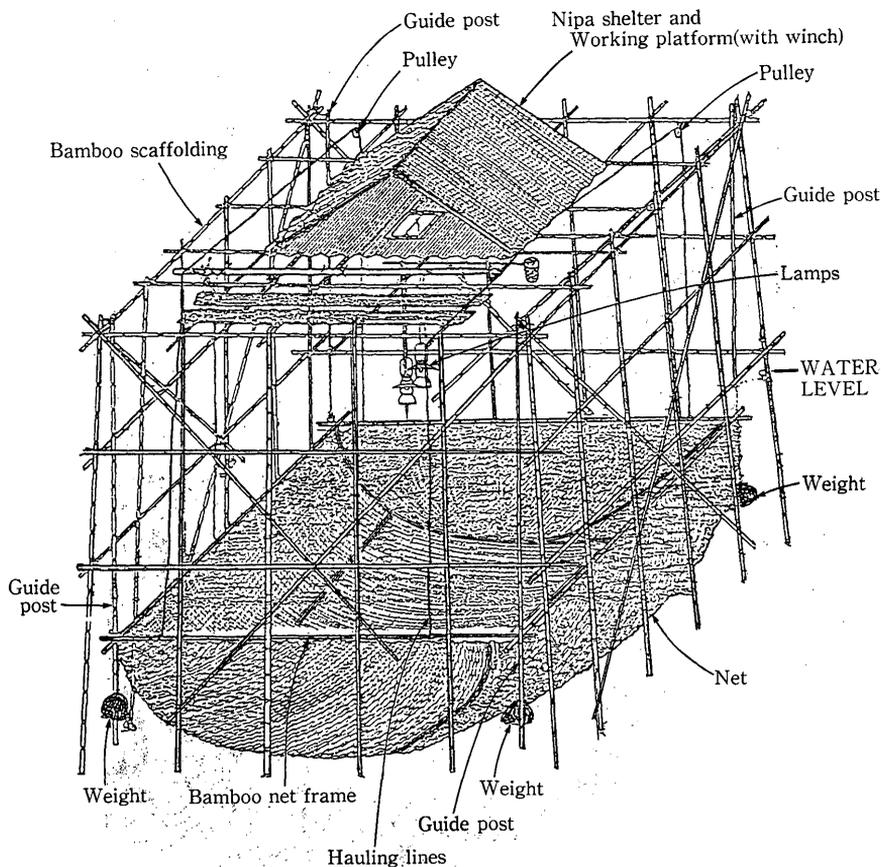


Figure 12. A Fixed Bagan Lift Net

bays with waters about 5 m deep and with muddy, sandy, or pebble-covered bottoms.

A scaffolding of bamboo poles is constructed about 1 m above the high tide mark (Fig. 12; Photo 4). A square net, weighted at the corners with stones so that the current does not fold it, and fitted with rings that slide up and down bamboo runners, is raised and lowered by a winch via pulleys secured at the corners of the platform. The net is lowered to the bottom and a kerosene lamp suspended under the platform is lighted and gradually dimmed to lure shrimp and fish. The net is gradually raised, until its edges appear just above the surface, by slowly turning the winch. The catch is then removed using long-handled scoop nets. In Bondo Village a *bagan* is operated at night from 18.00 to 06.00 hrs by a team of 5 men; two persons work the winch and three the light and the net. The light is switched on every 30 minutes for about half an hour to cause the shrimp to aggregate over the net, which is then winched-up like a bag.

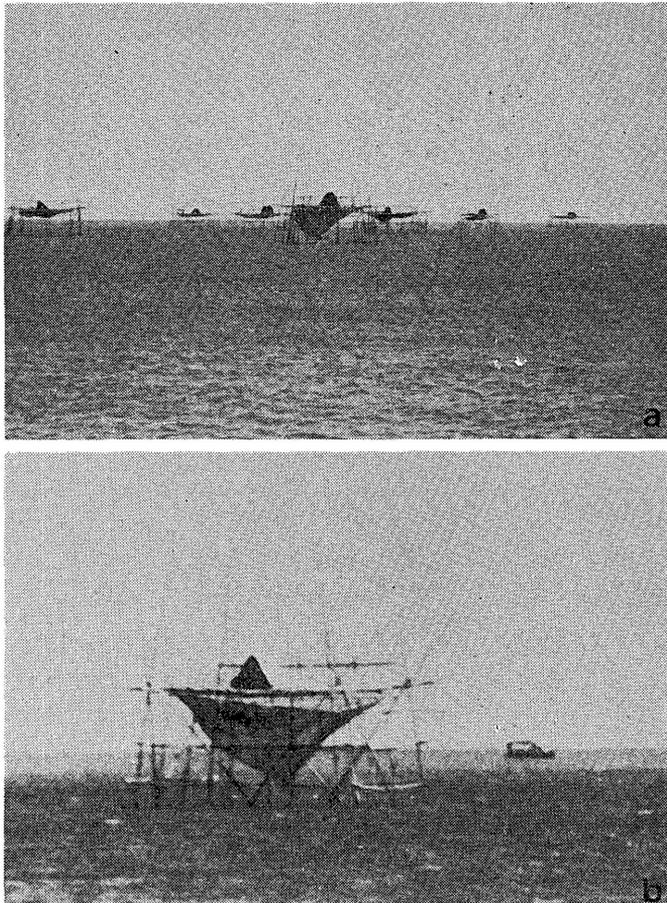


Photo 4 (a, b) Lift nets (*bagan*) at Bondo Village, Kapubaten Juwana, Central Java.

(iii) **Fixed Bag Nets**

A wide variety of fixed bag nets is used throughout Southeast Asia to catch planktonic shrimp. Since all operate on the principle of filtering the shrimp from the tidal current, only two representative examples are given here.

One such net is the *palopad* (Fig. 13), used in the Tigbauan area and elsewhere in the Philippines at night, as well as on rainy days when the water is turbid. These filter nets are constructed by driving two stout posts made of coconut trunk into the bottom, above which a bamboo working platform is fixed. Bamboo matting is fixed to bamboo posts as V-shaped leaders in front of the mouth of the net. On the opposite side a nylon net is fixed in position and stretched out by two bamboo guide posts. The nets are usually constructed in a linked series across a river mouth or narrow channel, with some nets in the series facing upstream and others down. Thus the *palopad* filters shrimp and fish migrating on

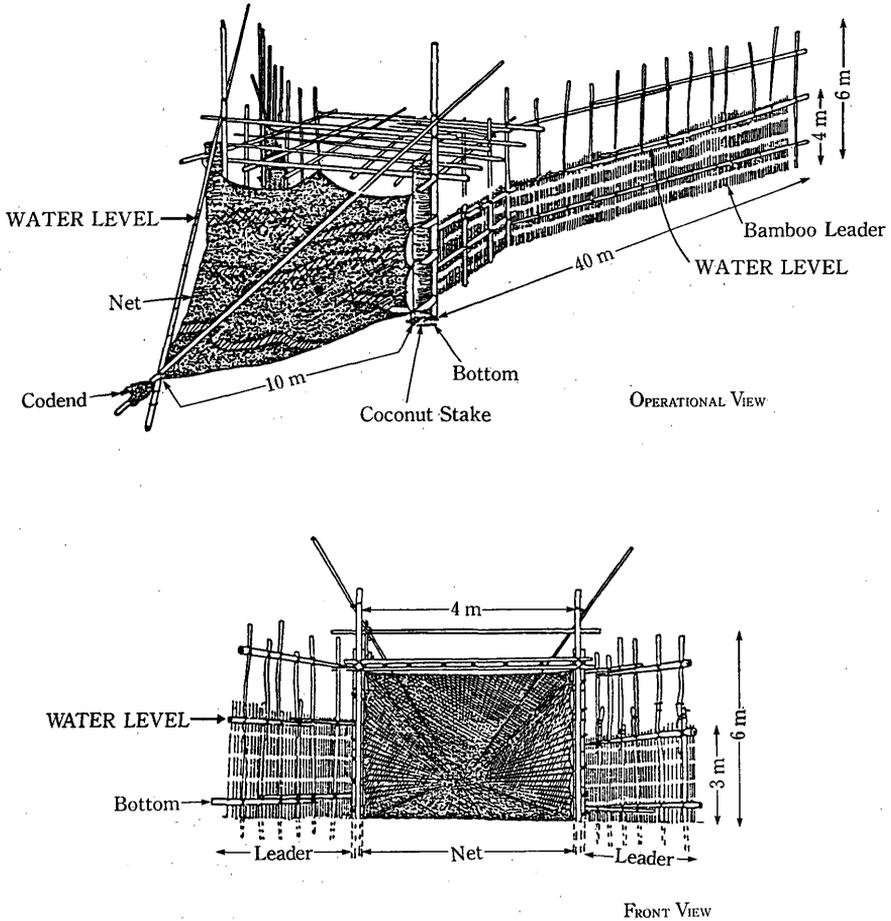


Figure 13. The *Palopad* Filter Bag Net

the tidal ebb and flow.

A fry filter net known as the *tangab* is also widely used at night in the Tigbauan area to provide raw materials for fermentation. These are fine mesh bag nets that have either net wings attached or are fitted with bamboo stake and mat leaders, both of which function to guide shrimp and small fish into the net (Fig. 14). A series of these nets are set at a depth of 12 m to filter the shrimp from the tidal ebb and flow.

## CONCLUSION

As the preceding discussions have demonstrated, in the coastal marine environments of Southeast Asia the aquatic resources utilized by the fermentation industry are abundant only seasonally in inshore and estuarine habitats, where

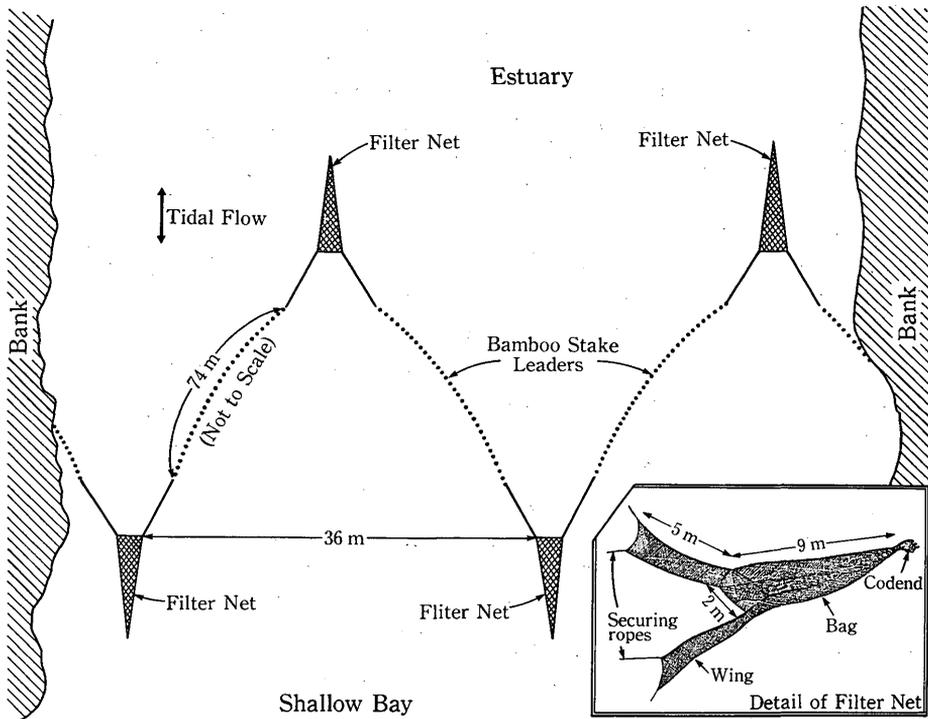


Figure 14. The Tangab Filter Bag Net

they can be easily caught in large quantities and at the size required for optimal fermentation. At other times of the year these same resources are either scarce or absent from the same localities and hence are either not available or not accessible to the technology customarily employed. Further, other than during specific seasons the preferred species are not available at the desired size.

The fisheries for finfish species, which mostly target juvenile clupeoid planktivores, are conducted mainly during the season of the offshore monsoon and during the inter-monsoonals, since the offshore monsoon causes coastal upwelling and therefore a sudden increase in plankton availability. Further, in this context I have put forward the hypothesis that the seasonality in food availability for these pelagic species influences their reproductive seasonality by enabling juveniles to arrive at inshore habitats at an appropriate time to utilize the phytoplankton, at which time they are fished. In addition, the fermentation industry also utilizes juvenile piscivores that predate on the vast shoals of juvenile planktivores.

In contrast, the fisheries for planktonic shrimp are mostly conducted during the season of the onshore monsoon and the inter-monsoonals, when the shrimp aggregate in immense swarms. However, the biological mechanisms controlling this rhythm remain to be precisely elucidated.

All the marine fisheries to supply the fermentation industry exploit these hypothesized feeding-recruitment migrations-aggregations of the juvenile planktivores, the feeding migrations of the juvenile piscivores, and the swarming behavior of planktonic shrimp. To do so they mainly employ types of gear adapted to the catching of large aggregations of small fish in shallow waters, and commonly of exploiting the photosensitivity of the species to force tighter aggregation.

Throughout Southeast Asia fermentation has been one of the major techniques used to preserve seasonally abundant marine food resources for use in the lean season to prepare condiments and savory side dishes to accompany the rice staple. Fermentation has the additional advantage of utilizing low cost raw materials of little or no alternative economic value.

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## 東南アジアにおける魚の発酵製品の原料魚の漁獲の季節性について ——海産魚をめぐる——

ケネス・ラドル

漁業をおこなうにあたって、魚の習性に関する経験的知識の蓄積が重要であることはいうまでもない。漁獲の季節的変動のいちじるしい魚種を対象とする漁業においては、魚の行動に関する知識が社会経済的にも重要な影響をおよぼしている。発酵食品の原料魚に関する漁業はその典型的な例である。魚の発酵製品は漁獲量のすくない時節にそなえて大量の魚を保存食品化したものであり、その原料の供給は顕著な季節性をもつ漁業にささえられている。

本論文は東南アジアにおける魚醤原料魚の主要な魚種を対象として、その行動の動物学的リズムを分析することによって、その季節性の生じる原因を地球物理学的および動物学的に解明し、また、そのような要因が漁業資源の開発にいかん適用されているかを立証することを試みたものである。

ビルマ、インドネシア、マレーシア、フィリピン、タイ、ベトナムにおける現地調査および、この分野に関する数すくない文献資料にもとづいて判明したところによれば、魚醤原料魚の主要なものはカタクチイワシ、ニシンの近縁種の魚、サバの近縁種の魚の稚魚あるいは成魚の若いものと、*Acetes* 属のプランクトン性の小エビである。これらのプランクトン食の魚類にくらべた場合、魚醤原料魚としての重要度ははるかに低いが、プランクトン食の魚類を捕食する食性の魚類の稚魚の利用もみられる。魚醤原料魚には魚体が小さく、市場価格が安価で、同一種あるいはすくなくとも同一属に所属する魚群の均一な漁獲が得やすいものが使用される特徴をもつ。現地調査によって、東南アジアにおけるモンスーンと密接な関連をもつ魚の産卵、増殖に関する行動の知識が魚醤原料魚の漁業に適応されていることがあきらかになった。

これらの魚類の行動に関して得られた新知見の主要な事柄は下記のとおりでである。

- (1) 魚醤原料魚類の漁獲期は主として海側への季節風が卓越する時期あるいはモンスーンの間期の季節に集中するのにたいし、魚醤原料の小エビの漁獲期は陸側への季節風の卓越する時期あるいはモンスーンの間期の時期に限定される。
- (2) 海側への季節風の卓越する時期には底水の海表への湧出現象がおり、その結果プランクトンの急激な増加がおこる。そのとき植物性プランクトンの食性をもつ魚類の稚魚が岸側に接近する行動をおこす。
- (3) このさいに集中したプランクトン食の魚群が魚食性の魚の稚魚の捕食対象となる。
- (4) このようなプランクトン食の魚種の稚魚の回遊と集中、それに応じた魚食性の魚種の稚魚の移動、プランクトン性の小エビの産卵行動によって規定される季節性をもつ漁獲物が魚醤原料魚として利用される。
- (5) これら魚醤原料の漁獲に利用される魚具は小型魚の浅海における集中現象を利用する種類のもので、光に魚群が集まる習性を利用したものが一般的である。

### Abstract

It is axiomatic that an empirical understanding of fish behavior is a prerequisite to catching fish. Such knowledge becomes of critical socio-economic importance in a highly seasonal fishery characterized by extremes of abundance and scarcity. This is the case of the fisheries that sustain the fermentation industry, the original purpose of which, it is assumed, was to preserve a large supply of fish or fish products for use in the lean season.

This paper attempts to clarify the physical and biological causes of seasonality in the supply of marine species for fermentation in Southeast Asia by an analysis of aspects of the biological rhythms of the principal species exploited, and how these characteristics are used to exploit the stocks. Field research in Burma, Indonesia, Malaysia, the Philippines, Thailand and Vietnam, together with the gleanings of a meagre literature, revealed that most of the fish fermented were juvenile and young adult clupeoids (stolephorid anchovies, herrings and herring-like fishes), and mackerels, together with planktonic shrimp of the genus *Acetes* and larval forms of other genera of shrimp. Although of far lesser importance, juveniles of piscivores that predate on those planktivorous fishes are also used. All fish fermented are small in size, cheap, and preferably of the same species (or at least genus). The seasonality of the fishery was also studied for each place in which field research was conducted. These observations were then correlated with the monsoon regime in Southeast Asia and information on the spawning and recruitment behavior of the species utilized.

The principal findings are: —

- (1) that fisheries for finfish species were conducted mainly during the season of the offshore monsoon and during the inter-monsoonals, whereas those for the shrimp were conducted during the season of the onshore monsoon and the inter-monsoonals;
- (2) that the offshore monsoon causes coastal upwelling and therefore a sudden increase in plankton populations, which are then consumed by planktivores;
- (3) that these vast shoals of planktivores are predated on by juvenile piscivores;
- (4) that all the fisheries to supply the fermentation industry exploit these feeding-recruitment migrations-aggregations of the juvenile planktivores, the feeding migrations of the juvenile piscivores, and the swarming behavior of planktonic shrimp;
- (5) that the principal types of gear utilized are adapted to the catching of large aggregations of small fish in shallow waters and commonly of exploiting the photosensitivity of the species to force tighter aggregation.

I propose the hypothesis that the reproductive strategy of the small pelagic species utilized is adapted to the seasonal fluctuations in food availability *i.e.*, it enables juveniles to arrive at inshore habitats to utilize the plankton blooms.