

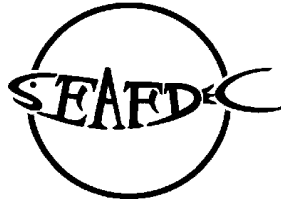
Purse Seine Fisheries of Thailand

Compiled by

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Preface

This report is purposed for recover the fishing technology skill on coastal purse seine before attended the research works on coastal purse seine fishing technology improvement, carried out by Tokyo University of Marine Science and Technology, Tokyo Japan. The research works is able to separate into 2 main categories, i.e. Purse seine net improvement by the study on mesh construction characteristic between horizontal net stripe and vertical stripe. The other research work is study on the feasibility to operate purse seine by Norwegian technology adaptation.

Authors, SEAFDEC Fishery researchers, have already comprehended on Japanese Purse seine style, one-boat mackerel purse seine that using various deck hauling devices, e.g. Purse winch, Purse drum, net shifter, net hauler, etc, regarding to the enrolled on MV Plattoo, SEAFDEC coastal purse seiner. She, however, has been retired since year 2004.

On the occasion, the participating on research work under Tokyo University of Marine Science and Technology at Tateyama Fisheries Training Station, Chiba Prefecture during 6-16 July 2009 is granted under JSPS-NRCT (Japanese Society for Promotion of Science- National Research Council of Thailand) support. Authors have to brush up the knowledge and skillful of purse seining in order to facilitate with this research works. By this reason, review on Purse Seine Fisheries of Thailand was compiled by gathering information related on Thai purse seine, as well as history of Thai purse seine and status of pelagic resources of Thai purse seine fisheries has been carried out. Research method is the compiling of secondary data from various fishing gear texts what fishing gear technologists, both Thai and foreign, have already conducted then presented within this report.

Authors sincerely wish that this report shall be advantage for fishing gear technologists and others who interested in Thai purse seine fisheries. Authors also take responsibility on mistaken information in this report and author shall be greatly appreciated in every discussion on this report with who interested in purse seine fisheries and extended all merit of this report to JSPS-NRCT program.

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1. Introduction: Purse Seine in General

Purse seine is one of the most advance types of fishing gears for surrounding schools of fish, *e.g.* anchovies, sardines, scads, mackerel, bonito and tuna. Purse seine was developed from two different fishing gears and methods, *i.e.*, Beach seine and Lampara. Purse seine has been used for more than 200 years while the modified purse seine started to evolve only about 100 years ago (Ben-Yami, 1994).

Nowadays, purse seine is still widely used by fishers in almost every parts of the world although with various modifications of the fishing gears and methods. From the different modifications of the fishing techniques, purse seine has been called by many names, *e.g.* purse seine net, ring net, two-boat purse seine, etc., where purse seine net generally consists of pieces of rectangular nettings, float line with float attached at the top, and sinker line with sinker attached at the lower side. The most salient feature of a purse seine is its ability to encircle and impound schools of fish from the bottom which can be closed by either a hook (in case of no purse line) or a purse line that passes through the purse rings at the end of the bridle rope attached to the sinker line at regular intervals, to prevent the fish from escaping through the bottom of the net (SEAFDEC, 1988).

At present, purse seine fishery shares the large portion of the world's total catch from marine fisheries. Clupeoids fisheries in South America, *i.e.* Peru and Chile, and African coasts of Angola and Namibia, accounted for a massive catch and became one of the world's top ranking fisheries in terms of marine fish production every year. Tuna purse seine fishery is also another major fishing operation that share large quantities of catch every year. Notwithstanding the technology innovations and massive investments in modern vessels in tuna and clupeoid fisheries, the great contributor to purse seine fisheries of the world is the vast number of small vessels landing small quantities of many kinds of fish species. These small vessels have multi-purpose uses and thus, it is difficult to come up with the exact estimate of the number of vessels involved in purse seine fisheries. However, a conservative estimate of the percentage of the catches by surrounding net fisheries would be 25% to 30% of the world catch from marine fisheries (Ben-Yami, 1994).

Federico (1997) noted that the world's purse seine fisheries had been mobilized by the requirements of the fisheries product processing industry as well as the varied market destinations. Catches from purse seine fisheries have two main categories of utilization, *i.e.* (1) direct human consumption, and (2) indirect human consumption. Although the catch species for direct human consumption are the large and medium size fishes, small species like anchovies and sardines continue to dominate as the target species for many Asian countries. The category on indirect human consumption is mainly in the form of fish meal for animal feeds. By definition and efficiency, small pelagic species are more profitable to be caught by purse seine.

However, there is now a trend of utilizing fish species, *e.g.* horse mackerel, sardines and anchovies that could produce fish meals with high protein concentration required for better animal production, especially in the Chilean and Peruvian fish meal industries.

Although there is a current trend to focus more on direct human consumption, fish meal products command good market price and are highly in demand. As a consequence, harvesting of the pelagic resources is expected to be in high quantities in the long term. Thus, purse seining technology should be continuously improved in order to reduce the cost of investments and enhance quality and quantity of the catches while at the same time conserving the resources.

2. Background of Thai Purse Seine Fisheries

2.1 History of Thai Purse Seine Fisheries

Surrounding nets have been used by Thai fishermen in coastal waters for a long time. Initially, these were small-scale gears used for catching planktonic shrimps, anchovies and other species found in shallow waters near the shore. Small cotton net was used by the fishermen with or without using rowing-boats. Later, two wooden poles were added to the gear for closing the bottom part of the net. This type of purse seine could be operated in either day or nighttime to catch Indo-Pacific mackerel and mixed schools of fish composed mainly of herrings, croakers, Indo-Pacific mackerel, thread-fin and sting ray (SEAFDEC, 1986).

Nomura and Yamasaki (1975) reported that Chinese fishermen from Fukien Province of China introduced the Chinese ring-net sometime in 1926. DOF/Thailand (1953) has categorized Chinese purse seine into two-boat purse seine and officially named in English as Chinese purse seine type II or *Uan Tang-ke* in the Thai language, but later, this was renamed as Chinese purse seine. The Chinese purse seine type II or *Uan Tang-ke* is operated using one large sailing boat as mother boat and two rowing boats. The net made of cotton yarn, is dyed using a liquid produced from the mangrove bark. This information is consistent with the report by Boon-lert (1987) which indicated that that the Chinese fishers operated the purse seine using a big sailboat with 2 small skiff boats, and targeted the Indo-pacific mackerel. The operation of the Chinese purse seine using the same procedure as the original method, continued until the mid of 1990.

Preparation of the Chinese purse seine operation starts with the loading of the purse seine net into the two (2) rowing boats fastened with the stern of the mother boat. When a fish school is located, the mother boat is maneuvered close to the fish school and the rowing boats are released. The rowing boats set the net in crossed direction with the fish school moving until completely surrounding the fish school. The purse line is manually hauled while 2 crew members use paddles and splash the at sea surface in order to prevent the escape of the fish school from the net gap. Then the net panel is hauled by the crew onboard the 2 rowing boats until reaching the bunt part. The mother boat then comes to the net circle and the crew scoops the catch, load onboard the mother boat, and store in the fish holds.

Although it has been official recorded that *Uan tang-ke* was introduced into the Kingdom of Thailand in 1926, the Siamese purse seine type I or *Uan Lard* in the Thai language, was first invented by Chinese fishers who migrated from China, but such information had not been recorded (Interview with Mr. Aussanee Munprasit in 28 June 2009). The first official record of the Department of Fisheries of Thailand (DOF/Thailand) showed the initiative of purse seine fisheries after World War II in 1935.

The Siamese purse seine (official name given by DOF/Thailand) or *Uan Lard* or *Uan Chon* in the Thai language (**Fig. 1**), was the only type of surrounding net recorded during that period. *Uan Lard* was one of the surrounding nets fixed with purse rings and made use of purse line to close the bottom part of the net. This type of purse seine could be operated in either daytime or nighttime targeting the Indo-Pacific mackerel and mixed schools of fish composed mainly of herrings, croakers, threadfins and sting rays that inhabit around the coastal areas (SEAFDEC, 1986). The operation of *Uan Lard* could be separated into 2 methods, *i.e.* (1) single boat method, and (2) two-pair or one-pair method.

(1) **Single boat method** is operated only in the daytime by employing 7 crew members. When the fish school is located by the master-fisherman through observation of the turbid waters caused by the fish school, the crew row the vessel towards the fish school and the net is dropped around the fish school. When one end of the net is close to another end, a wooden pole is stuck into the sea bottom. A diver passes both ends of the purse line through 2 snatch blocks at the end of wooden pole. The crew onboard haul the purse line until all rings got stuck at both blocks, then the crew bring the wooden pole with all purse rings up onboard. Purse line hauling with wooden pole is used in order to prevent the net bottom from being lifted from the sea bottom and the fish school from escaping the net circle. When the net bottom is closed the net panel is manually hauled until reaching the bunt part and the fish is scooped up and stored into the fish holds.

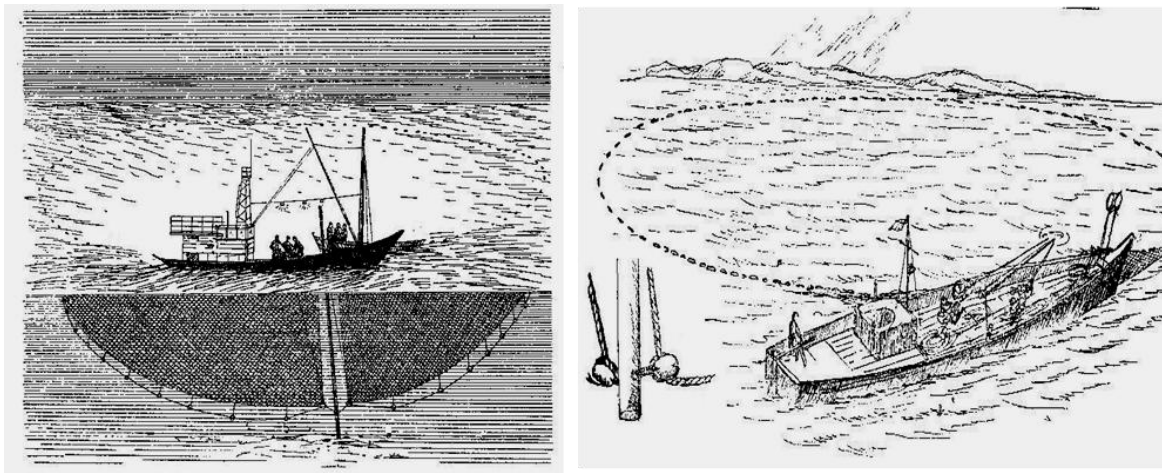


Fig. 1. Siamese purse seine type I (*Uan Lard* in Thai): Single boat method
Source: Department of Fisheries of Thailand (1969)

(2) **One-pair or Two-pair method** is operated while big school of fish is located and the quantity is observed to be over the capacity of only one net boat, which means that one piece of net was not enough to surround such big school. Thus, the net radius is expanded to be double in range in order to completely surround the fish school. The setting position starts with the two net boats rowing opposite side of each other. The crew from both boats set their respective net panels by rowing the vessel towards the school followed by shooting the net around the fish school until reaching the starting end of net that belongs to the other boat (**Fig. 2**).

The crew of the net boats stuck their respective wooden poles into the sea bottom. Each boat has a diver and in the sea bottom, the divers pass the end of both purse lines belonging to each net boat, passing through 2 snatch blocks at the end of the wooden pole. The end of the net in the other boat is fastened at the wooden pole in the deck. Then purse line hauling is carried out as in one boat's method facilitated by the divers in order to prevent being entangled with the net bottom. While all rings got stuck at both blocks, both wooden poles are in the opposite side position then all purse rings are carried up onboard. The net panel is hauled by hand until reaching bunt part and fish is scooped and stored in the fish holds. The other two skiffs assist the net boats during the net hauling operation so that this method is called one-pair or sometimes two-pair method. This operation could be carried out both in daytime and night time.

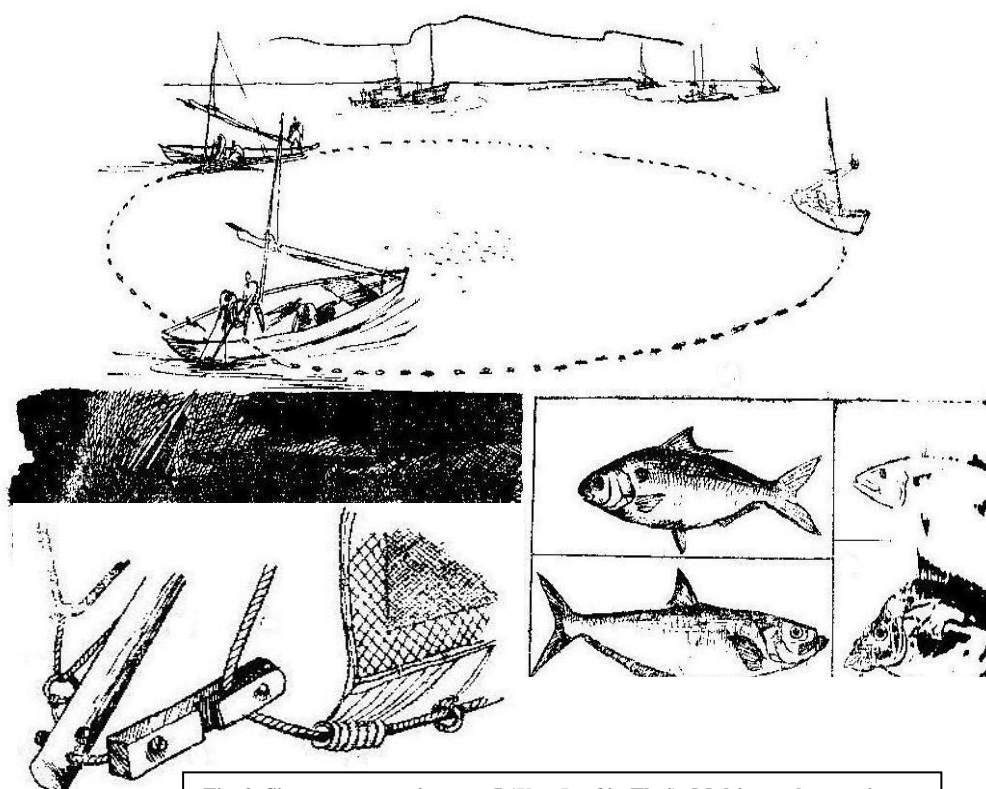


Fig. 2. Siamese purse seine type I (*Uan Lard* in Thai): Multi-vessel operation
Source: Department of Fisheries of Thailand (1969)

DOF/Thailand (1953) recorded the existence of purse seine without wooden pole, called the Chinese purse seine type I (*Uan Dum* or *Uan Cha-lorm*) operated by one boat. The Chinese purse seine type I was later renamed as the Thai purse seine by the DOF of Thailand.

Nomura and Yamasaki (1975) cited that Chinese fishermen for Fukien Province of China introduced the Chinese ring-net in 1926. This Chinese purse seine was a two-boat purse seine with one large sailing boat (mother boat) and 2 rowing-boats forming a fishing unit, targeting the mackerel (Ben-Yami, 1994). The DOF/Thailand (1953) had categorized the Chinese purse seine into Two-boat purse seine and officially named it as Chinese purse seine type II or *Uan Tang-ke* in the Thai language. Later, this has been renamed as Chinese purse seine.

The Chinese purse seine type II or *Uan Tang-ke* is composed of one large sailing boat and two rowing boats, and the net is made of cotton yarn treated with a liquid from the mangrove bark, with Indo-Pacific mackerel as the target catch. This information is very similar to the report by Boon-lert (1987) which indicated that the Chinese fishers operated the purse seine using a big sailboat with 2 small skiff boats, targeting the Indo-pacific mackerel.

The introduction of marine engines from Japan in 1935 allowed the Chinese purse seiners to replace their sailboats with motorized boats, and the first revolution on fisheries of Thailand was recorded. With the introduction of Nylon netting materials in Thailand in 1954, the old indigenous surrounding net with wooden purse pole also underwent major modifications. The poles were no longer used, and the netting was made of black-colored and later of green-colored nylon. Since 1956, it had been possible to distinguish the so-called Thai purse seine, whose main catch was also the Indo-Pacific mackerel (SEAFDEC, 1986). The second revolution of Thai fisheries occurred when the bottom trawl was successfully promoted from 1960 to 1965. The Thai purse seine fishing was also developed parallel with the bottom trawl net fishery in accordance with the development of the fishing materials, fishing techniques and fishing boats during that period.

Fish finders and the echo sounder were introduced to Thai fisheries since 1977 while the sonar was introduced later in 1980 (Masthawe, 1986). One boat purse seiners had rapidly increased, conversely decreasing the number of Chinese purse seiners which had continuously appeared since 1967. Specifically, twelve units were recorded in 1986 and 24 units in 1991 only in the Andaman Sea, and definitely these disappeared from the Gulf of Thailand since 1992. As for the statistics from 1992 to 2004, there were no records of the Chinese purse seine operations, nevertheless, few units were observed by the SEAFDEC during the fishing gear survey in 2004 at the Port of Phuket in the Andaman Sea.

At present, the Thai purse seiners are large vessels of over 100 gross tons with modern equipment on board such as radar, sonar, echo sounder, fish finder, wireless radio and power block. On the other hand, the Chinese purse seine had already disappeared from being used, but in some places in Thailand, it is still possible to find the original type of surrounding net such as the anchovy and rock-fish surrounding nets at Ban Ao Makhampom in Rayong Province and in Chumphon Province.

In Thailand, the DOF/Thailand and SEAFDEC distinguished two main groups of surrounding nets, those with and those without purse line. The nets without purse line are small and simple, but do not usually appear as a separate category in fishery records. Surrounding net with a purse line, on the other hand, are large-scale gears whose number has been increasing annually. The evolution of the purse seine fisheries in Thailand is summarized in **Table 1**.

Table 1. Evolution of purse seine fisheries in Thailand

Year	Particulars
1926	First record on two-boat purse seine
1935	First official record on Siamese purse seine (purse seine with pole), however the origin period must have been before this year (based on interview with various persons)
	Introduction of marine engine for fishing boats
1947	First official record of the number of Thai purse seiners
1953	First official record of Thai purse seines without pole
1954	Development of netting materials
1955	Statistics on purse seiner officially started
1956	New history of Thai purse seine with netting made of black-colored and later of green-colored nylon with main catch also the Indo-Pacific mackerel
1957	Statistics of marine catch by purse seine fishing officially started
1960	Development of Trawl fishing
1967	Number of two-boat purse seine starts reducing
1977	Introduction of Echo sounder for fishing operations
1980	Introduction of Sonar for fishing operations
1987	Introduction of tuna purse seiner, R/V Chulabhorn by DOF/Thailand
1992	Official statistics no longer showed the number of two-boat purse seine in Thai fisheries
	Introduction of tuna purse seiner, M.V. SEAFDEC by SEAFDEC/TD
1995	Introduction of tuna purse seiner, F.RV. Mahidol by DOF/Thailand
1998	Introduction of tuna purse seiner, F/V Mukmanee by Thai Offshore Fisheries Association
2001	F/V Mukmanee stopped operating because of internal business problems

2.2 Statistics on Thai Purse Seine Fisheries

It has been noted that the official statistics on marine fisheries in Thailand was first recorded in 1957. Henceforth until 1973, the systematic recording was focused on the total quantity, quantity by species, quantity of marine products (import-export), and the quantity of catch by province, region and fishing ground. However, the statistics on the category of individual of fishing gear were not collected during such period. Meanwhile, the statistics on marine catch (quantity) by surrounding net fisheries was first compiled in 1974. Monitoring of the target catches was based on the 4 main categories of purse seine, *i.e.* (1) purse seine operated by surrounding the free schooling, (2) purse seine operated by surrounding FAD (*Sung* in Thai), (3) two-boat purse seine, and (4) anchovy purse seine.

The statistics on the quantity of catch by purse seine during this period revealed that the purse seine surrounding FAD accounted for the continuously increasing production year by year from about 70,000 metric tons in 1974 to 390,000 metric tons in 1983. On the other hand, production from the purse seine operated by surrounding the free fish schooling had gradually decreased from 59,000 metric tons in 1974 to 14,000 metric tons in 1983.

The statistics also indicated that the catch from two-boat purse seine had obviously fluctuated from 1974 to 1983. In 1984, the country's statistical system was reformatted by grouping the purse seine searching fish schools and surrounding FAD within same category. Thus, the purse seine fishing gear during this period was classified into 3 categories, *i.e.* (1) purse seine, (2) anchovy purse seine, and (3) two-boat purse seine.

It is also noticeable that from 1984 to 2006, the quantity of catch from purse seine (**Fig. 3**) had gradually increased from about 400,000 metric tons in 1984 to 770,000 metric tons in 1995, but it gradually decreased to 530,000 metric tons in 2006. On the other hand, production of the anchovy purse seine has continuously increased from 87,000 metric tons in 1984 to 150,000 metric tons in 2003 until 2006. It was also observed that the catch from two-boat purse seine disappeared from the statistical records starting in 1986 (**Fig. 4**).

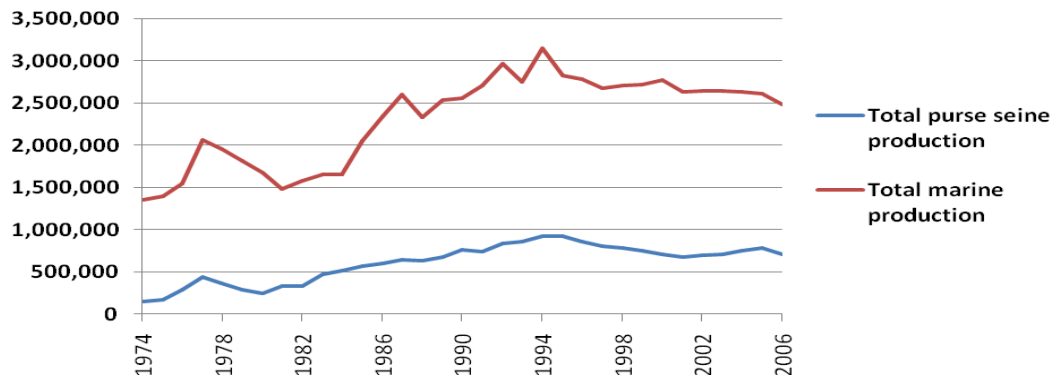


Fig. 3. Quantity of catch in metric tons, by marine capture and purse seine fisheries (1974-2006)
Source: Department of Fisheries of Thailand (1964-2009)

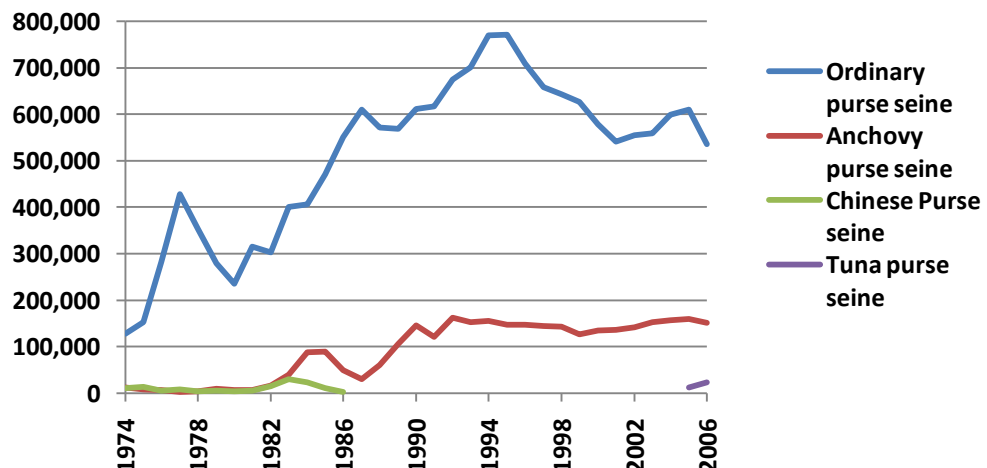


Fig. 4. Quantity of catch (in metric tons) by type of purse seine (1974 to 2006)
Source: Department of Fisheries of Thailand (1964-2009)

It should be considered that in totality, the quantity of catch from the country's purse seine fisheries fluctuated from 1974 to year 2006. Although the catch reflected a remarkable increase from 150,000 metric tons in 1974 to 900,000 metric tons in 1995, after 1995 until the present, the catch quantity had slightly decreased to 700,000 metric tons in 2006. On the other hand, it has also been observed that the statistics on the catch from tuna purse seine fisheries had been recorded separately since 2005, which could be due to the significant utilization of tuna materials for the tuna canning industry in Thailand. The statistics on fishing boats and/or fishing units (**Fig. 5**) had been compiled earlier in 1955 than the statistics on marine production. In the beginning from 1955 to 1972, the official statistics on purse seine had been classified into 2 categories, *i.e.* (1) Siamese purse seine, and (2) Two-boat purse seine. The data indicated that the number of fishing boats in 1955 was almost equal between these two categories, *i.e.* 139 Siamese purse seiners and 175 two-boat purse seiners. While the number of two-boat purse seiners was mostly constant from 1955 to 1967, the number of all types of purse seiners rose to 1000 vessels in 1985 and drastically increased to 1600 vessels from 1990 to 1991. From 1962 to 2006, number of one-boat purse seiners had narrowly fluctuated from 1300 to 1500 fishing vessels.

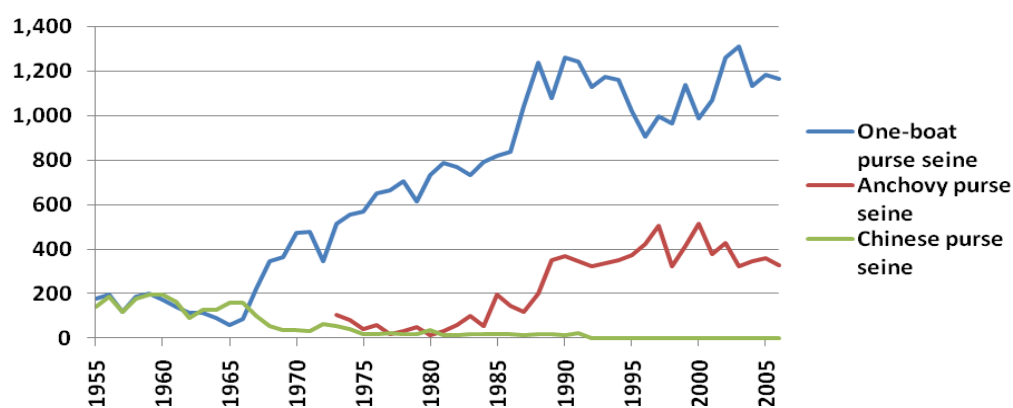


Fig. 5. Number of purse seiners in Thailand classified by type (1974-2006)
Source: Department of Fisheries of Thailand (1964-2009)

On the other hand, the records also showed that the number of two-boat purse seiners drastically decreased starting in 1968 and definitely disappeared from official records in 1992. This could be due to the lack of fisher power and the development of some efficient hauling devices as well as modern deck machineries. Since 1973, the category of anchovy purse seine was separated from the ordinary Thai purse seine, which recorded about 103 fishing boats, and since 1984, the number of anchovy purse seiners had been below 100 vessels. However, the number started to increase from 197 in 1985 to 500 fishing boats in 1997 and 2000, but then gradually decreased to 326 in 2006. Over the last decade, it had been observed that Malaysian anchovy purse seiners had been operating under joint ventures with Thai fishers in Chumphon and Satun Provinces. In summary, the compilation of statistics on Thai purse seiners was started in 1955 under the sub-category of Siamese purse seine with

175 vessels. The number gradually increased to 500 vessels in 1973 and 1000 vessels in 1987. From 1987 to 2006, number of one-boat purse seiners had been narrowly fluctuating from 900 to 1000 fishing vessels. The significant fishing ports of the Thai purse seiners are shown in **Fig. 6** while the important fishing grounds both central and lower Gulf of Thailand are shown in **Fig. 7**.

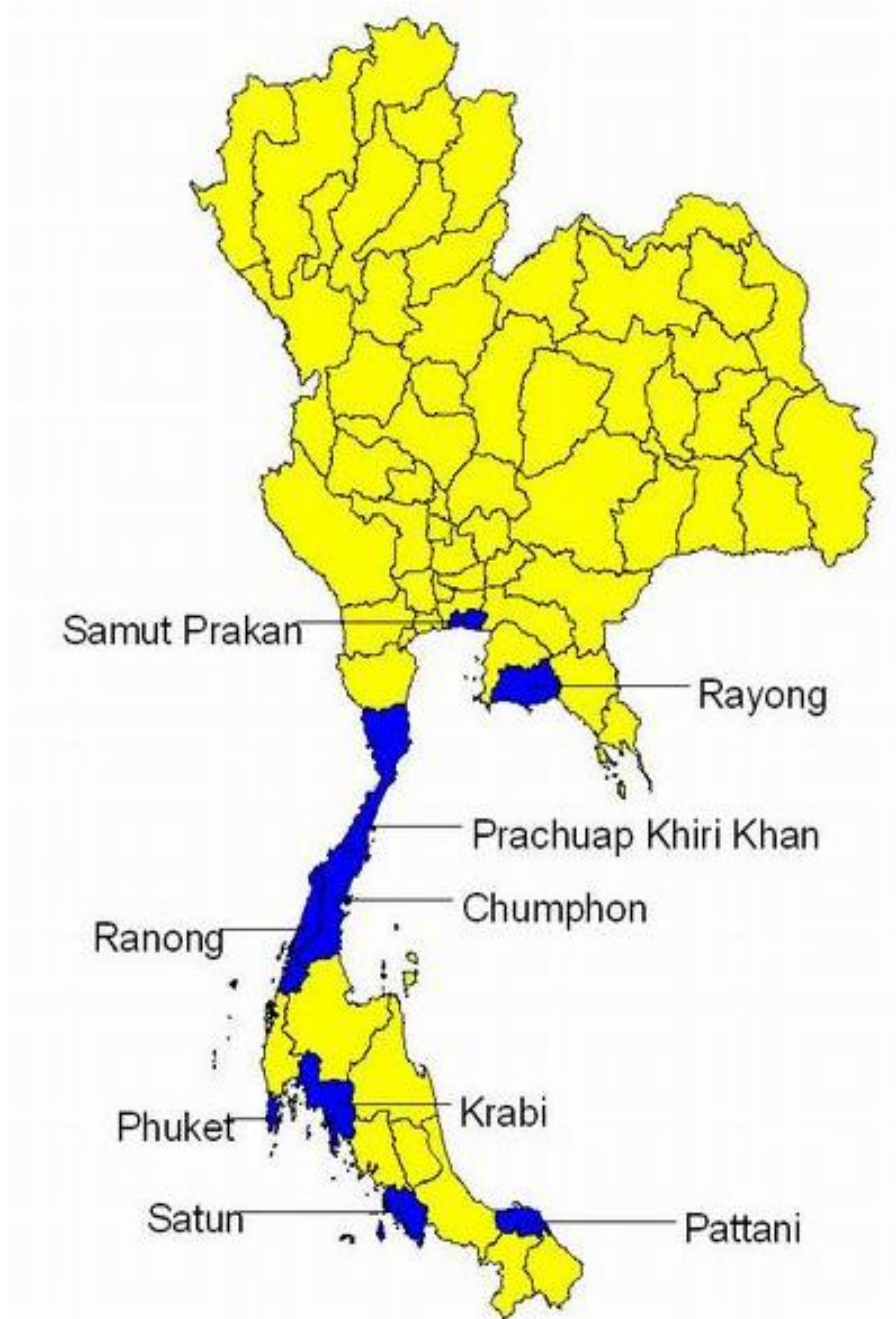
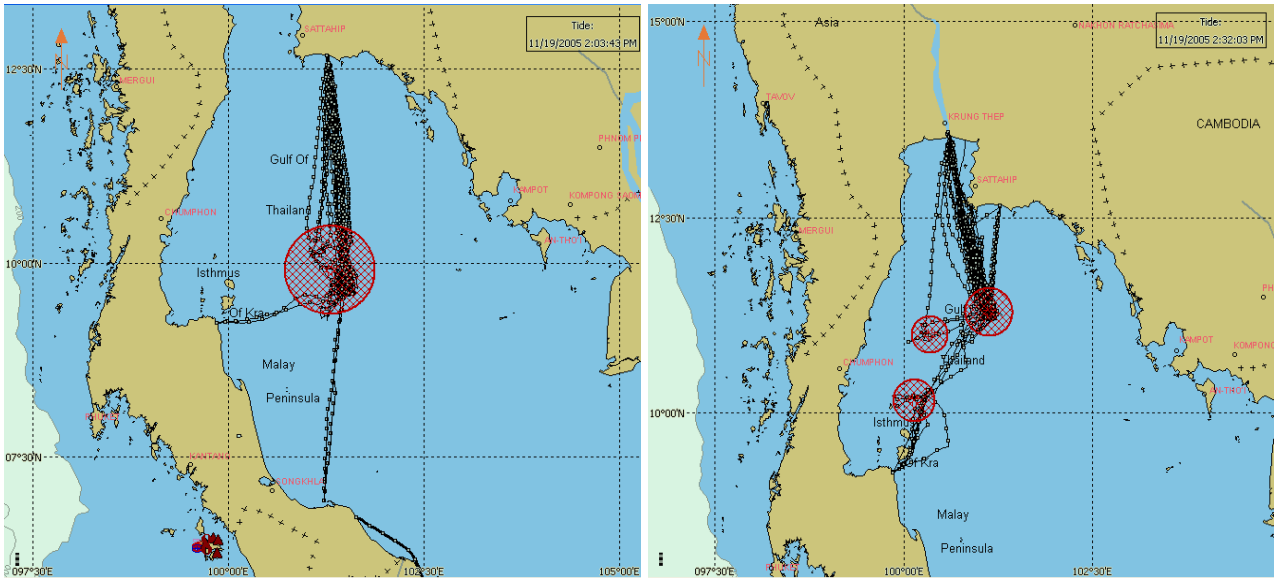
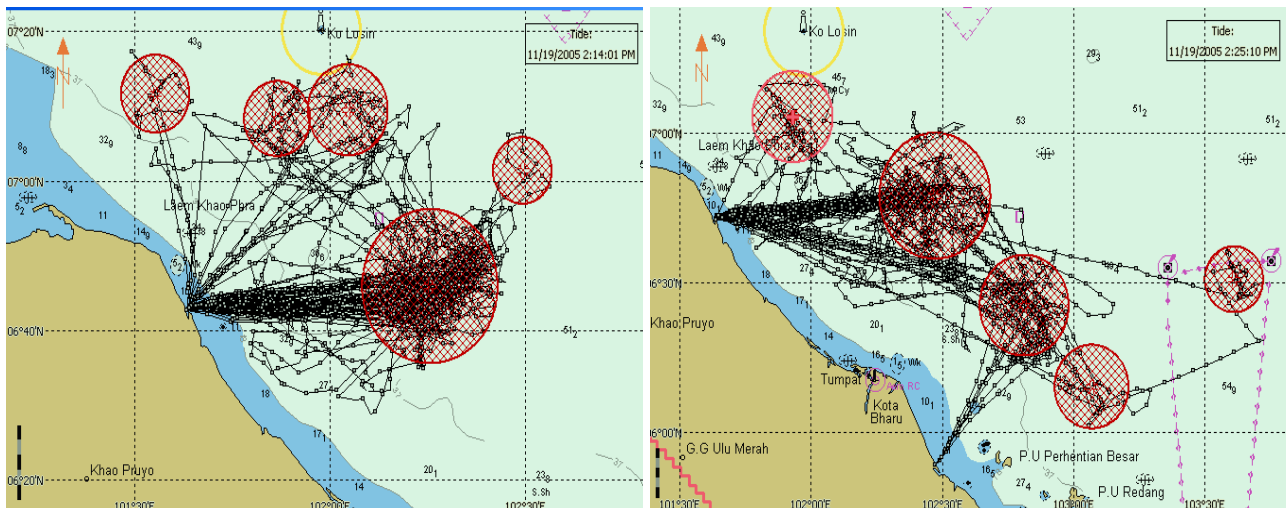


Fig. 6 Important fishing ports of Thai purse seiners
Source: SEAFDEC (2004)



Central Gulf of Thailand, off the coast of Chumphon Province



Lower Gulf of Thailand, off the coast of Pattani Province

Fig. 7 Important fishing grounds of Thai purse seine fishing in the Gulf of Thailand
 Source: Somboon Siriraksophon (2005)

3. Categories of Purse Seines in Thailand

Based on the classification of fishing gear and methods established by FAO, purse seine is a kind of surrounding net that can enclose the fish schools through a purse line. Some fishing gears, however, are operated like purse seine nets, *e.g.* encircling net but the capturing mechanism could be different in terms of gilling or enmeshing. This had oftentimes made the people misunderstand that such gear is a kind of gillnet. Hence, encircling net had not been classified under the surrounding net category. Beach seine and Lampara net is believed to be one of the origins of purse seine net. More particularly, Lampara net fishing had been recorded in history as practiced in Egypt since the 14th century. Thus, the beach seine and Lampara net had been assumed as the origin of surrounding nets without purse line (FAO, 1990). However, since Lampara net was not well-known in Thailand during that period, the beach seine in combination with the bunt net of bamboo stake traps could be the origin of the Thai purse seine.

Beach Seine net is a type of fishing gear which had been used in Thailand for a long time (**Fig. 8**). Since it is a very simple fishing gear and requires simple method to operate, it is popularly used by the small-scale fishermen in exploiting the fisheries resources along or near the shore and targeting the *Acetes*, shrimps, anchovies, mullet, and other miscellaneous fishes. Beach seine is an inshore dragnet consisting of two (2) long wing sections which are assembled by a large mesh-sized net panel and small mesh-sized net at the central of the net panel, called bunt. If the central part is designed in a pouch-shape or bag-shape, it is called the bag or pocket part. In bag-less beach seine, the central section is also the deepest part of the net. The deep beach seine fitted with spring ropes (foot rope hauling line), and operated offshore can be regarded as a prototype of the ring-net. The same net, if fitted with rings and purse line, could be regarded as a prototype of a purse seine.

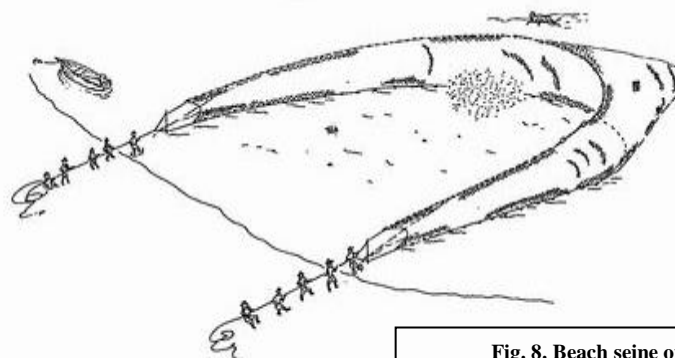


Fig. 8. Beach seine of Thailand
Source: SEAFDEC (2004)

Some fishing gear technologists classified the surrounding net of Thailand under the ring-net category. This could be due to its design which has been modified from the combination of the beach seine, Lampara net and the cod-end net of bamboo stake trap. Notwithstanding, many fisheries institutes in Thailand, the Department of Fisheries of Thailand and the Southeast Asian Fisheries Development Center/Training Department (SEAFDEC/TD) had named the Thai surrounding net as purse seine net and not as a ring net.

The classification of purse seine under the DOF/Thailand system is different from the SEAFDEC/TD system. The DOF/Thailand classified the purse seine by mesh size as had been stipulated under the country's fisheries regulations. The classification by mesh size also reflects the target catch as well. On the other hand, SEAFDEC/TD classified the type of purse seine based on a different system which is more related to the category of the statistics compiled during the period from 1970 to 1980. Thus, SEAFDEC/TD classified the purse seines by taking into consideration three (3) main prominent characters, *i.e.* (1) target catch, (2) characteristics of the net, and (3) mechanism of the fishing techniques.

The descriptions by DOF/Thailand and SEAFDEC/TD are described in this part of the document. The classification by DOF/Thailand was based on the Definition and Classification of Fishing Gear in Thailand (DOF, 1994), while the SEAFDEC/TD classification was derived from Fishing Gear and Methods in Southeast Asia I: Thailand (SEAFDEC, 2004).

3.1 Categories of Surrounding Nets Classified by the Department of Fisheries of Thailand

3.1.1 Surrounding nets without a purse line

The simplest gears in terms of construction and in the method of operations are the surrounding nets without a purse line. These gears have traditionally been used by small-scale fishers operating in coastal waters for catching anchovies, rocky fishes and other near-shore species. Before, this kind of surrounding net was rarely employed by the Thai fishers because of the lack of divers. Thus, there were only less than 20 fishing boats operating this type of gear. Nowadays, this kind of surrounding net had been modified by using a purse line. Surrounding nets without purse line are classified into two (2) main types, *i.e.* 1) surrounding nets without a purse line (mesh size less than 10 mm), and 2) surrounding nets without a purse line (mesh size larger than 10 mm).

3.1.1 (1) Surrounding nets without a purse line (mesh size less than 10 mm)

This type of surrounding net is called *Uan glud ta-khaw* in Thai. It is usually operated from a small boat (8-14 meters length, 6-150 HP engine) by 6-10 fishermen. The net is rectangular in shape, 200-400 m in length and 10-15 m in depth. The main net consists of 6.4x6.4 to 7.4x7.4 mm nylon minnow net or 5.5 to 8.3 mm raschel net. Polyethylene 250 d/12 netting is used for the lower selvedge. The float line is longer than the sinker line, and the buoyancy force is about double that of the sinking force. The ground rope is fixed with 200 g lead at intervals of 50 cm. While no purse line is assembled with the net, 30 pieces C-shaped steel hooks of 9 cm length are used to close the bottom part of the net. The only other piece of equipment onboard apart from the net is an air compressor to supply air to the fisherman who dives when the bottom of the net has to be closed.

The main target species are anchovies and planktonic shrimps, but some by-catch such as the predators that feed on anchovies could also be caught. This gear is operated in fishing grounds that are sandy or muddy and sandy, the most common characteristics of the waters in Rayong, Chantaburi and Trat Provinces.

3.1.1 (2) Surrounding nets without a purse line (mesh size larger than 10 mm)

This type of surrounding net is called *Uan lom lung hin* in Thai. It is usually operated from a small boat (8-14 meters length, 6-150 HP engine) by 6-10 fishermen. This net is able to surround an underwater rocky area or coral area. In view of the country's limited fishing grounds, this kind of net is not widely used in Thailand.

Since this net was modified from the anchovy surrounding net, the fishing method is almost same although there are some differences in terms of the net materials and the choice of the suitable fishing grounds. This purse seine net is rectangular in shape, 250-300 m in length and 10-20 m in depth. The mesh size of the main net is 25 mm. Nylon 210 d/6 is used for the main net while 30 mm polyethylene net 380 d/12 is used for the selvedge. The float line is longer than the sinker line, and buoyancy force is about double than that of the sinking force. The ground rope is fixed with 200 g lead at intervals of 100 cm. Although no purse line is assembled with the net, 30-40 pieces of C-shaped steel hooks 7 cm in length are used to clip for closing the bottom part of the net (**Fig. 9** and **Fig. 10**). As in the previous purse seine, the only piece of equipment onboard apart from the net is an air compressor to supply air to the fisherman who dives when the bottom of the net needs to be closed.

The fishing grounds for this purse seine should have rocky bottom or around a reef. The main target species are the yellow-tail fusiliers, rabbit fish, cavalla, barracuda and other coral fishes. This gear is commonly found in the eastern part of the Gulf of Thailand, especially in Makhampom Bay in Rayong Province.

3.1.2 Surrounding nets with a purse line

The information in the country's fisheries statistical record indicated that there were 840 registered purse seiners in 1982, most of which were categorized into 10-100 gross tonnage, and used luring devices such as fish aggregating devices (FADs) and light. Some purse seiners had been equipped with modern equipments onboard, such as wireless set radio communication, echo-sounder, sonar, and radar. In 1985, some boats were even installed with satellite navigation system that made fishing ground has been precisely recorded. Many auxiliary fishing gears and hauling devices are also used onboard, *i.e.* capstan winch (mechanical or hydraulic), davit pulley, boom crane, electric generator, fish luring lamps and power block. Usually however, there are no freezers onboard, so wet or dry ice is used instead to preserve the catch. This method of fishing would necessitate a rather large manpower requirement, which may in time, become a disadvantage. There are five main kinds of surrounding nets with a purse line and respective mesh sizes classified under this category.

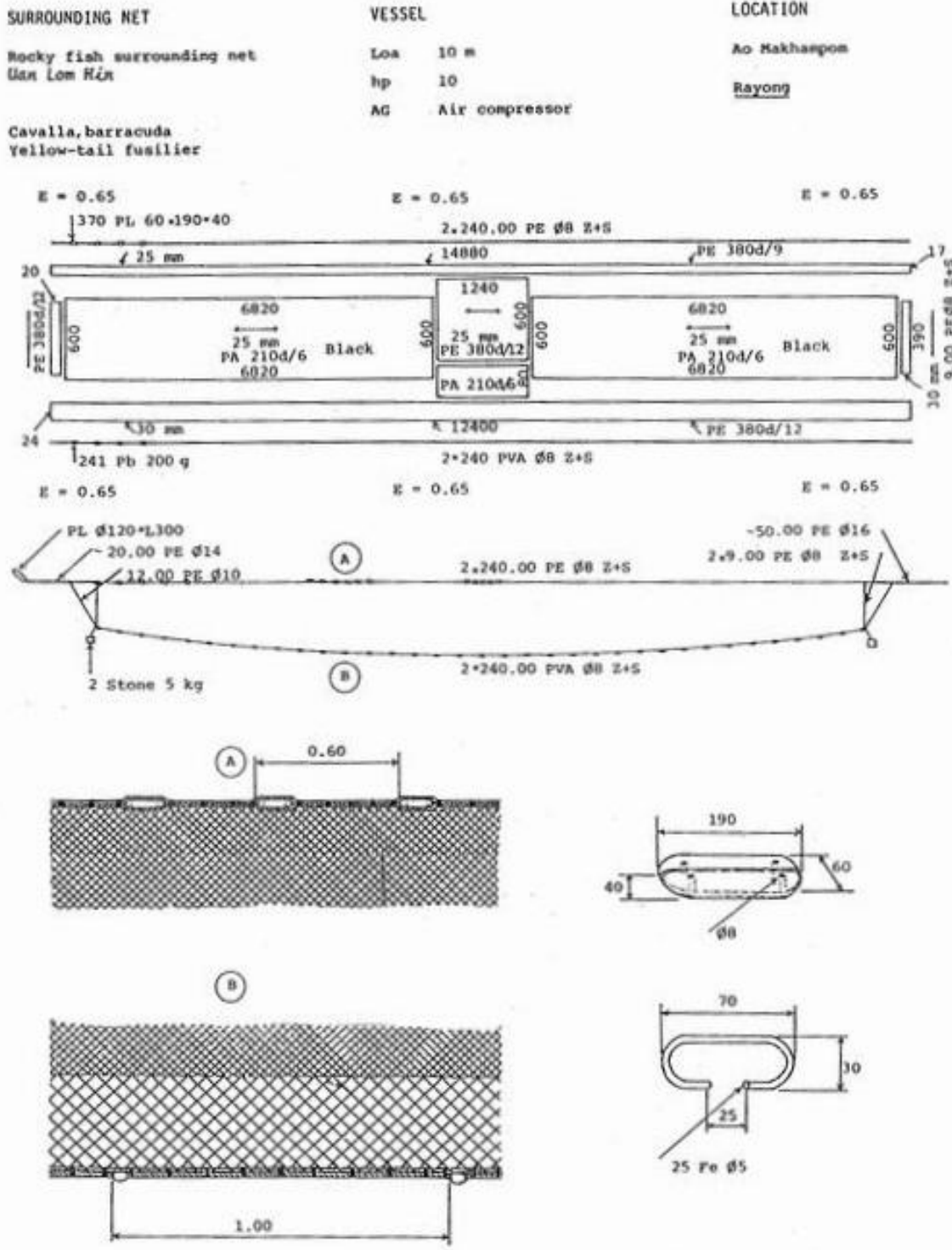


Fig. 9. Surrounding net without a purse line (mesh size larger than 10 mm)
Source: SEAFDEC (1986)

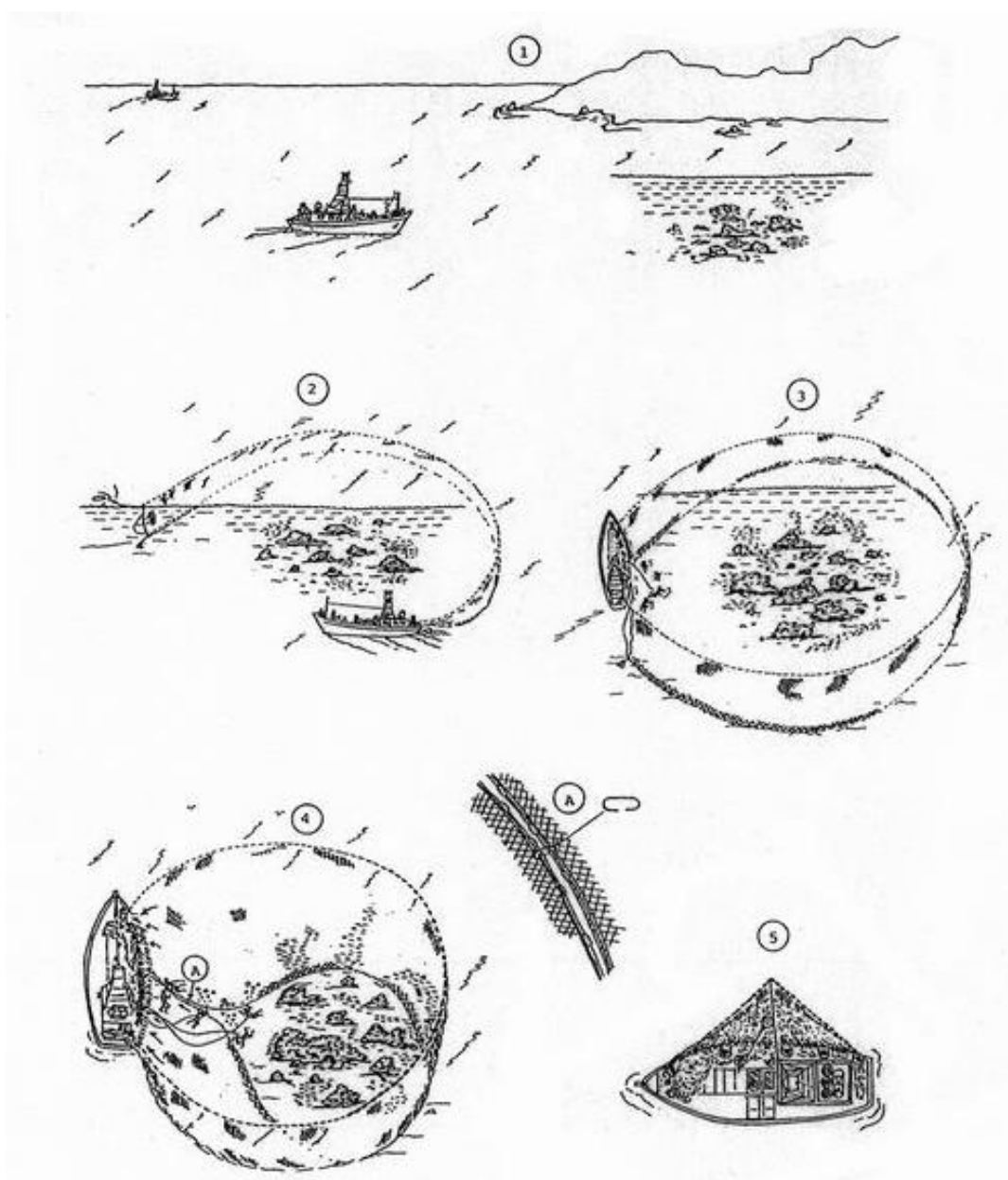


Fig. 10. Fishing operation of surrounding net without purse line (mesh size larger than 10 mm)
Source: SEAFDEC (1986)

3.1.2 (1) Surrounding nets with a purse line (mesh size less than 10 mm)

In the Thai language, this type of surrounding net is called by various names, *i.e.* *Uan lom chub pla katak* or *Uan lom chub pla jing-jung* or *Uan lom chub pla hau-on*. The net construction is similar to that of the anchovy surrounding net without purse line except that a purse ring is attached to the sinker line, hence the bottom of the net can be closed with the purse line (**Fig. 12**). It is usually operated from a small boat (10-22 m in length, 20-300 HP engine) by 6-30 fishermen.

The fishing boat is usually installed with a fish finder, GPS and radio transceiver. The fishing grounds are reported to be around Trad, Rayong, Chumphon, Surat-Thani and Satun Provinces. Some fishing boats, particularly those operating around Chumphon, Surat Thani and Satun Province, had been introduced from Malaysia (Fig. 13) and installed with boilers for dry preservation and processing of the catch onboard.

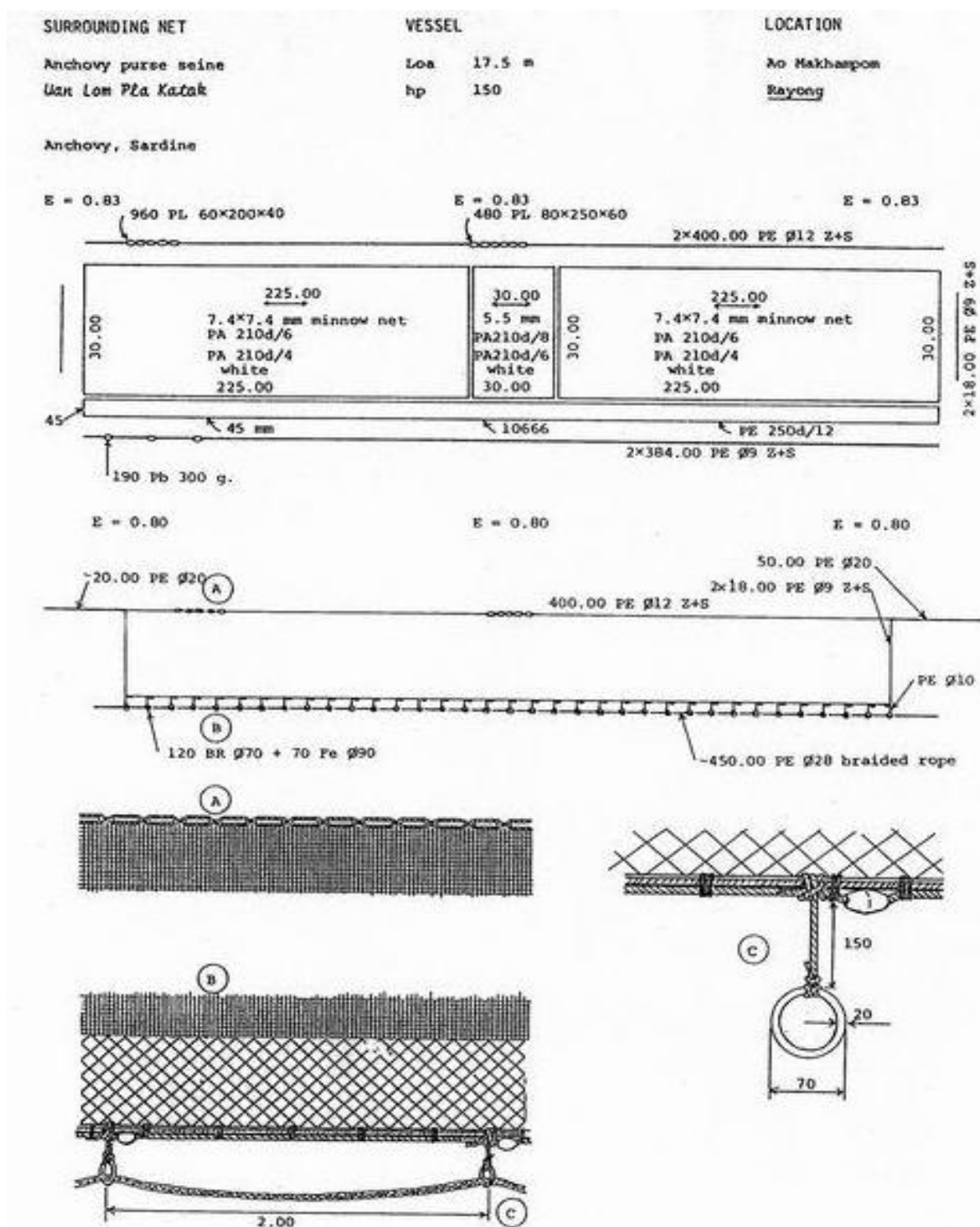


Fig. 11. Surrounding net with a purse line (mesh size less than 10 mm)
Source: SEAFDEC (1986)

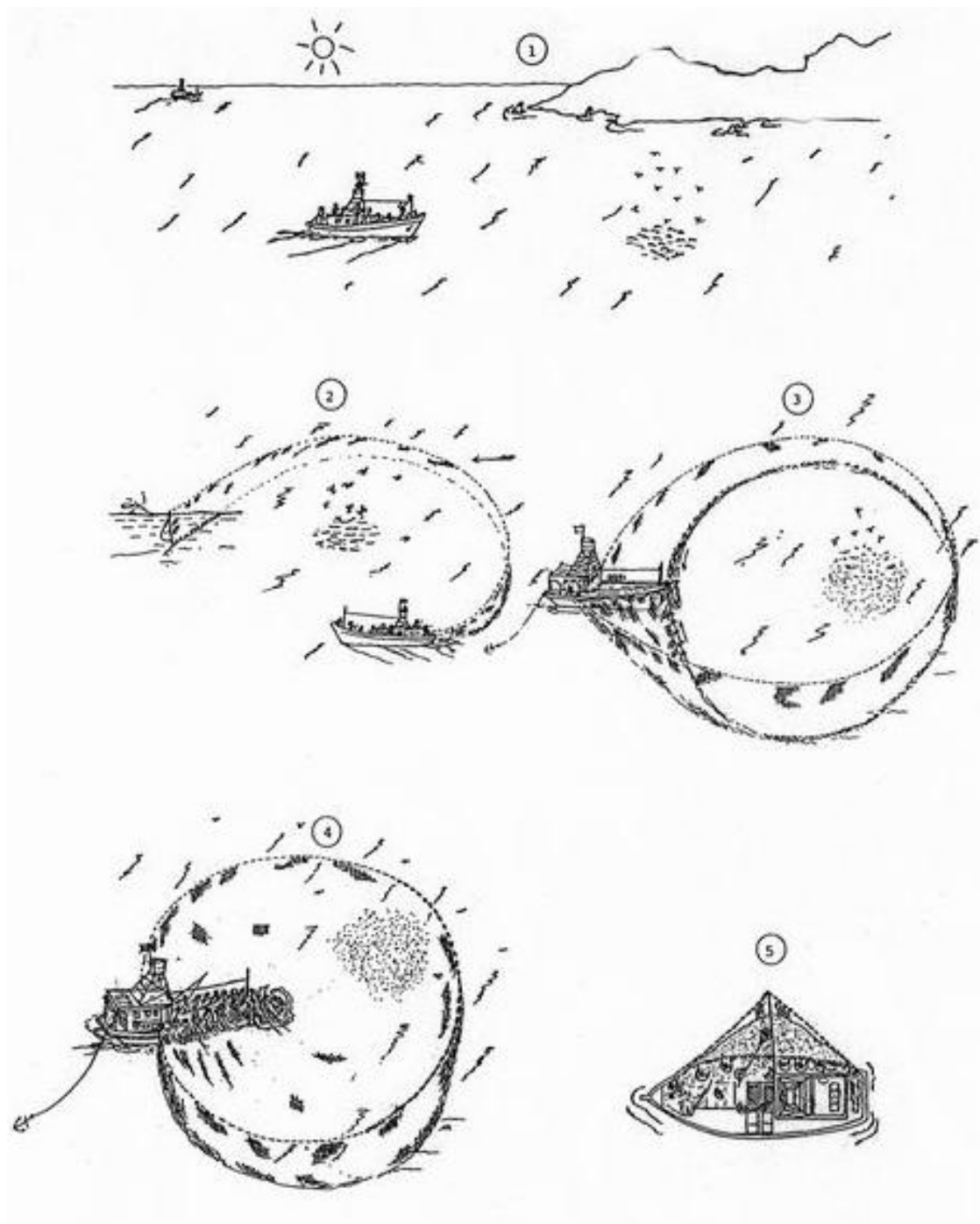


Fig. 12. Fishing operation of surrounding net with a purse line (mesh size less than 10 mm)
Source: SEAFDEC (1986)

The net is rectangular in shape, 250-450 m in length and 15-80 m in depth. The float line is shorter than the sinker line (hanging ratio (E) = $0.83/E=0.93$). The main net is blue polyethylene minnow net 2 x 2 mm and/or green nylon raschel net 4.0-8.3 mm mesh size and the size of the twine is 110 d - 210 d/5. Polyethylene net, twine size 380 d/12-15 and 25 mm mesh size, is used for selvedge at the sinker line. Iron purse rings, diameter 10-15 mm, are attached on the sinker line with 2-3 kg lead at intervals of 1.5 to 3.0 meters. A polyethylene cross-rope, 26-40 mm diameter, is used for the purse line. Buoyancy force is about twice that of the sinking power (**Fig. 11**).



Fig. 13. Purse seiner of surrounding net with a purse line (mesh size less than 10 mm)
Left: Thai model; Right: Malaysian model
 Photo by SEAFDEC (2004) and A. Munprasit (2009)

Fishing methods of this gear are classified into two (2) main categories, *i.e.* (1) fishing operation without luring light, and (2) fishing operation with luring light, and mainly targeting the various species of anchovies. By-catch including other pelagic fishes and squids attracted by the luring lights are also caught. Anchovy purse seine can be found in the east coast of the Gulf of Thailand (Rayong, Chantaburi, and Trat), in the southern east coast (Surat Thani), and in the southern part of the west coast of Thailand, especially in Phuket, Krabi and Satun.

3.1.2 (2) Surrounding nets with a purse line (mesh size 10.0-24.9 mm)

This type of surrounding net is called *Uan lom loog-mha (Puppy Purse seine)*, *Uan lom muk*, *Uam lom hang-ya* and *Uan lom ta-kieng* in Thai. The fishing boat used is small-scale with an inboard or outboard engine. The fishing operation is able to conduct both searching for fish schools and use of luring lights (**Fig. 14**). The gear is usually operated from a small boat (9-14 m in length with 24-150 HP inboard engine or 10 HP outboard engine) by 4-20 fishermen. The fishing boat is installed with fish finder, GPS, radio transceiver and luring raft.

The net is rectangular, 100-400 m in length and 14-40 m in depth. The main net is green or black nylon net, mesh size 16-20 mm. Polyethylene net, twine size 380 d/12-15 and mesh size 25 mm, is used for selvedge at sinker line. Iron purse rings, 10-15 mm diameter, are attached on the sinker line with lead having a total weight of 0.5-2.0 kg/piece. Twisted-rope, 16-28 mm diameter is used for the purse line (**Fig. 15**). The fishing method can be classified into: (1) fishing operation without luring lights, and (2) fishing operation with luring lights. The operational procedure is the same as that of the other surrounding nets with purse line. Most purse seiners, however, are not equipped with any hauling devices. The principal target species are the Indo-Pacific mackerel, scads and squids. By-catch such as pony fish and other juvenile fishes are also caught. Surrounding nets with purse line with mesh size between 10.0-24.9 mm are mostly found in Chumphon Province.



Fig. 14. Luring light boats at a fishing port in Rayong Province



Fig. 15. Purse seiner of surrounding net with a purse line (mesh size 10.0-24.9 mm)
Photo by SEAFDEC (2004)

3.1.2 (3) Surrounding nets with a purse line (mesh size 25.0-29.9 mm)

This type of surrounding net is called in Thai as *Uan dum* and *Uan lom sung* and *Uan tang-ke* (two-boat purse seine), and is widely used in the Gulf of Thailand and the Andaman Sea (**Fig. 16**). The net construction is similar for the *Uan dum* and *Uan lom Sung* types except for *Uan tang-ke* (two-boat purse seine). Nowadays, large vessels are already equipped with sonar and echo sounder for detecting schools of fish. In the past and even today in the case of small vessels, a fish school has to be spotted by ocular inspection at twilight time. Sometimes, however, Thai purse seines are operated with fish luring lights and fish shelters (FADs), which causes some difficulties and confusion in the compilation of the corresponding fishery statistical data.

Purse seine is usually operated from a medium-scale boat (14-26 m in length, 20-700 HP engine) by 10-30 fishermen. A net hauler is always installed on the port side. One or two luring light boats or lighted rafts and one skiff boat to serve as a luring boat usually make a fleet complete. Special two skiff boats are used for the operation of *Uan tang-ke* (two-boat purse seine) which is different in terms fishing techniques although with the same mesh size.

The net of *Uan dam* is rectangular but the length varies, *i.e.* usually 400-600 m for luring light operation and 800-1800 m for free schooling operation (**Fig. 17** and **Fig. 18**), 60-110 m in depth and the cod end is assembled at the middle of the net. The main net is made of black-colored nylon net with 25 mm mesh size and twine size of 210d/9-12. The float line is shorter than the sinker line ($E = 0.6-0.7/E=0.65-0.75$). The bunt part is Polyethylene net twine 380d/18 in size with 25.0 mm mesh size. The buoyancy force is 1.3-2 times higher than the sinking power. Polyethylene cross-rope, diameter 26-40 mm is used for the purse line.



Fig. 16. Purse seiner of surrounding net with a purse line (mesh size 25.0-29.9 mm)

Uan dam has mesh size 25.0 to 29.9 mm which is operated by different luring methods (**Fig. 19**) and also with different float line lengths. *Uan dam* operated by luring light lamp has the shortest float line, however *Uan dam* operated by sonar searching has the longest float line and the deepest compared with the other two luring methods where the fish schools are aggregated by light (**Fig. 20**) or FADs (**Fig. 21** and **Fig. 22**), but are less active than the free swimming fish schools. The principal target species largely consist of Indo-Pacific mackerel and scads. The fishing grounds are in the eastern and western parts of the Gulf of Thailand, in the inner Gulf, and the southern part of the Andaman Sea. The main ports are located in Samut Sakhon, Chonburi, Langsuan (Chumphon Province) and Kantang district (Trang Province).

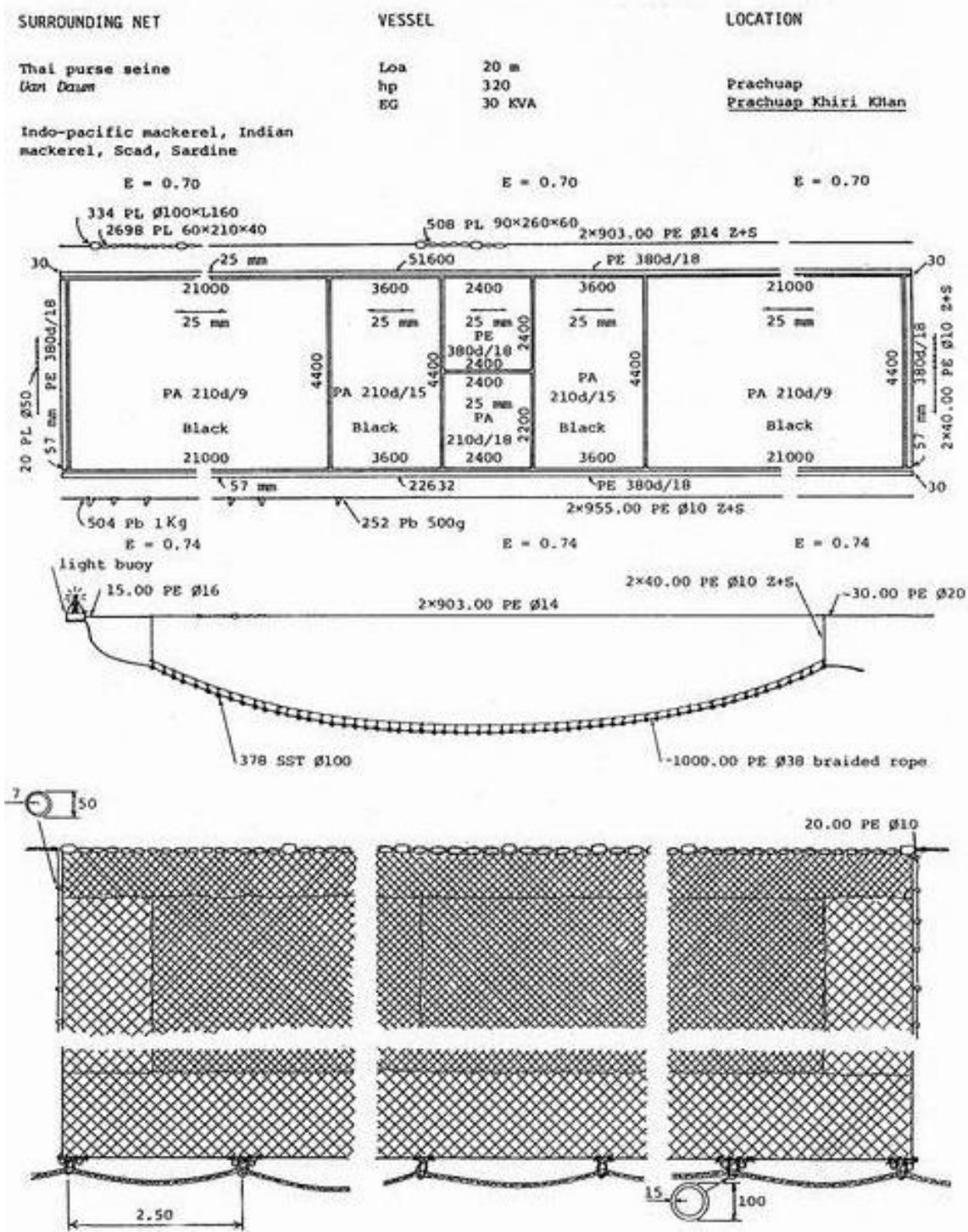


Fig. 17 Surrounding net with a purse line (mesh size 25.0-29.9 mm): Free schooling surrounding method
Source: SEAFDEC (1986)

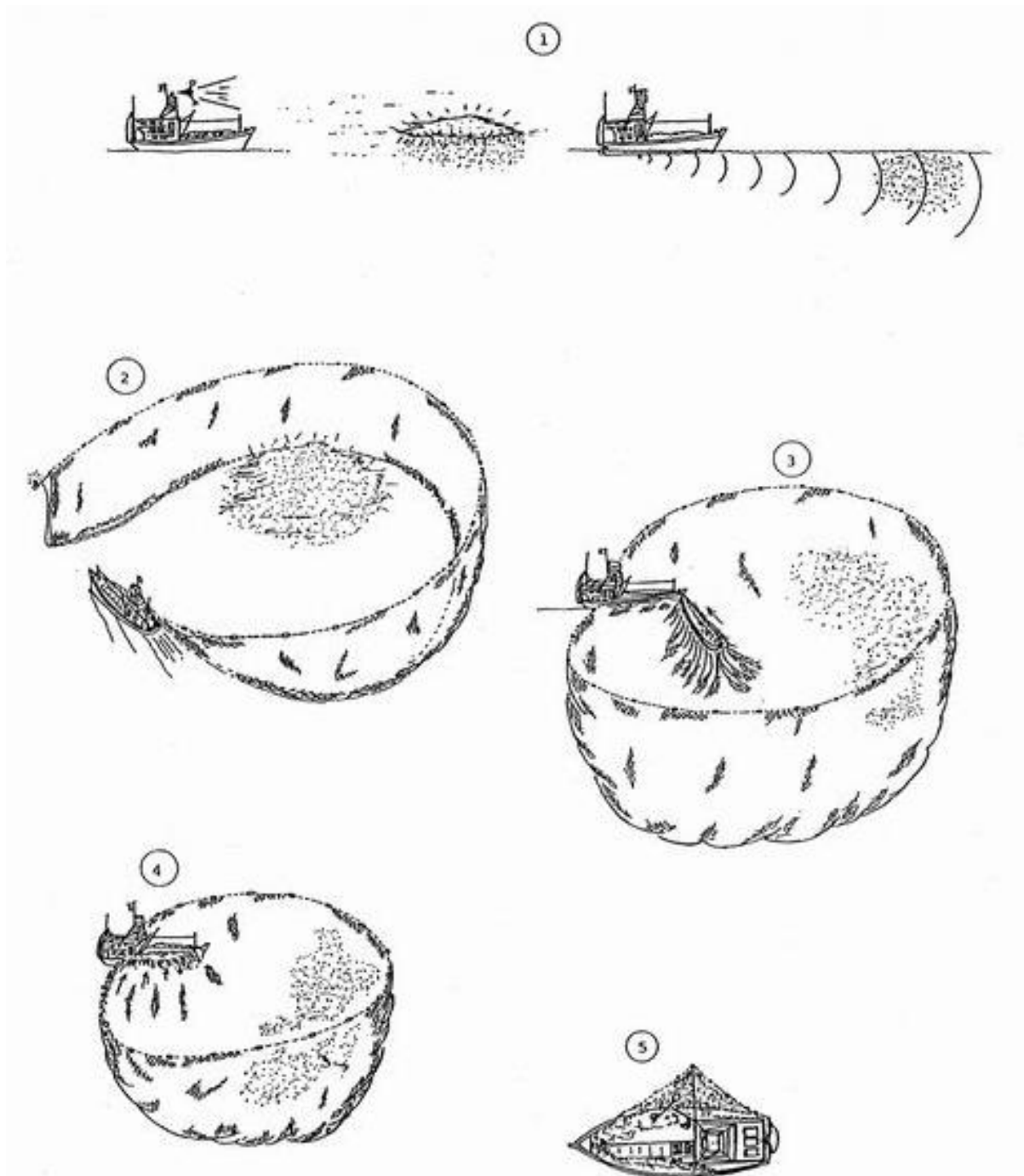


Fig. 18 Fishing operation of surrounding net with a purse line (mesh size 25.0-29.9 mm): Free schooling surrounding method by visual searching
 Source: SEAFDEC (1986)

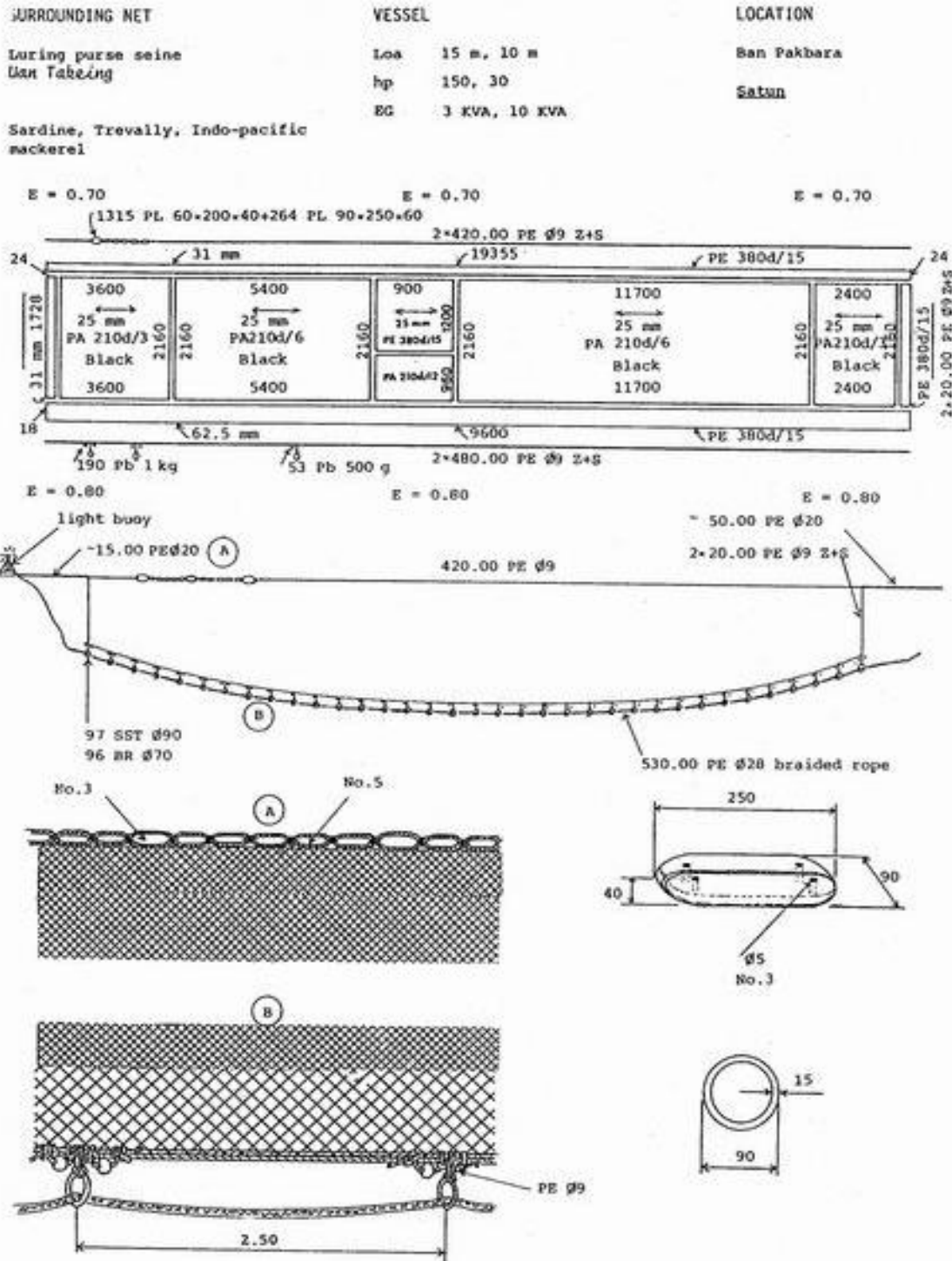


Fig. 19 Surrounding net with a purse line (mesh size 25.0-29.9 mm): Luring light surrounding method
Source: SEAFDEC (1986)

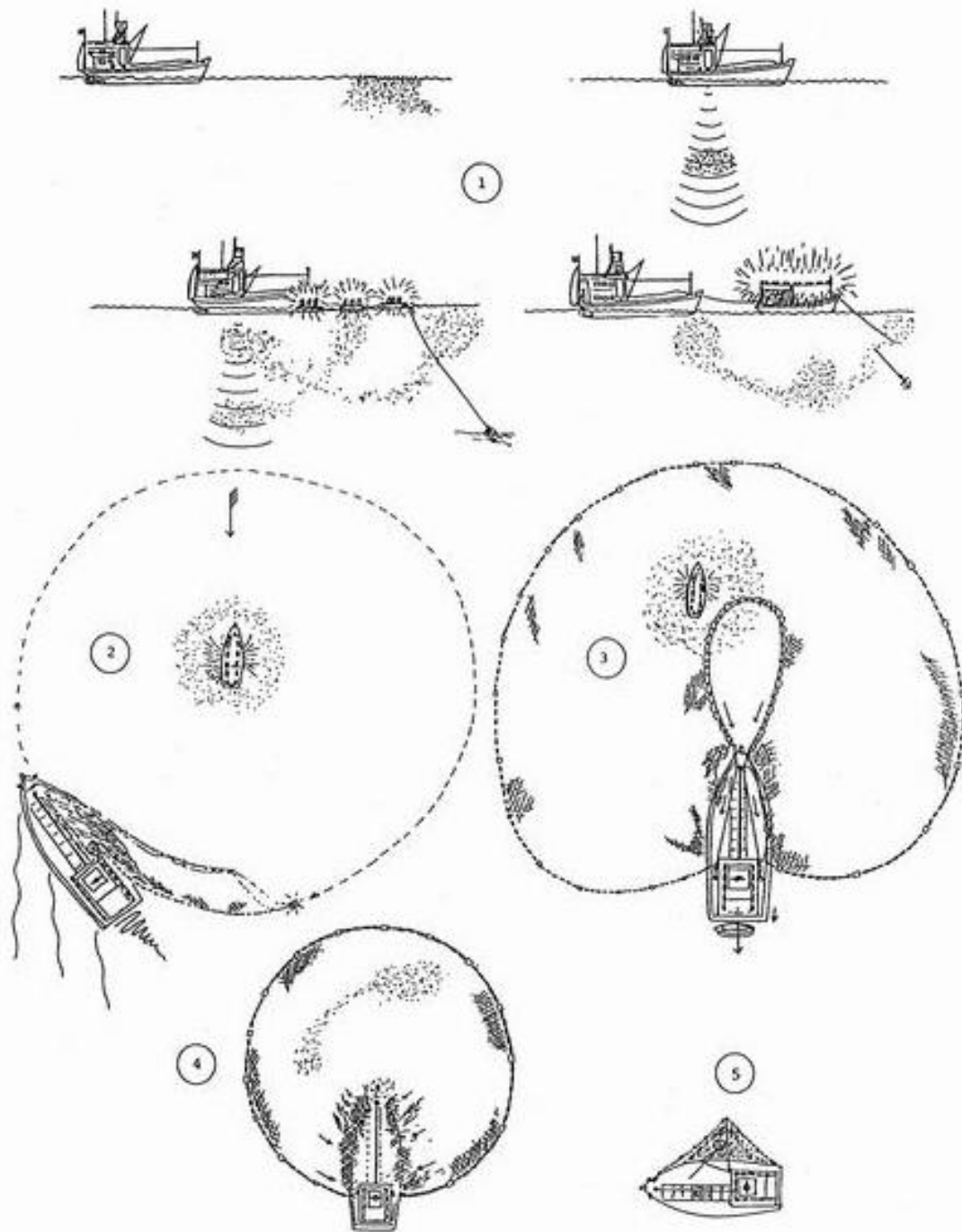


Fig. 20. Fishing operation of surrounding net with a purse line (mesh size 25.0-29.9 mm): Luring light surrounding method
Source: SEAFDEC (1986)

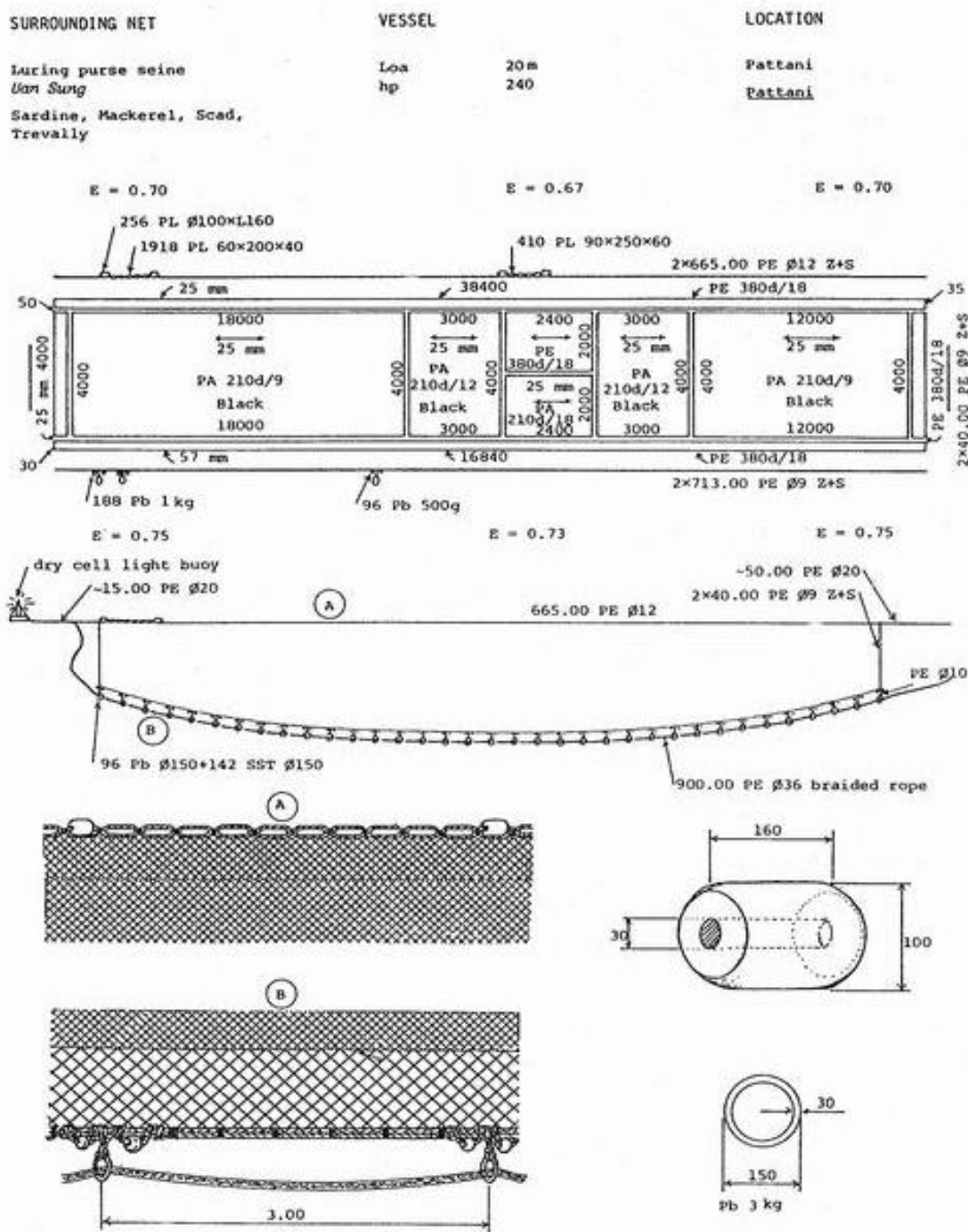


Fig. 21. Surrounding net with a purse line (mesh size between 25.0-29.9 mm): FAD surrounding method
Source: SEAFDEC (1986)

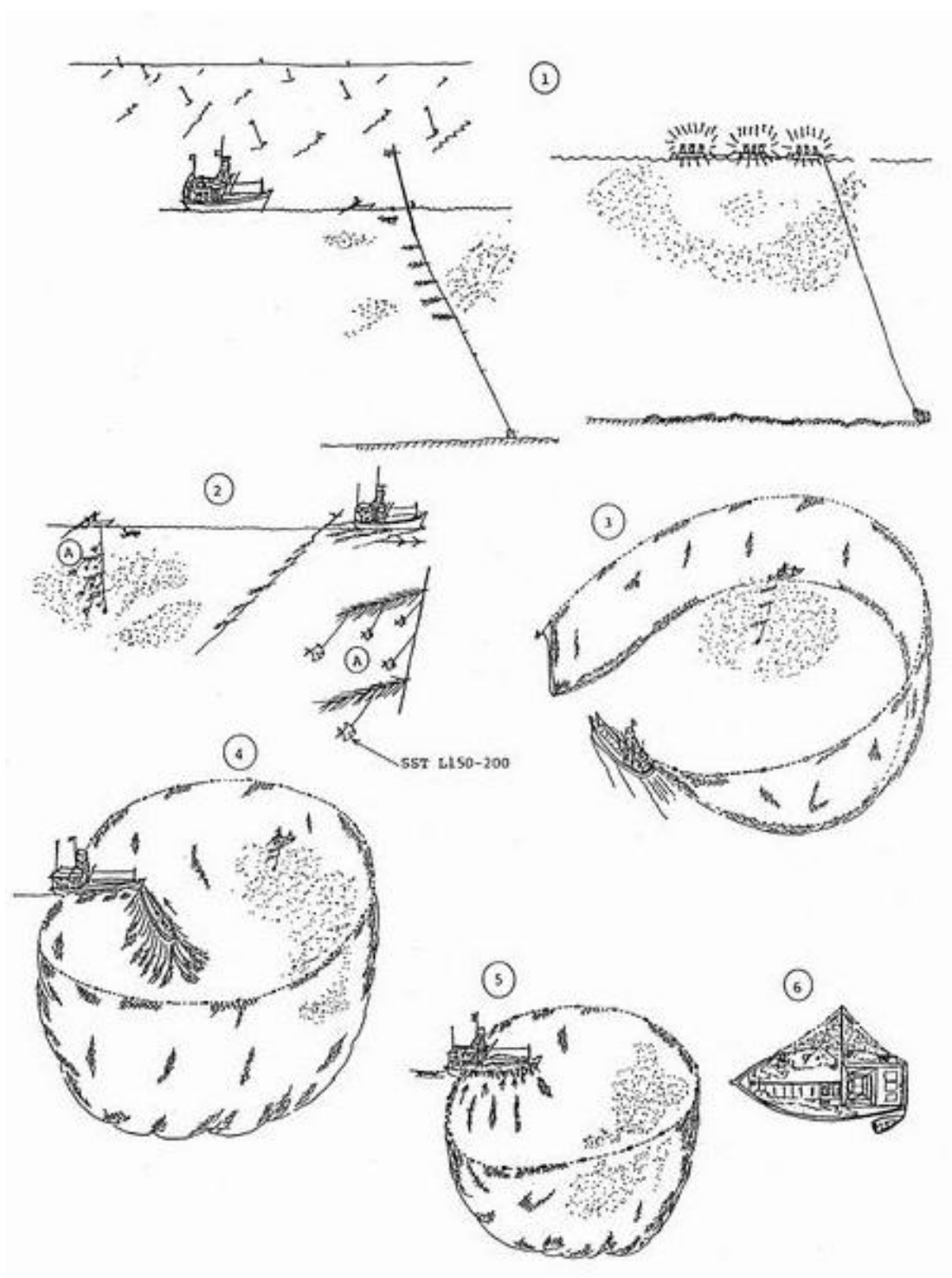


Fig. 22. Fishing operation of surrounding net with purse line (mesh size 25.0-29.9 mm): FAD surrounding method
Source: SEAFDEC (1986)

Apart from *Uan dum* and *Uan lom sung*, several vessels are required for the operation of *Uan tang-ke*. The mother boat is 16-20 m long, wooden vessel with a 100-250 HP main engine (Fig. 25). Two rowing-boats (8x2x0.8 m) are used as net boats, and another rowing boat also participates during the fishing operation. The net is rectangular, 350 x 60 m, made of black-colored nylon net, 25 mm mesh size and twine size is 210 d/9-12. Polyethylene, 25

mm, 380d/15, is used for the top and bottom selvedge net. The float line is shorter than the sinker line ($E = 0.8/E=0.93$).

The bunt part is nylon net, 25 mm mesh size and twine size is 210d/12. Two purse lines, polyethylene cross-rope, diameter 28-32 mm, are assembled at the middle of the net. The main target species are scads, barracuda, cavalla, trevally, Spanish mackerel, mackerel, and bonito. The fishing grounds are along the Andaman Sea coasts of Phuket, Trang, and Satun Provinces.

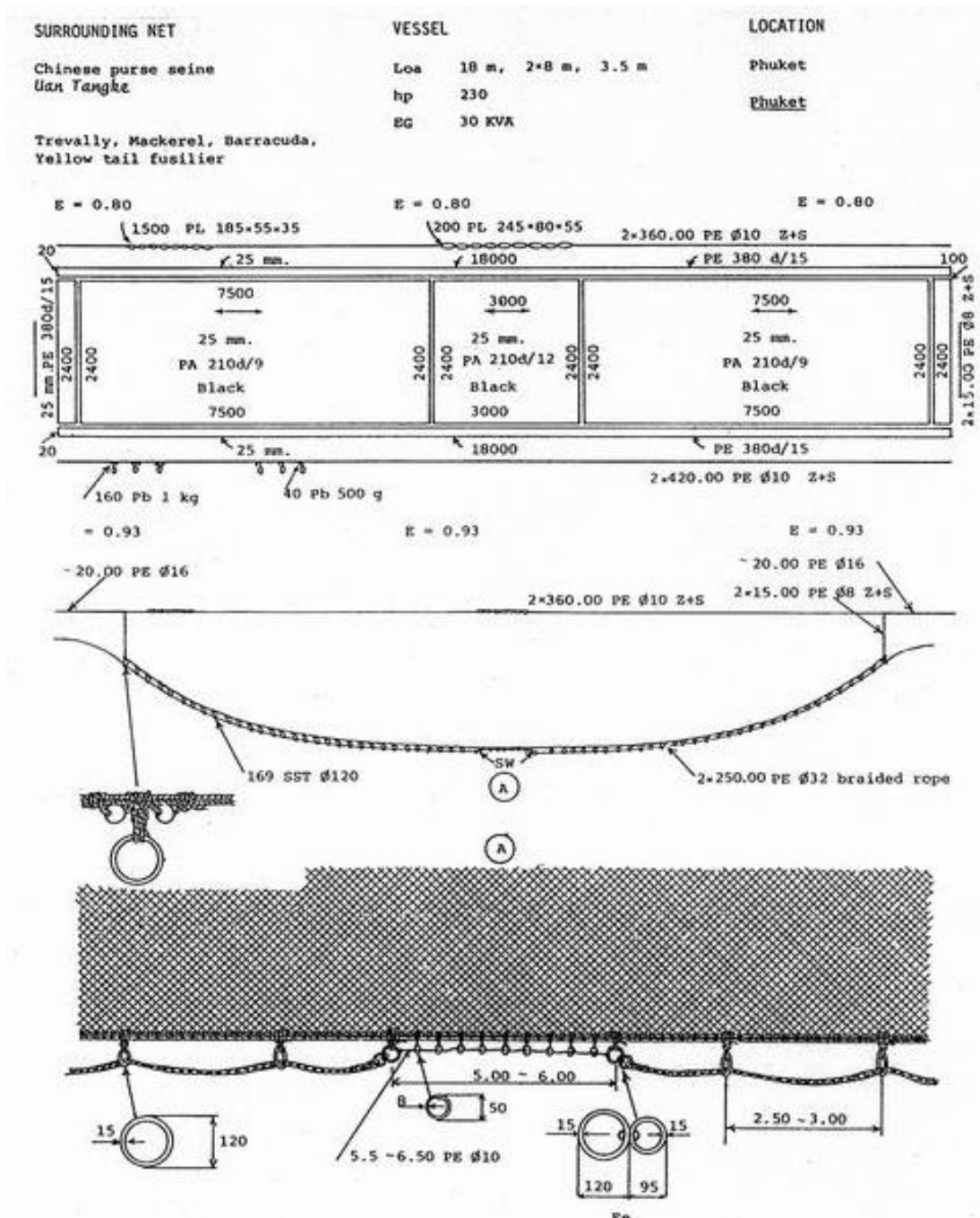


Fig. 23. Two-boat purse seine (*Uan Tang-ke*)
Source: SEAFDEC/TD (1986)

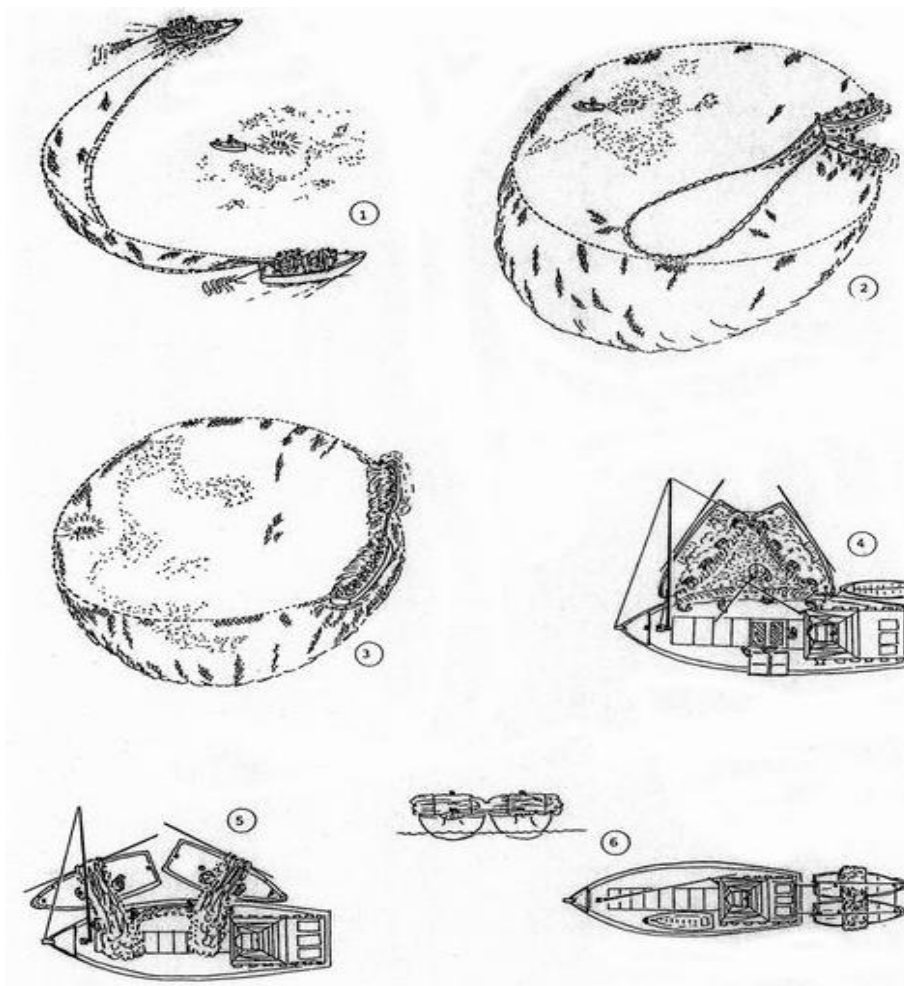


Fig. 24. Fishing operation of two-boat purse seine (*Uan Tang-ke*)
 Source: SEAFDEC/T (1986)



Fig. 25. Two-boats purse seiner
Left: Mother boat
Right: Rowing boats
 Photo by SEAFDEC (2004)

3.1.2 (4) Surrounding nets with a purse line (mesh size between 30.0-45.0 mm)

This kind of surrounding net makes use of sonar to detect the fish schools. The purse seine is usually operated from a medium-scale boat (10-20 m in length, 24-300 HP engine) by 10-30 fishermen. A net hauler is always installed on the port side, and the operation is mostly conducted by surrounding the free schooling fish.

The purse seine net is 400-800 m in length and 40-80 m in depth. The main net has 38-42 mm mesh-size, the material is black and green nylon net, twine size is 210 d/12-24 and cod-end is polyethylene with twine size 380 d/9-36 based on the target species. The float line is shorter than the sinker line ($E=0.7-0.9/E=0.75-0.9$). The ratio between the depth and the length of net is 1/5-1/7. The ground rope is attached with iron purse rings and sinker with a total weight of 2-3 kg/point. Polyethylene cross-rope, diameter 20-30 mm is used for the purse line (**Fig. 26** and **Fig. 27**).

The main target species largely consist of big size Indo-Pacific mackerel, hardtail scads, pomfrets, little tuna, and bonito. The fishing grounds are in the central Gulf of Thailand, while the main fishing ports are located in Samut-Sakorn, Samut-Songkram, Prachaub-kirikarn, Rayong, Songkhla and Pattani Provinces.

3.1.2 (5) Surrounding nets with a purse line (mesh size larger than 45.0 mm)

This is one of the largest purse seines in Thailand which was developed for catching bonito in the Gulf of Thailand. The purse seine is usually operated from a medium-scale boat (20-32 m in length, 300-520 HP engine) by 30-45 fishermen. A net hauler is always installed on the port side. The operation is mostly conducted by surrounding the free schooling fish both at daytime and nighttime by visual and sonar searching methods (**Fig. 28**).

The purse seine net is from 800 to 1800 m in length and 100-120 m in depth. The main net has 47-100 mm mesh-size, the material is black and green nylon 210 d/12-36 and 210/18 mixed with Saran and polyethylene 380 d/18-36 with 25 mm mesh size at the cod-end. The float line is shorter than the sinker line ($E=0.7/E=0.75$). The ratio between the depth and the length of net is 1/5-1/7. The ground rope is attached with iron purse rings and sinker, the total weight is 2-3 kg/point. Polyethylene cross-rope, diameter 38-40 mm is used for the purse line.

Fish schools are detected by sonar. Fishing is done at twilight and nighttime mainly targeting eastern little tuna, bonito, skipjack, hardtail and scads. The fishing grounds are in the central Gulf of Thailand, South China Sea and Andaman Sea including Myanmar waters. The main fishing ports are located in Samut-Sakorn, Samut-Songkram, Prachaub-kirikarn, Rayong, Songkhla, Pattani, Ranong, and Phuket Provinces.

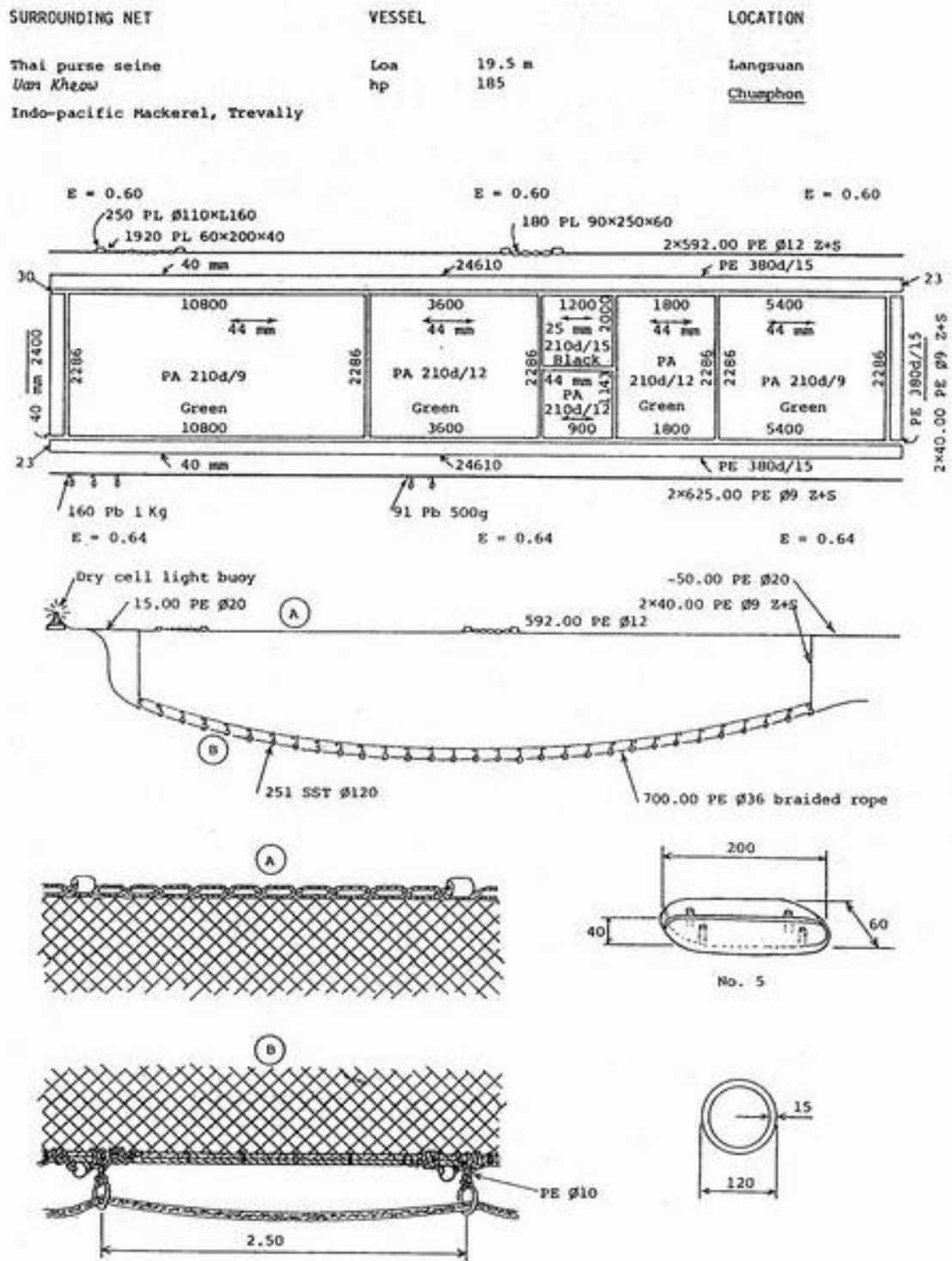


Fig. 26. Surrounding net with a purse line (mesh size 30-45 mm)
Source: SEAFDEC (1986)

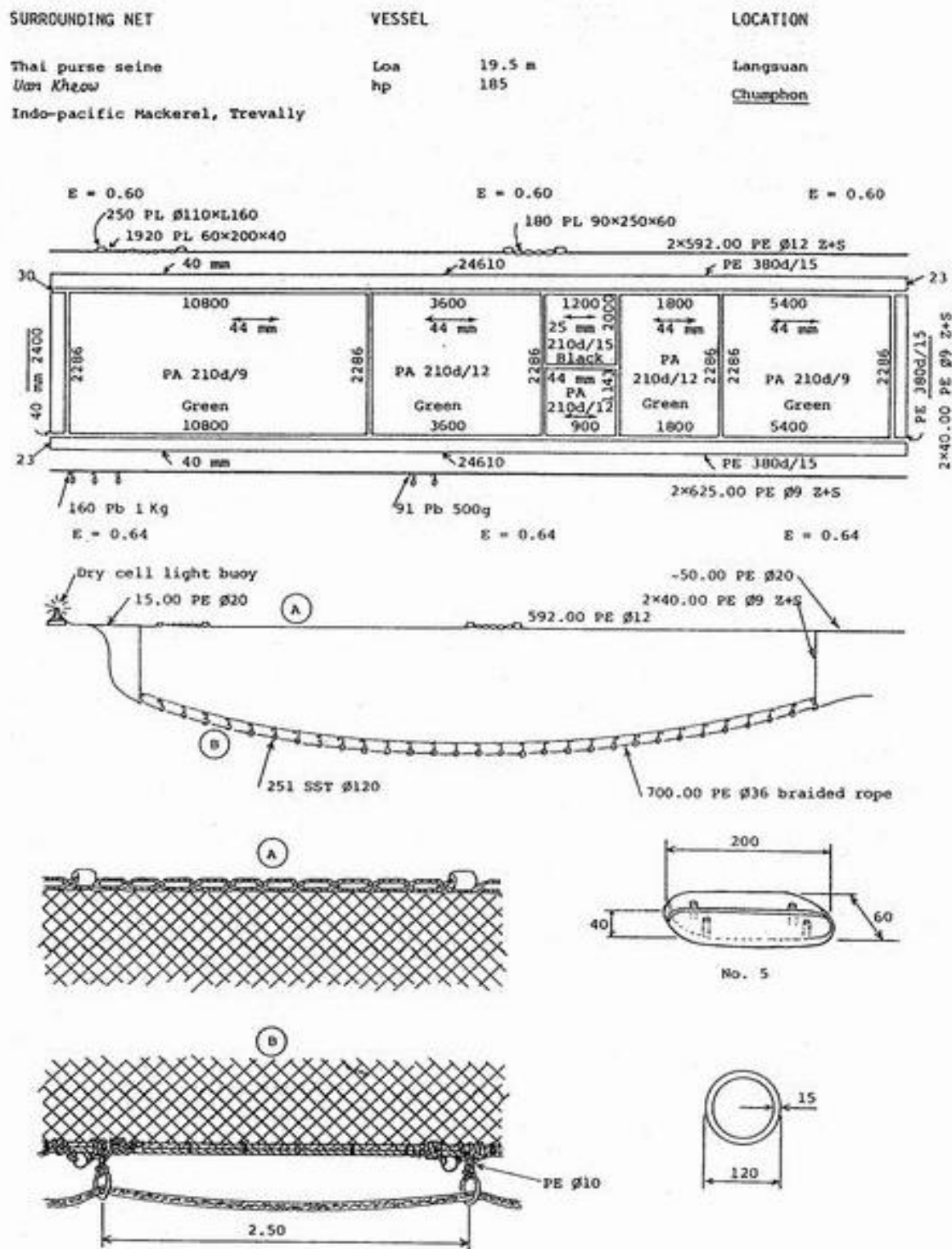


Fig. 27. Surrounding net with a purse line II (mesh size 30-45 mm)
Source: SEAFDEC 1986

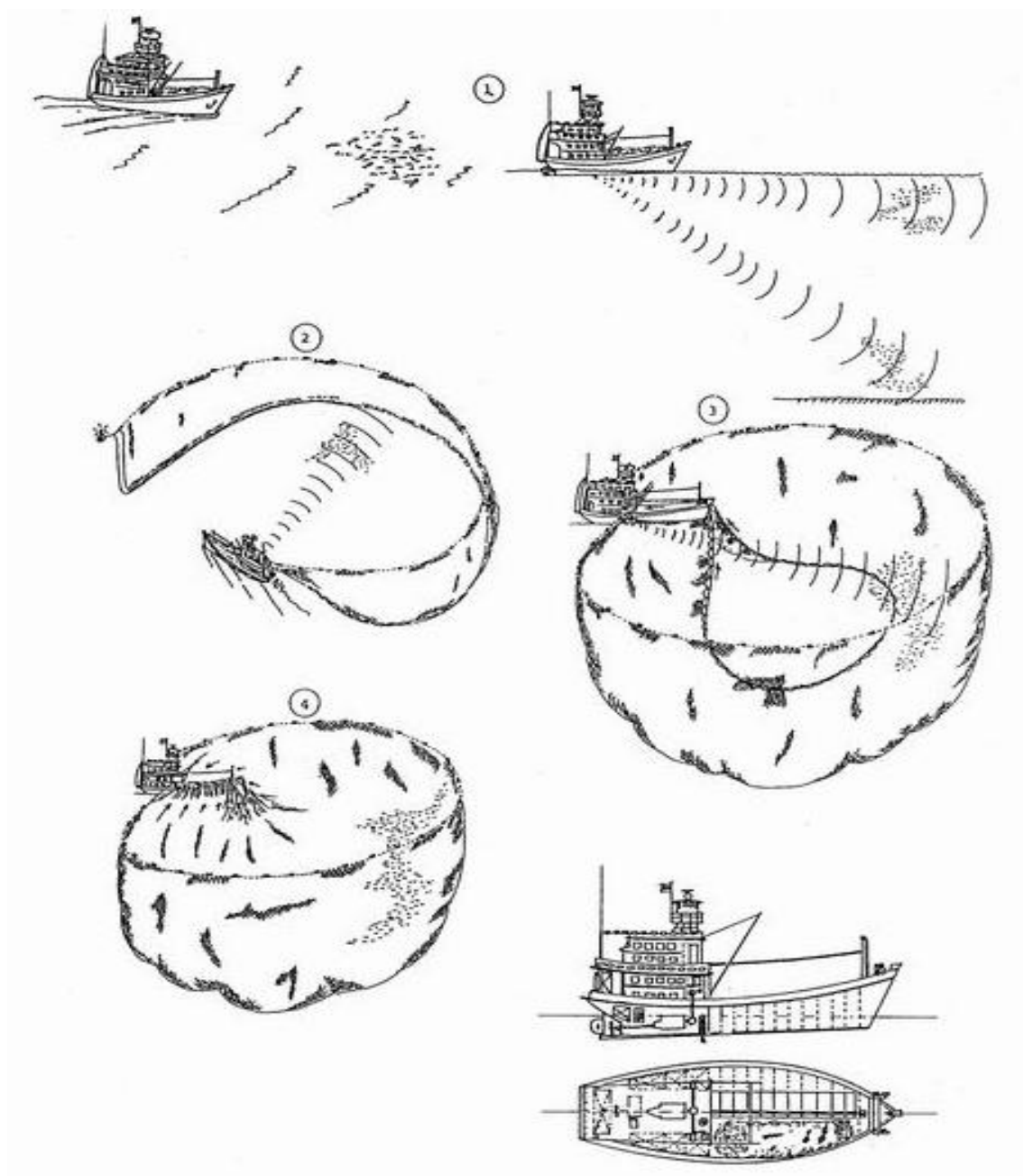


Fig. 28. Fishing operation of surrounding net with purse line: free-schooling search by hydro-acoustic equipment
Source: SEAFDEC (1986)

3.2 Categories of Surrounding Nets Classified by SEAFDEC/TD

SEAFDEC/TD had classified the types of purse seines with different system which is more related to the statistics compiled during period from 1970 to 1980. Thus, SEAFDEC/TD classified the purse seine categories considering 3 main prominent characteristics, *i.e.* (1) target catch, (2) characteristic of net, and (3) mechanism of the fishing techniques.

3.2.1 Surrounding nets without a purse line

Details of the fishing gear and methods are the same as the category of surrounding nets classified by DOF/Thailand (3.1).

3.2.1 (1) Anchovy surrounding net (*Uan Glud Takhao*)

Details of the fishing gear and methods are the same as the category of surrounding nets without a purse line (mesh size smaller than 10 mm) classified by DOF/Thailand (3.1.1 (1)).

3.2.1 (2) Rock-fish surrounding net (*Uan Lom Lung Hin*)

Details of the fishing gear and methods are the as the category of surrounding nets without a purse line (mesh size larger than 10 mm) classified by DOF/Thailand (3.1.1 (2)).

3.2.2 Surrounding nets with a purse line or purse seines

SEAFDEC/TD classified the surrounding nets with purse line into 6 models based on the target species, characteristics of the catch, fishing net and luring techniques. In some cases, this had caused confusion on the category as it could be considered as some kind of surrounding net, *e.g.* Thai purse seine (*Uan dum*) and Luring purse seine (*Uan Sung* and *Uan Ta-geang*) or Bonito purse seine (*Uan lon pla-o*) and Luring purse seine (*Uan Sung* and *Uan Ta-geang*).

3.2.2 (1) Chinese or two-boat purse seine (*Uan Tang-Ke*)

Details of the fishing gear and methods are the as the category of surrounding nets with a purse line (mesh size between 25.0-29.9 mm), and partial information of Chinese or two-boat purse seine (*Uan tang-ke*) as classified by DOF/Thailand (3.1.2 (3)).

3.2.2 (2) Anchovy purse seine (*Uan Lom Chub Pla Katak*)

Details of the fishing gear and methods are the same as the category of surrounding nets with a purse line (mesh size smaller than 10.0 mm) as classified by DOF/Thailand (3.1.2 (1)).

3.2.2 (3) Thai purse seine (*Uan Dum*)

Details of the fishing gear and methods are the as the category of surrounding nets with a purse line (mesh size 25.0-29.9 mm, 30.0-45.0 mm and larger than 45.0 mm) as classified by DOF/Thailand (3.1.2 (3), 3.1.2 (4), 3.1.2 (5)).

3.2.2 (4) Luring purse seine (*Uan Sung and Uan Tageang*)

Details of the fishing gear and methods are the as the category of surrounding nets with a purse line (mesh size 25.0-29.9 mm, 30.0-45.0 mm and larger than 45.0 mm) as classified by DOF/Thailand (3.1.2 (3), 3.1.2 (4), 3.1.2 (5)).

3.2.2 (5) Bonito purse seine (*Uan Lom Pla-o*)

Details of the fishing gear and methods are the as the category of surrounding nets with a purse line (mesh size larger than 45.0 mm) as classified by DOF/Thailand (3.1.2 (5)).

3.2.2 (6) American tuna purse seine (*Uan Lom Pla Too-na*)

For fifteen years (1982-1997), the most advance Thai fishing gear was the Tuna purse seine on the Super Seiner. In 1987, the Department of Fisheries of Thailand acquired one large fisheries research vessel, the R.V. Chulabhorn from Hayashikane Dockyard of Japan. Although the vessel was basically constructed as a trawler, the design was meant for multipurpose uses, i.e. stern trawler, pelagic & bottom longliner, gillnetter and purse seiner.

In 1994, The Southeast Asian Fisheries Development Center/Training Department (SEAFDEC/TD) also acquired a multipurpose fishery research and training vessel, the M.V. SEAFDEC from Miho Dockyard of Japan. It was basically constructed is a tuna purse seiner (Super Seiner), however she was also concurrently designed to function as longliner and gillnetter as well as for pot during certain cruises at some period of time.

Moreover in 1995, the Department of Fisheries, Thailand constructed a new Tuna Fisheries Research Vessel, the R.V. Mahidol through the Hayashikane Dockyard in Japan. A 1270 gross tonnage vessel, she was designed for an American tuna purse seine class being a typical type tuna purse seiner. Then in 1999, the Thai Offshore Fisheries Association has employed a typical tuna purse seiner, the M.V. Mukmanee, about 990 gross tonnage used as a purse seiner. Her original name and owner was Tokiwa Maru No.1, from Taiyo Fisheries of Japan, respectively.

Most of the abovementioned vessels are mainly operated in the Indian Ocean and rarely in the Andaman Sea because of the latter's current condition which always changes in terms of direction and velocity, thus American type tuna purse seining operation is not possible. Although the M.V Mukmanee had operated in the Eastern Indian Ocean from November 1998 to June 2001 (Praulai et al., 2002), it had stopped its operations because of some business losses on the part of the operator and was reported to have been sold later to a Philippine company. Furthermore, the R.V. Chulabhorn has also stopped its operation in tuna purse seine fishing and at present, its functions include longline and deep sea pot fishing as well as in oceanographic surveys.

The fishing nets employed during the fishing trials of the aforementioned vessels vary in length from 1000 to 2000 m and in depth from 250 to 300 m. The mesh size is 90 mm at the bunt part and 210 mm at the body and wing, and operated with fish aggregating devices (FADs) or Payao as it is called in the Philippines. The main target species are skipjack, yellowfin tuna, and bigeye tuna while the by-catch could include the rainbow runner, horse mackerel, dolphin fish, and leather-jacket.

3.3 Categories of Surrounding Nets Classified by FAO (ISSCFG)

In 1971, the FAO adopted the International Standard Statistical Classification of Fishing Gear (ISSCFG), where the sequence and numbering of the gear categories correspond to the numerical code used by the ISSCFG. The numerical code was adopted during 10th session of the Coordinating Working Party of Atlantic Fisheries Statistics in Madrid in July 1980.

The description of surrounding net established by Claude N. and J Prodo (1990) indicated that the net could catch fishes by surrounding them from both sides and from underneath, thus preventing them from escaping in the deep waters by swimming downwards. Moreover, they also considered the surrounding net as surface net where the float line is supported by numerous floats. As shown in **Fig. 29**, FAO classified surrounding nets into two (2) main categories, *i.e.* Surrounding net with purse line (Purse Seines) and Surrounding net without purse line (Lampara Nets). The summary of the classifications of surrounding nets by DOF/Thailand and SEAFDEC/TD are also shown in **Fig. 30** and **Fig. 31**, respectively. Moreover, the comparison of the classifications by FAO, DOF/Thailand and SEAFDEC/TD is shown in detail in **Table 2**.

3.3.1 Surrounding net with purse line (Purse seines)

The net under this category is a purse seine characterized by the use of a purse line at the bottom of the net (**Table 3** and **Table 4**). The purse line enables the net to be closed like a purse and thus retain all the fishes that are caught in the net.

Purse seines (Standard Abbreviation: PS) could be very large and operated by one boat (Standard Abbreviation: PS1) or two boats (Standard Abbreviation: PS2). In most usual cases, a purse seine is operated by a single boat with or without auxiliary skiff.

3.3.2 Surrounding net without purse line (Lampara Nets)

The Lampara net is the type most represents this category. Its particular design shows the central bunt in the form of a spoon and two lateral wings, making it possible to retain a school of fish when the two wings are hauled up at the same time. Lampara net is generally operated by a single boat, usually of small tonnage (**Table 4**). The Standard Abbreviation of Lampara net is LA.

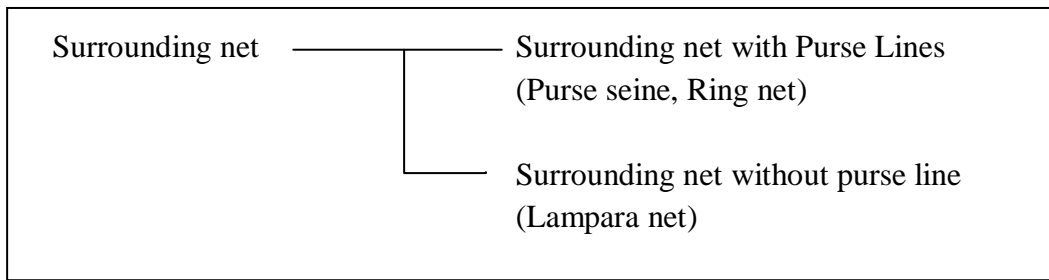


Fig. 29. Categories of surrounding nets classified by FAO
 Source: FAO (1990)

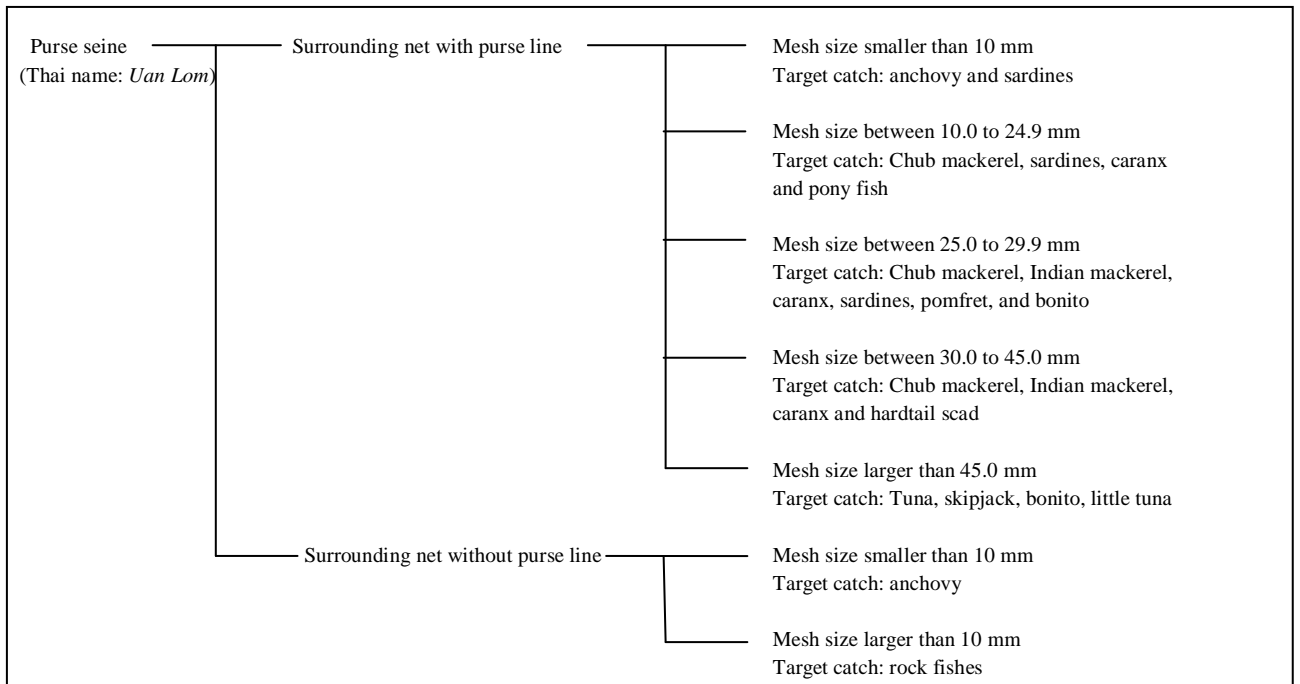


Fig. 30. Categories of Thai surrounding nets classified by the Department of Fisheries of Thailand
 Source: DOF/Thailand (1997)

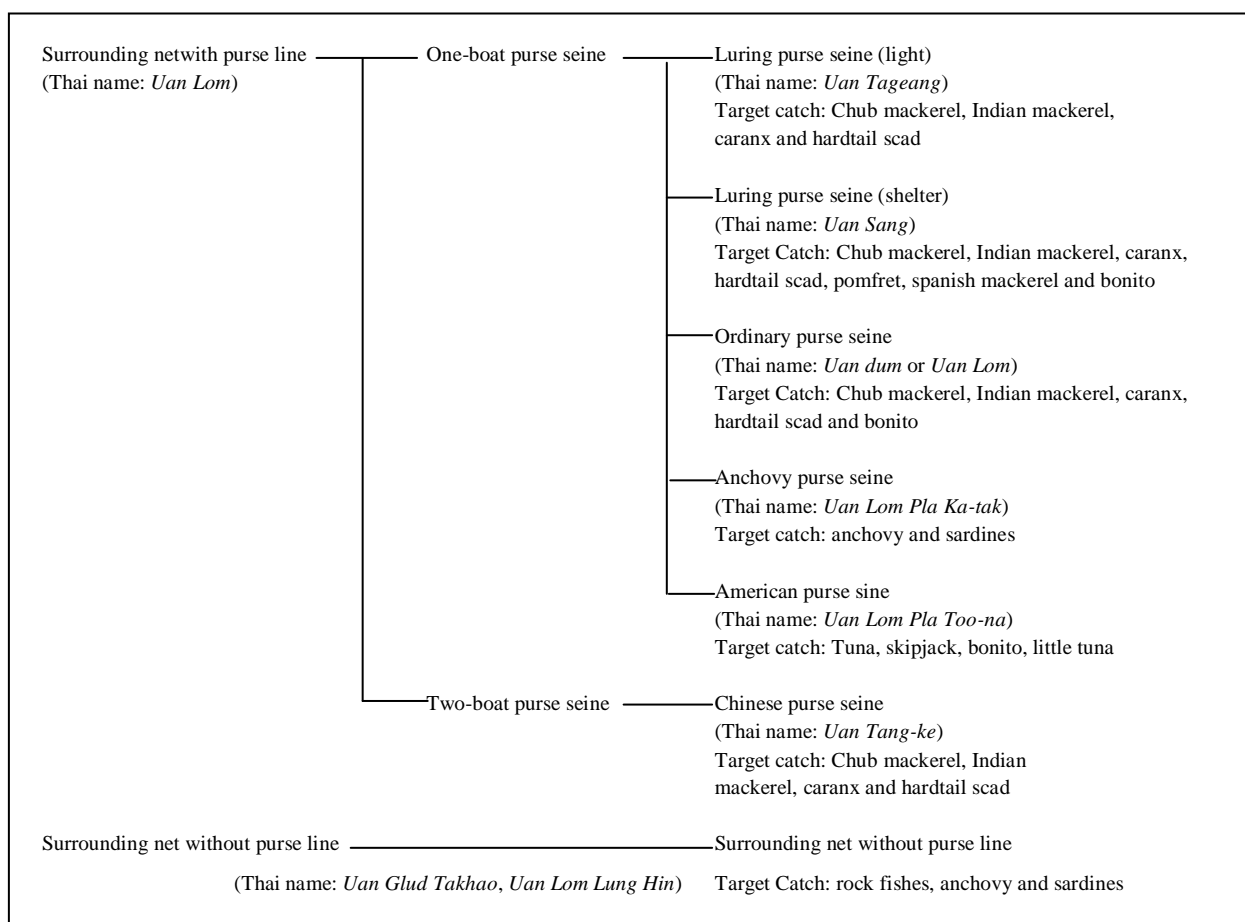


Fig. 31. Categories of Thai Surrounding nets classified by SEAFDEC/TD
Source: SEAFDEC/TD (2004)

Table 2. Comparison of the categories of surrounding nets

FAO Category	SEAFDEC Category		DOF/Thailand Category
Surrounding net with purse line (Purse seine, Ring net)	One-boat purse seine	Anchovy purse seine <i>Uan Lom Pla Ka-tak</i>	Mesh size smaller than 10.0 mm
		Luring light purse seine <i>Uan Tageang</i>	Mesh size between 10-24.9 mm
		Fish shelter purse seine <i>Uan Sang</i>	Mesh size between 25.0-29.9 mm
		Ordinary purse seine <i>Uan dum</i> or <i>Uan Lom</i>	Mesh size between 30.0-45.0 mm
		American purse seine <i>Uan Lom Pla Too-na</i>	Mesh size bigger than 45.0 mm
	Two-boat purse seine	Chinese purse seine (Mesh size between 25.0 mm) <i>Uan Tang-ke</i>	
Surrounding net without purse line (Lampara net)	Surrounding net without purse line (One-boat) <i>Uan Glud Takha</i> or <i>Uan Lom Lung Hin</i>		Mesh size smaller than 10.0 mm <i>Uan Glud Takhao</i>
			Mesh size bigger than 10.0 mm <i>Uan Lom Lung Hin</i>

Table 3. Comparison of the types of surrounding nets with and without purse line

Types of Surrounding nets	Without purse line		With purse line					
	Anchovy	Rock fishes	Chinese purse seine	Anchovy	Mackerel, Caranx, sardines	Mackerel, Caranx, sardines	Mackerel, Caranx, sardines	
Luring technique	Searching		Luring light	Searching	Luring light	FADs	All technique	
Length of fishing boats	14 m	10 m	18 and 8 (2) m	17.5 m	15 m	20 m	28 m	
Main engine (HP)	180	10	230	150	150	240	520	
Net Structure	Bunt at net center (15×30 m)	Bunt at net center	Bunt at net center	Bunt at net center	Bunt at net center	Bunt at net center	Bunt at wing part	
Length of net float line	300 m	240 m	360 m	400 m	420 m	665 m	1197 m	
Length of sinker line	290 m	240 m	420 m	384 m	480 m	713 m	1283 m	
Approx. depth of net	15 m							
Shrinkage of Float line	0.85	0.65	0.80	0.83	0.70	0.70	0.70	
Shrinkage of Sinker line	0.83	0.65	0.93	0.80	0.80	0.75	0.75	
Mesh size	Bunt (mm)	6 × 6 mm	25 mm	25 mm	5.5×5.5 mm	25 mm	25 mm	25 mm
	Net body	7 × 7 mm	25 mm	25 mm	7.4×7.4 mm	25 mm	25 mm	25 mm
	Selvage	45 mm	25 mm	25 mm	45 mm	31, 62.5 mm	25, 57 mm	40 mm
Material	Bunt	PA 210/6,8	PE 380d/12	PA 210d/12	PA 210d/6,8	PE 380d/15	PE 380d/18	PA 210d/30
	Net body	PA 210/4, 6	PA 210d//6	PA 210d/9	PA 210/4, 6	PA 210d/3, 6, 12	PA 210d/9, 12	
	Selvage	PE 250/12	PE 380d/9,12	PE 380d/15	PE 250d/12	PE 380d/15	PE 380d/18	PE 400d/18
Total float in number	185+925	370	360	1620	1315+264	1918+256	3990	
Total float in buoyancy	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Total sinker in number	580	241	420	81	190+53	188+96	334	
Total sinker in weight	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

N/A: Not available

Table 4. Techniques adopted in fishing with surrounding nets (with purse line) with the corresponding main target species

Type of Surrounding net	With purse line						
	Mackerel, Carang, sardine s	Bonito, little tuna, hardtail scad	Bonito, little tuna, pomfret	Bonit, little tuna, hardtail scad	Bonit, little tuna, hardtail scad	Skipjack, tuna	
Luring technique	Searching	All technique	FADs	All technique	Searching	FADs	
Length of fishing boat	19.5 m	30 m	15 m	28 m	32 m	65 m	
Main engine (HP)	185	350	240	460	400	2800	
Net Structure	Bunt is at net center, size	Bunt is at net center, size	Bunt is at net center, size	Bunt is at net center, size	Bunt is at net center, size	Bunt at the wing part	
Length of net Float line	592 m	1009 m	810 m	1610 m	1729 m	1266 m	
Length of Sinker line	625 m	1116 m	810 m	1728 m	1853 m	1440 m	
Approx. depth of net							
Shrinkage of Float line	0.60	0.70	0.90	0.70	0.70	0.74	
Shrinkage of Sinker line	0.64	0.75	0.90	0.75	0.75	0.84	
Mesh size	Bunt	25 mm	43.8 mm	50 mm	50 mm	50 mm	90 mm
	Net body	44 mm	43.8 mm	50 mm	50, 98 mm	50, 98 mm	60, 90, 105, 210 mm
	Selvage	40 mm	50 mm	25, 50 mm	57 mm	57 mm	150 mm
Material	Bunt	PA 210d/ 15	PE 380d/ 18	PA 210d/ 9	PA 210d/ 36	PA 210d/ 36	PA 210d / 180, 224
	Net body	PA 210d/ 9, 12	PA 210d/12, 18, 24	PA 210d/ 6	PA 210d/18, 21 PA210d/ 18 + SN	PA 210d/18, 21 PA210d/ 18 + SN	PA 210d/ 40, 60, 90, 120 T 250d/ 210
	Selvage	PE 380d/ 15	PE 380d/ 21	PE 380d/ 12	PE 380d/ 18	PE 380d/ 18	PE UC 320ply
Total float in number	1920+250	2754+697	1620	2648+674	5160+590+960	N/A	
Total float in buoyancy	N/A	N/A	N/A	N/A	N/A	N/A	
Total sinker in number	160+91	160+320+240	81	1204+344	396+134	N/A	
Total sinker in weight	N/A	N/A	N/A	N/A	N/A	N/A	

4. Principles of Thai Purse Seine Fishing Operations

4.1 Surrounding nets without a purse line

Surrounding net without purse line is always operated near shore in the daytime, in the early morning and evening, where the water depth is 2-10 m. The mesh size of the net is less than 10 mm, and the targeted fish school is located by simple visual search. Setting and hauling is operated at starboard side of the boat. During hauling operation, an anchor must be dropped into the sea bottom to fix position of the boat and prevent it from drifting into the net circle, and 1-2 fishermen dive underwater and clip the bottom part of the net using the C-shape steel hook, starting from the net part near fishing boat (Fig. 10). Each C-shape steel hook is set at 2-3 m interval. The crew then hauls the purse seine net at the starboard until reaching the bunt part at the center of the net.

4.2 Surrounding nets with a purse line (mesh size less than 10 mm)

The fishing methods for the purse seine with mesh size less than 10 mm, targeting mainly the anchovies are classified into two (2) main operations, *i.e.* without using luring light and with luring light.

4.2.1 Fishing operation without luring light

Fishing operation using surrounding net without luring light, is always conducted in the early morning or evening. The fish schools are located by ocular sighting or by using the fish finder. The fishing net is released while the fishing master finds the school of fish. The purse line is hauled to close the bottom part of the net. In Rayong Province (Fig. 14), the fishing vessels are normally less than 14 m in length having special wooden pole fixed with 2 iron purse rings, which is 15 cm in diameter at the tip of the pole. The tip of pole with 2 purse rings are put underwater at depth of 7-8 m and passing the purse line through the 2 rings. This is meant to reduce the gap at the foredeck prevent the fish from escaping. Some larger purse seiners, however, usually drop 1-2 pieces of sinkers weighing about 50 kg for closing the net opening/gap at the foredeck. After hauling the purse line, net body is hauled by manually or with the use of a net hauler at both sides, *i.e.* starboard and port side of the fishing boat (Fig. 17 and Fig. 18). One to five fishing operations can be done within a day.

4.2.2 Fishing operation with luring light

For surrounding net with luring light (Fig. 19 and Fig. 20), the fishing operation is always operated at nighttime, usually starting in the evening by searching for fish schools. Nowadays, three luring boats are anchored to light the location where some fish schools are detected or sometimes the luring lights are set near the FADs. Luring light period would last for at least 2 hours. Recently, underwater lamps are used during the purse seine operation,

which is meant not only for attracting fish schools but also for preventing the fish schools from escaping from the net circle.

The fishing operation could be started while the quantity of fish in the school is adequate for surrounding. The anchor of the light boat is hauled up and shooting operation is started by surrounding the light boat. While the purse line is hauled, the light boat leaves the net circle by pushing the float underwater and passing across the float line. The remaining process is the same as the operation in daytime.

4.3 Thai Purse seine

Surrounding operations of purse seine with a purse line with mesh size greater than 25 mm, can be classified with three (3) main methods, *i.e.* surrounding the free schooling fishes, surrounding with the use of luring light, and surrounding by means of FADs.

4.3.1 Surrounding free fish schooling

Fish schools are located by visual searching or using the fish finder. The fishing net is released while the fishing master finds the fish schools. The purse line is hauled to close the bottom part. The net is hauled manually or using a net hauler on both sides of the vessel. In case of *Uan tang-ke* (two-boat purse seine), the fishing operation is conducted from a single boat (**Fig. 24** and **Fig. 25**). The net is hauled by hand on both sides of the boat, while the purse line is pulled by a capstan winch driven by the main engine of the vessel.

Masthawe (1986) described the operation of ordinary Thai purse seine with traditional searching technique for the fish schools which could be conducted at daytime and nighttime. When the purse seiner arrive the fishing ground, two (2) main fish school detection methods could be adopted, *i.e.* 1) visual or 2) using hydro-acoustic equipment. In case of the visual detection method, fishing operation could be started while fish schools had already been located (Fig. 18). On the other hand, the searching process using hydro-acoustic method is little bit different (Fig. 28). The fishing vessel must be controlled with limited speed during the hydro-acoustic sighting based on the data from the sonar dome installed below the hull of the vessel. If the master fisherman could locate the fish school, a marked buoy or light raft is set at the location of the targeted school and the circle net is dropped as the remaining part of the fishing operation of a Thai purse seine as shown above is conducted.

After detecting a large fish school either visually or through the hydro-acoustic equipment, the master fisherman must check the other environmental conditions, *e.g.* wind speed and direction, current speed and direction, swimming speed and direction of the fish school, sea depth as well as the characteristics of the sea bottom. The arrangement of the crew for the fishing operation could be separated into four (4) main duties, *i.e.* 1) one crew for shooting the purse line, 2) one or two crew members for shooting the wing part of the net, 3) one crew for shooting the float line, and 4) one crew for shooting the marked buoy or light raft if operation is done at nighttime.

The shooting position should be with the wind direction, at a distance of roughly 30 to 60 m from the fish school since the fish school usually swims against the wind direction. The shooting speed should be the same as the full engine speed after which the speed can be reduced when $\frac{3}{4}$ of net length has been released. When the fishing boat arrive the marked buoy or light raft, the clutch is released and the marked buoy or light raft connected with the wing net is retrieved onboard. Both ends of the purse line are then passed through the snatch block at the foredeck main-mast. Purse line hauling could be done by using the capstan winches on the starboard and port side. During the purse line hauling, few crew members may swim near net gap at the foredeck in order to frighten the fish and prevent them from escaping the net circle. After the purse line hauling, all purse rings are attached at the foredeck and the purse line is pulled out of the purse rings then all crew could start hauling the net at both sides of the vessel.

The bunt part of the net is hauled at the starboard side then the fishes are scooped. Finally, the whole bunt part is lifted up onboard and all the remaining fish are transferred from the bunt to the fish holds. Then, the purse seine net is rearranged for the next fishing operation. The time spent for each operation depends on the number of crew, efficiency of the crew, sea and weather conditions as well as the amount of fish. Nevertheless, the hauling time usually takes 1-1:20 hours for a 600 m net with 16 crew members and the quantity of fish is about 1.0 to 1.5 metric tons.

4.3.2 Luring light operation

The fishing operation is started while the quantity of fish in a school is adequate for surrounding. The anchor of the light boat or light raft is hauled up and shooting operation is started by surrounding the light boat. While the purse line is already hauled, the light boat leaves from the net circle by pushing the float down the water and the light boat passes across the float line. The light raft is restored at the stern deck. The remaining process is same as the operation during the daytime.

Masthawe (1986) also described the operation of ordinary Thai purse seine (*Uan dum*) with luring light lamps, where one to thirteen light rafts connected with an anchor was deployed into the sea (Fig. 20). Some purse seiner fleet could consist of few luring light boats operating in the fishing ground. The operation must wait until adequate fish schools gather around the luring light boat or raft. If the weather and sea conditions are not favorable enough for the fish to gather, the crew retrieves the light rafts onboard then the lights are turned off with only the rafts remain in the sea. A small row-boat is deployed into the sea and the small anchor at the remaining light raft is heaved up. Then the row-boat tows the raft away from the net boat against the wind direction. After the surrounding operation, the row-boat with the light raft must be maintained far away from the net gap at the foredeck of the net boat. The lights of the mother boat must be turned off in order to prevent the fish school from escaping from the net gap. After the purse line hauling, the light at the raft is turned off and both row-

boat and raft are removed from the net circle. Then net hauling operation is performed in the same manner as that described in the 4.3.1.

Nowadays, 20-30 set of mercury lamps 500 w, 1000 w and 1500 w are installed onboard a purse seiner and 10-20 lamps are installed at the light boat. During the luring light operation, the net boat and light boat are tied together in the expected area of the target fishes. The light boat and net boat are used at the start of the luring light operation which is usually before twilight or in the early evening. When the fish school is observed to be in adequate quantity and the environmental condition is suitable, the light boat is released from the net boat and the lamps on the net boat are turned off one by one while the crew prepares for the operation. The fishing operation starts by surrounding the light boat and hauling the purse line after which the light boat crosses outside the circle net by pressing the float line beneath the hull of the light boat. Some purse seiners deploy the light raft with row-boat instead of a light boat. Hence, the lights in the raft must be turned on to aggregate the fish from the net boat. Then the fishing operation continues as in the aforementioned.

4.3.3 Fish Aggregating Devices (FADs or *Sung*) operation

Thai fishermen prepare the anchored FAD using bamboo poles, wire and coconut leaves, which together is fastened to a concrete block (Fig. 22). The purse seine operation by surrounding FAD (coconut leaf shelter) as described by Masthawe (1986) is classified into two (2) main operations, *i.e.* daytime fishing operation and nighttime fishing operation (Fig. 21 and Fig. 22).

4.3.3 (1) Daytime fishing operation with FADs

This operation is conducted during the daytime usually after sunrise and before sunset. Before the fishing operation, fish schools are located by hydro-acoustic equipment or by ocular checking method. If there is inadequate fish school beneath the FADs, the first FAD is pulled slowly by the net boat towards the second FAD. The fish school under the shelter usually follows the first FAD. While approaching the second shelter, the net boat accelerates its engine to full speed, pulling the first FAD passing the second FAD and resetting in another location. The fish school from the first FAD usually moves to gather at the second FAD. If the quantity of fish school is still inadequate, the fish school from the second FAD is aggregated with the fish school under the third FAD by same method. The operation starts by deploying a row-boat with a portable FAD. The row-boat slowly moves against the current direction, while the FAD is slowly pulled by the net boat passing the row-boat with the portable FAD. While the net boat is pulling FAD and reaching the row-boat with portable FAD, the net boat accelerates its engine to full speed, pulling the FAD while passing the portable FAD and resetting in the other location. The fish school from the FAD is gathered under the portable FAD. Then, purse seiner starts its shooting operation by surrounding the row-boat and the portable FAD.

During the purse line hauling, the row-boat and portable FAD will be maintained at the center of the net circle, far away from the net gap and foredeck of the purse seiner until the purse ring is hauled up on the purse seiner. The portable shelter will be pulled up and stored in the row-boat. The row-boat moves out of the net circle during the net hauling operation. The remaining fishing operation is the same as in the aforementioned procedure.

4.3.3 (2) Nighttime fishing operation with FADs

Conducted during the nighttime from sunset to sunrise, this technique is more effective because the fishes are less frightened at night than at the daytime. In order to gather big fish school, the FADs may be grouped by same method as in the daytime operation. A light raft is attached at the FAD where sometimes more than one raft is set at different FADs indicating that the operation for that night could be equal to the number of light rafts attached with FADs. Before the fishing operation starts, the row-boat and portable FAD is deployed into the sea and set against the current direction, 15-25 m far from the anchored FAD. The light raft is moved from the FAD to the row-boat with portable FAD.

The purse seiner pulls the FAD with fish school passing the row-boat with light raft and portable FAD. While the net boat is pulling the FAD and upon reaching the row-boat with portable FAD, the net boat accelerates its engine to full speed while pulling the FAD, passing the portable FAD and resetting in another location. The fish school from FAD is gathered under the light raft and portable FAD. Then, the purse seiner starts the net shooting operation by surrounding the row-boat and portable FAD. The fishing operation is the same as already described in the aforementioned procedure. After the hauling and the catches are transferred to fish hold, the operations are continued to the other light rafts with FADs as done before.

Most purse seine operations in Thailand make use of the combination of two of the three luring methods, *i.e.* using fish shelters and fish luring lights. The fishermen aggregate the fish school by tying the light raft with the anchored FAD. While the fish school is observed to be of adequate quantity for the fishing operation, a small boat takes the light raft away from the anchored FAD. Fishing operation is conducted by surrounding the small boat and the light raft.

For *Uan dam* and *Uan lom sung*, fishing operation is conducted from a single boat. The net is hauled by hand on both sides of the boat, while the purse line is pulled by a capstan winch which is driven by the boat's main engine. Nowadays, a net hauler is installed at the port side to save on manpower.

4.4 Two-boat purse seine or *Uan Tang-ke*

Fishing operation of *Uan Tang-ke* is conducted by using two row-boats each boat carries half the piece of the purse seine net. The fishing operation starts by searching the

fish school both visually and using hydro-acoustic method. Searching is carried out on the mother boat and when the fish school is located, the 2 row-boats are released into the sea (**Fig. 25**). Both row-boats will row and shoot the net around the fish school. Then the purse line is hauled up on the 2 row-boats manually or by the capstan winches until the bottom part is closed. The wing parts are hauled up manually on the row-boat until reaching the bunt part. Then the mother boat is maneuvered to attach the float line of bunt for transferring the catch to the fish holds. Finally, the purse seine net will be arranged for the next fishing operation. The number of crew on both boats could be 18-30 persons, depending on the size of the 2 row-boats and the net. Considering that the fishery resources had already been depleted, the Chinese purse seine applying the luring light technique is also used to aggregate the fish school. The light raft and light boat are used only to control the light during the nighttime operation.

5. Thai Purse Seiner

Masthawe (1986) described the Thai purse seiners as made of wood, size between 10 to 120 gross tonnage and length overall (LOA) is between 12 to 24 m. The purse seiner is usually installed with motor engine, some of which could be used marine engine while some could be modified truck engine between 22 to 500 HP (**Fig. 16**). An electric generator and electric pump are generally installed in the engine control room.

The wheelhouse is located at the stern occupying slightly less than half of vessel's width. The top of wheelhouse is installed with main crew's nest where the fishing master stays while searching for the fish school. The fish finder, sonar and echo-sounder including a radar and radio transceiver are installed in the crew's nest (**Fig. 32**). The foredeck main mast is installed near the bow, the height of which is between 1.3 to 5.0 m depending on the length of the purse seiner. There are 2 snatch blocks installed at both sides of the vessel's foredeck for passing the purse line to the capstan winches at the front of wheelhouse, and the other 2 blocks hung on the main foredeck main mast, for facilitate hanging of the purse rings after completing the purse line hauling operation. In front of wheelhouse, 2-4 capstan winches are installed, to be used in hauling the purse line, anchor line and scoop line as well as for transferring the catch from the bunt into the fish holds. Catches are stored in 3-10 fish holds, installed under the working deck.

A bamboo or Polyethylene or stainless pole, diameter 4-5 inches, is fixed from foredeck main mast to the wheelhouse to be used in rearranging the net after each fishing operation. There are 2 utility booms fixed at the starboard and port side. Starboard boom is used for pick up the float line of the bunt part above the sea surface to prevent the fishes from escaping from the bunt. A utility gondola is also stored at the stern deck which is heaved up onboard using the winch at the foredeck.



Fig. 32. Thai anchovy purse seiner
Photo by A. Munprasit (2009)

6. Design of Fish Aggregating Devices (FADs) for Purse Seining in Thailand

Fish Aggregating Devices (FADs) have been used by Thai fishers to aggregate fish schools for a long time. As of 1969, there are few designs of FADs based on the target species and fishing gear, the most common of which are the bush pile for encircling net and fish shelter for purse seine and lift net.

6.1 Bush pile for encircling net

Called *Grum* in Thai language, the bush net is used in sea depths of less than 8 m based on the target species. It is made of wooden poles or tree branches stuck into the sea bottom. The fishing gear operating with bush pile encircles the net or the bamboo screen block trap.

6.2 Fish shelter for purse seine and lift net

Also known as *Sung* in Thai language and *Uyuam* in Malay language, this FAD is very famous for purse seining operation in Thailand. In the marine fisheries statistics of Thailand, marine production by purse seine with FAD had been recorded in 1974 as almost equal to the data from purse seine by free fish schooling (See Appendix 2). FADs in Thailand come in various designs for small-scale and large-scale fisheries purposes. FADs for purse seine fishing operations are being used in the Gulf of Thailand as well as in the Andaman Sea (Fig. 33).



Fig. 33. Local FAD in a fishing ground of the Andaman Sea
<http://www.chinglewtackle.com/index.php>

Masthawe (1986) and the result of a fishing survey by SEAFDEC fishing gear technologists in 2003 described the materials and construction of the Thai FADs for purse seining in the central part of the Gulf of Thailand, which are usually set in depths ranging from 20 to 50 m. The FAD is composed of bamboo pole, anchor line, weight and coconut leaves, the details of which are described below:

- 1) One to three bamboo poles, 10-15 m in length are tied together by iron wire. A hole is drilled at the base of the bamboo pole for passing the iron wire or a piece of 40 mm diameter polypropylene rope. The iron wire or rope is spiked into a big ring to serve as joint with the anchor line.
- 2) Coconut leaves are individually tied with the anchor line. The number of coconut leaves would depend on the sea depth, but usually 7 to 20 fronds are set with a FAD at intervals of 1-3 m.
- 3) Iron wire No.12 or No.13, diameter 3-4 mm, 3-5 pieces are twisted together or polyethylene rope diameter 10-12 mm, or iron wire 5-6 mm diameter, is used as anchor line. The length of the anchor rope is shorter than sea depth by about 3-5 m.
- 4) Stone or sand bag weighing 40-50 kg serves as sinker in shallow water area. In the deeper areas, the sinker used for fixing FAD should weigh 70-130 kg. Nowadays, some concrete weight is used replacing the stone because big stones suitable for a sinker of the FAD are rarely found.

Construction of a FAD is carried out onboard during the trip to the fishing ground and setting is done one by one in the fishing ground. The interval of each coconut leaf-FADs should be 500-1000 m distance. Generally, purse seiners deploy 20-50 sets of FADs for their fishing operations. The fish schools usually concentrate around the FADs after 1-2 weeks from setting, although in some areas where fish is abundant, aggregation in the FADs could be observed after 3-5 days. The life expectancy for this model of FAD is 2-3 months.

Other FADs design was found in the eastern part of the Gulf of Thailand in Rayong Province. The details of the FAD constructed by small-scale fisherman for squid jigging, set at the depths of around 20-25 m are described below and shown in **Fig. 34**.

- 1) One bamboo pole, 5-7 m in length is tied together with a piece of Styrofoam with buoyancy of about around 2 kg. Coconut leaves are individually tied with the anchor line. The number of coconut leaves is depends on the sea depth but usually 5 to 7 fronds are set with a FAD at intervals of 1-2 m.
- 2) Polyethylene or Polypropylene rope diameter 5-7 mm is used as anchor line. The length of the anchor rope is shorter than sea depth about 1-2 m. A stone or sand bag weight or concrete weight, 15-20 kg serves as sinker.

FADs in Rayong Province are usually deployed in groups. Each group of FADs is composed of 5-7 individual FADs. The design of the FADs in the Andaman Sea, specifically in Phan-gna Province, is almost same as the FADs design in the Gulf of Thailand. On the other hand, for purse seine fishing at the deeper depths in the Gulf of Thailand at around 50-60 m, the design of the FADs is detailed below:

- 1) One bamboo poles, 6-8 m in length are tied together with a piece of Styrofoam with buoyancy of around 2 kg. Coconut leaves are individually tied with the anchor line. The number of coconut leaves depends on the sea depth.
- 2) Polyethylene or Polypropylene rope diameter 10 mm or iron wire 4-5 mm diameter is used as anchor line. The length of the anchor rope is shorter than sea depth by about 3-5 m. A few pieces of concrete weight made of 200-liter drum filled with concrete, is used as sinker.

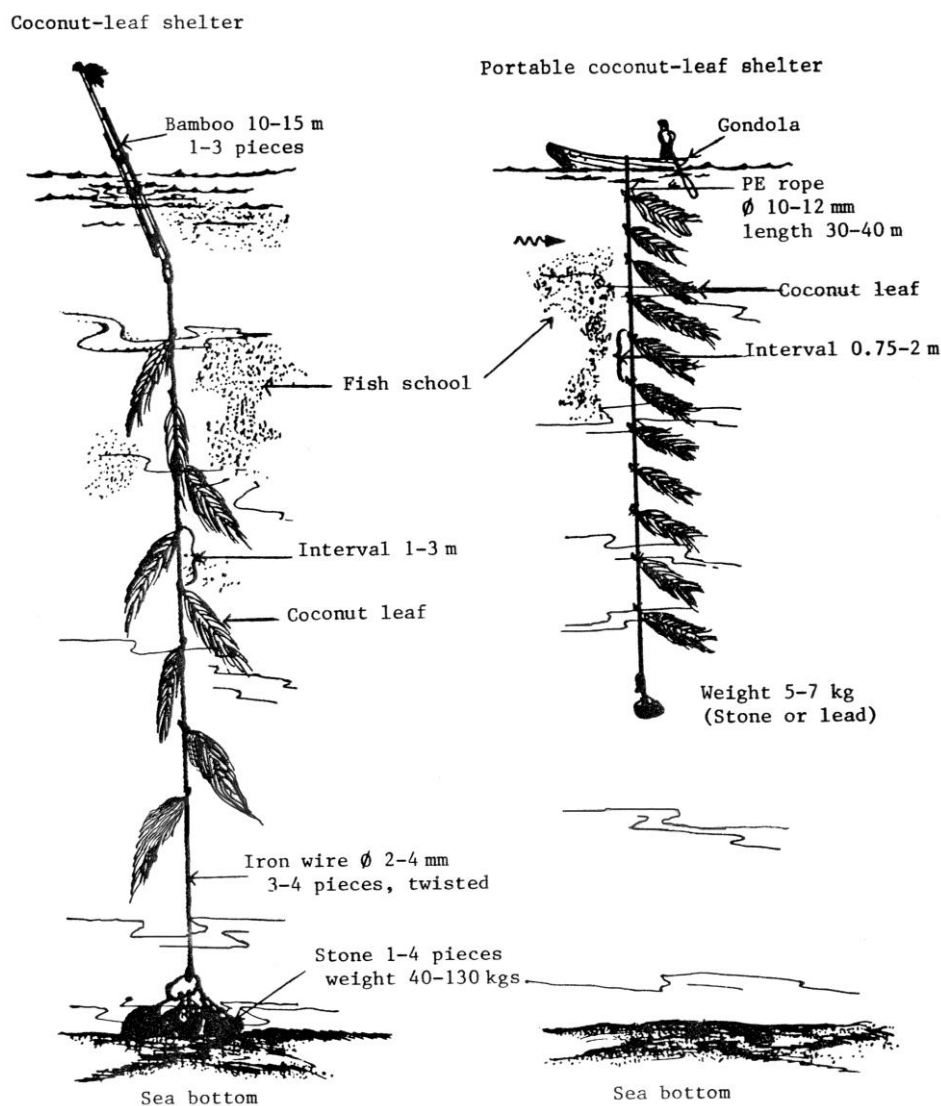


Fig. 34. Construction of FAD (*Sung*) for Thai purse seining in the central part of the Gulf of Thailand Masthawe, 1986

7. Pelagic Resources for Thai Purse Seine Fisheries

There are six (6) important pelagic resources that are targeted for purse seine fisheries in Thailand, which had been summarized by Bhatayasevi (1997) and Ratanawalee (2009).

7.1 Indo-Pacific mackerel (*Rastrelliger brachysoma/neglectus*)

Found in the Thai waters of the Gulf of Thailand and the Andaman Sea, the Indo-Pacific mackerel (Fig. 35) inhabits the coastal area in the Gulf of Thailand at depth of 50 m or less. When its length reaches 10 cm, it migrates to a spawning area particularly in the western part of Gulf of Thailand to northern part, where it seeks for food and grows where there is high productivity of phytoplankton.



Fig. 35. *Rastrelliger brachysoma*
<http://www.fishbase.org>, (2009)

Several tagging studies on the Indo-pacific mackerel revealed that there are two stocks of Indo-Pacific mackerel in the Gulf of Thailand. One is a straddling stock between the eastern part of the Gulf of Thailand and Cambodian waters, while the other is a migratory stock between the inner and the upper Gulf of Thailand (Bhatiyasevi referred to Somjaiwong and Chullasorn, 1974).

Indo-Pacific mackerel is also found in the Andaman Sea at depths ranging from 10 to 40 m, most substantially in Phang-Nga Bay to Satun Province in the border area between the Thai EEZ and Malaysian EEZ. The fishing ground is also found in Ranong Province in the border area between Thai the EEZ and Myanmar EEZ. A migratory tagging study found that the Indo-Pacific mackerel in the Andaman Sea can be categorized into three (3) groups. The first group is distributed around Ranong Province in the border area between the Thai EEZ and Myanmar EEZ, which means that this group is a shared stock between Thailand and Myanmar. The second group is distributed around Phuket Island and Krabi Province. The third group is distributed in Satun Province in the border area between the Thai EEZ and Malaysian EEZ, suggesting that this group is a shared stock between Thailand and Malaysia (Somchaiwong et al., 1984).

The annual catch of the Indo-Pacific mackerel in the Gulf of Thailand from 1971 to 1994 ranged from 26,129 to 99,638 metric tons with the minimum in 1977 and maximum in 1984. The assessment on the state of stock indicated that the maximum sustainable yield (MSY) is about 104,000 metric tons at an exerted fishing effort of about 146,600 days of a Thai purse seine (Rattanawalee referred to Tantisawetrat, 1994). This indicates that the Indo-Pacific mackerel in the Gulf of Thailand has been fully exploited since 1984.

7.2 Indian mackerel (*Rastrelliger kanagurta*)

The Indian mackerel (**Fig. 36**) is generally distributed in the Gulf of Thailand both in shallow and deep waters, with the peak of the catch in depths ranging from 30 to 50 m. The spawning grounds are in two areas based on the spawning season. From July to August, the spawning ground is around Prachau Kirikharn Bay, and during January to March, the spawning ground is around Surat Thaini Bay.



Fig. 36. *Rastrelliger kanagurta*
<http://www.fishbase.org>, (2009)

The Indian mackerel in the Andaman Sea is distributed along the coasts from Ranong Province to Phan-Nga Province, Phuket and adjacent areas off Trang Province and limited area in the northern of Taru-tao Island. The fisheries for Indian mackerel had been remarkably observed since 1973 due to the development and expansion of the luring purse seine fisheries to the offshore areas. Since then, production increased from 12,690 metric tons in 1973 and peaked to 50,574 metric tons in 1983. After this period, the catch had been reported to have somewhat fluctuated showing slightly decreasing tendencies.

Rattanawalee (2009) referred to Tantisawetrat (1996) estimated that the maximum sustainable yield for the Indian mackerel in 1984-1993 in the west coast of the Gulf of Thailand (areas II, III and VI) applying the virtual population analysis and surplus production model was 32,866 metric tons and 32,533 metric tons, respectively. The analysis indicated that an optimum fishing effort should be 112,500 days fishing using luring purse seine. This indicated that no definite sign of overfishing has been observed yet. In this regard, it has been suggested that the mesh size of the luring purse seine should be enlarged to 3 cm instead of 2.5 cm used at the present because records have shown that small size fish had been caught in substantial quantities, then more yield of about 20% could be obtained.

7.3 Sardines (*Sardinella spp.*)

Six (6) species of sardines have been found to be dominantly distributed in the Gulf of Thailand (Fig. 37 and Fig. 38). However, three (3) most common species, i.e. *Sardinella gibbosa*, *S. frimbriata* and *S. albella* share 95% of the country's total catch of sardines. Small sardines inhabit the waters from the shoreline to 20 m depth, while big size are found in the deeper waters from 20 to 50 m. The fishing grounds for sardines in the Gulf of Thailand are separated into various areas. The fishing ground in the Upper Gulf of Thailand is in Samutprakarn and Petchaburi waters.

For the Western Gulf of Thailand, the fishing grounds are in Prachaub Kiri Kharn, Chumphon and Surat-Thani waters, while for the Southern Gulf of Thailand, the fishing ground is from Nakhon-Sri-Thammarat to Pattani waters. The fishing ground of sardines in the Central of Gulf of Thailand is off Chumphon where the depth greater than 45 m. The Fishing ground of sardines in the Andaman Sea is distributed along coastline of Ranong Province where the fishing ground is scattered, while the fishing ground in the southern part of Phuket in Phan-Nga Bay is spread area to Krabi, Trang and Satun Provinces.

Sardines are exploited in substantial amount after 1973 similar to the Indian mackerel. Its production had increased year after year and hit the peak of 203,364 metric tons in 1977. The production showed a decreasing trend to 68,447 metric tons in 1985 and henceforth, it increased again to about 110,000-140,000 metric tons per annum.

From 1983, the number of purse seines showed an increasing trend but the production of sardines did not subsequently increase. It is estimated that the maximum sustainable yield of the sardine stock in the Gulf of Thailand should be around 104,000 metric tons with an optimum fishing effort of about 190,000 days of luring purse seine. It is obvious that fishing effort expended to sardine fisheries was beyond the optimum level since 1988. Therefore, sign of overfishing is obvious and it is recommended that the fishing effort should be reduced by about 14% in order to save the depleted sardines stock.

7.4 Round scads (*Decapterus* spp.)

The species of round scads (**Fig. 39**) that share 96.6% of the total production of scads is the long-finned round scad (*Decapterus maruadsi*), while the short-finned round scad (*Decapterus macrosoma*) share 3.4%. The distribution of the round scads is generally in water depths of 20 to 70 m. The fishing ground in the Gulf of Thailand is around the central part of the Gulf of Thailand, particularly off the coast of Rayong and Trat Provinces. The



Fig. 37. *Sardinella gibbosa*
<http://www.fishbase.org>, (2009)

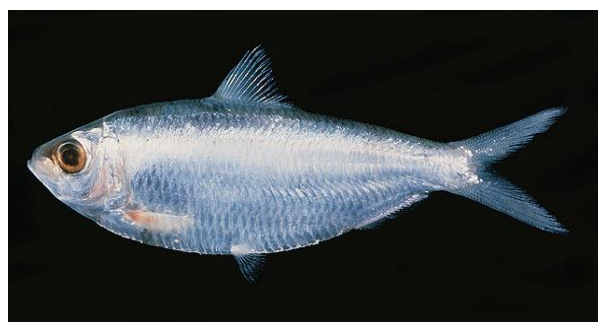


Fig. 38. *Sardinella frimbriata* (top) and
Sardinella albella (bottom)
<http://www.fishbase.org>, (2009)

fishing season is between October to February, while the spawning season in the Gulf of Thailand is throughout the year but peaks in February to March and July to August.

Three species of round scads are found in the Andaman Sea, i.e. long-finned round scad (*Decapterus maruadsi*), short-finned round scad (*Decapterus macrosoma*), and the other one is the big round scad (*D. macarellus*). All species of round scads are found scattered along the coast of the Andaman Sea from Ranong to Satun Provinces. Spawning season of round scads in the Andaman Sea is during northeast monsoon season (December to May).

It is well known that the remarkable development of purse seine fisheries in Thailand arose from the discovery of new fishing grounds in the middle of the Gulf of Thailand since year 1973, particularly for the round scads which are mainly caught by luring purse seine using the bunches of coconut fronds or FAD as lure operated at daytime in the water depth of 30-50 m.

This resulted in the abrupt increase in the catch from 660 metric tons in 1972 to be 12,690 metric tons in the next year and increasing steadily to its maximum catch of 129,800 metric tons in 1977, and after which it decreased year after year to only about 20,000 to 40,000 metric tons/year during the past 15 years. There is no doubt that the round scads that had been heavily exploited in such short period of time, and had already been depleted since 1977 up to the present.



Fig. 39. *Decapterus maruadsi* (top) and *Decapteru macarellus* (bottom)
<http://www.fishbase.org>, (2009)

7.5 Anchovies (*Stolephorus* spp.)

There are 10 species of anchovies (Fig. 40) found in the Gulf of Thailand and the Andaman Sea, and *Encrasicholina heteroloba* (*Steleophorus heterolobus*) is the most common accounting for 86.6% of the total anchovy production from the Gulf of Thailand and 78.9% from the Andaman Sea. The distribution along the eastern of the Gulf of Thailand is



Fig. 40. *Encrasicholina heteroloba*
<http://www.fishbase.org>, (2009)

from the coast of Cambodia to the coastal areas of Chonburi Province. Anchovies have also been found to be abundant around Chang and Kood Islands.

The distribution along the coast of the western part of Gulf of Thailand is from Prachaub Kirikharn, Chumpon, Surat Thani, around Tao, Pha-Nhga and Samui Islands. The fishing ground is also found along the southern part of the Gulf of Thailand from Nakhorn-Sri-Thummarat to the Malaysian waters. Anchovy fishery is heavily found in Phuket and Satun Provinces.

The catch of anchovies have been remarkably increased after 1981 due to the development of fishing techniques using light to attract fish schools at night time and the efforts of fisheries to move further offshore. This resulted in the increase of catch from the level of 10,000-20,000 tons to 103,101 metric tons in 1985 and the catch has been maintained at the level of 110,000-120,000 metric tons during the past 5 years. It has been estimated that the maximum sustainable yield of anchovies in the Gulf could be around 104,000 metric tons. This means that the anchovy resources had been heavily exploited since 1985, thus attempts to increase the fishing effort should be carefully considered.

7.6 Neritic tunas (*Thunnus tonggol*, *Euthynnus affinis* and *Auxis thazard*)

The small or neritic tunas (**Fig. 41**) found in the Gulf of Thailand are of three (3) dominant species, *i.e.* longtail tuna (*Thunnus tonggol*), kawa kawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*). Fishing grounds in the Gulf of Thailand are spread out in the coastal areas from the eastern part of the Gulf of Thailand, Trad Province along the coast to the western part of Gulf of Thailand, Surat Thani Province and around Ko Pha-Nhga and Ko Samui Island. Other offshore fishing grounds are in the deep waters in central part of the Gulf of Thailand, *i.e.* off Chumphon Province coast to Nakhon Sri Thammarat Province. Fishing season in the Gulf of Thailand is affected by the monsoon season, thus the fishing season in western Gulf of Thailand is from October to April (northeast monsoon season) and in Eastern Gulf of Thailand is from April to September (southwest monsoon season). The fishing season along the Thai-Malaysian waters is during the northeast monsoon from March to December (Bhatiyasevi, 1998 referred to Spongpan and Saikliang, 1987). Fishing ground in the Andaman Sea is scattered along the coastal areas. Kawa kawa and frigate tuna are distributed in Surin and Similan Islands, Trang Province but rarely in Satun Province. Longtail tuna is less dense compared with the other small tunas.

The neritic tuna resources in the Gulf of Thailand prior to the 1980s were relatively low with production of 3,298-19,929 metric tons, but the fishery was rapidly developed after 1982 due to strong demand from the country's tuna canning industries. Since 1982, neritic tuna fisheries had also been dramatically expanded due to the improvement in fishing gear and fishing methods using the purse seine. Furthermore, new fishing boats of bigger sizes had been installed with built in freezers to preserve the catch in the high seas where a longer period of time is needed for one trip. Thus, the catch has increased from 39,368 metric tons in 1982 to 157,163 metric tons in 1992, which was also partly due to the promotion of tuna

fisheries outside the Thai waters through joint ventures or fishing agreements with neighboring countries, and also the exploration for new fishing grounds. The maximum sustainable yield for neritic tunas which had been estimated by observing the yield curve established from the relationship between the total catch and fishing effort, was 86,000 metric tons (Rattanawalee, 2009 referred to Chuenpun, 1996).

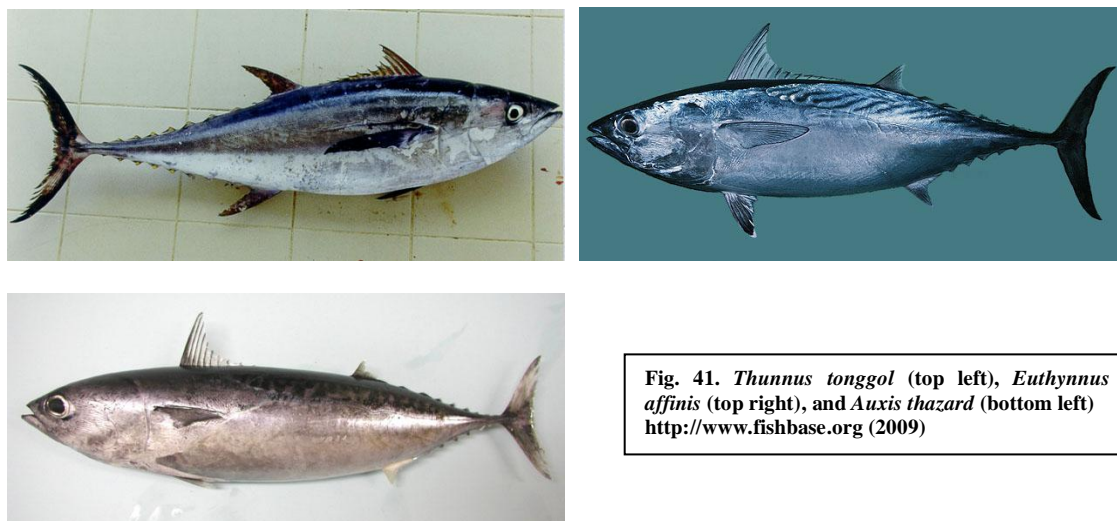


Fig. 41. *Thunnus tonggol* (top left), *Euthynnus affinis* (top right), and *Auxis thazard* (bottom left) <http://www.fishbase.org> (2009)

In order to mitigate the aforementioned depletion of the country's pelagic resources, the DOF/Thailand had issued various diversified fisheries regulations for implementation in the Thai Waters. Rattanawalee (2009) summarized the current management regimes with regards to purse seine fisheries, as shown in **Table 5**.

Table 5. The marine fisheries management measures in Thailand.

Period of prohibition	Management measures	Types of gear
Whole year	Distance of 3,000 m in some areas of Prachuab Khiri Khan and Chumphon Provinces affected by Typhoon "Gay"	Trawls, Push net, Purse seine, Shortnecked clam dredge, the fishing gear with light luring
Whole year	Some areas in Trat Province (within 15 km from shore)	Purse seine with light luring
Whole year	All areas in the Gulf of Thailand and the Andaman Sea	Purse seine mesh less than 2.5 cm (used in night time operation)
Whole year	Sea turtles and turtle's eggs Sea Dugong Sea Corals Dolphins No fishing in the preservation area Certain areas in Phuket Province Certain areas in Chumphon Province Certain areas in Trat Province Certain areas in Phang-nga Province	All gears

Table 5. (Cont.) The marine fisheries management measures in Thailand.

Period of prohibition	Management measures	Types of gear
Whole year	Distance of 3,000 m from shoreline in certain areas in Prachuab Khiri Khan to Chumphon Province used for the pilot CBFM project	Trawl, Push net, Purse seine, Clam dredge and Light luring nets
3 months (15 Feb-15 May)	Protection of fish spawners and larvae in certain areas in Prachuab Khiri Khan, Chumphon and Surat Thani Provinces	Pair trawl, Otter board trawl, Purse seine, Mackerel encircling gill net, except otter-boom and beam trawl fishing at night time during 15 Feb-31 Mar and fishing at both night and day time during 1 Apr-15 May
3 months (Oct-Dec)	No fishing of female eggs-berried mud crab, swimming crab and <i>Charybdis feriatus</i>	All gears
3 months (1 Dec-28 Feb)	Protection of Horse Shoe crab in Phang-nga Bay including in the rivers around Phang-nga Bay	All gears
2 months (15 Apr-15 Jun)	Protection of fish spawners and larvae in Phang-nga Bay, from Krabi to Phuket Provinces	All trawlers, Purse seine, Gill net with mesh size not less than 4.7 cm

Source: Fish Stocks and Habitats of Regional, Global and Trans-boundary Significance in the South China Sea: Case Study on the Gulf of Thailand

8. Appendices

Appendix 1: Thai fisheries in General

Rattanawalee (2009) summarized Thailand's marine fisheries, which are as complex as the fisheries in other tropical countries. The large number and different sizes of fishing boats employing multi-gear in multi-species fisheries traditionally feature the type of fisheries in Thailand, classified nonetheless in two categories, *i.e.* small-scale and commercial fisheries. The small-scale fisheries employ small fishing boats (not larger than 5.0 gross tons displacement), equipped with simple fishing gear, either without engine or with engines that are not bigger than a 30 HP. Fishing operation is largely conducted in inshore fishing grounds (not more than 5 km from the shore). The small-scale fisheries are subsistent, and operated mainly by family members in 2,500 coastal villages throughout the country. On the other hand, commercial fisheries employ fishing vessels of larger sizes, with efficient gears and are capital intensive. Generally, the marine fisheries of Thailand can be described as follows:

Fishing households

Referring to the marine fisheries inter-census survey in 2000, some 57,801 families are engaged in either full-time fishing or part-time supplemented with aquaculture. The number of fishing households increased by 8.8% from that enumerated during the 1995 marine fisheries census.

Fishers

The survey report in 2000 revealed that from the total number of 158,166 fishermen, the great majority (82.2%) are male. Some 56.3% of the fishermen are from 30 to 50 years of age, followed by 24.3% younger fishermen, and the rest 19.4% belonged to the group of older fishermen. Despite the substantial increase of 15.1% in the number compared to that in the 1995 census, a noticeable drop in the number of young fishermen group from 32.5% to 24.3% connotes a waning interest in fishing career among the young generations. Greater job opportunities in other economic sectors coupled with the risky and laborious nature of working at sea may have pushed the younger Thais to turn away from fishing.

Fishing gear

Fishing gears can be classified into two major groups, *i.e.* small-scale and commercial fishing gears. In 2000, it was found that more than one-half (54.8%) of the small-scale fishing families employed gillnets (largely shrimp trammel net and crab gill net), followed by 15.2% who used traps (fishing for cephalopods, blue swimming crabs, and mud crabs). Between 1995 and 2000, trawling became less popular both in small-scale and commercial fisheries; however, more small-scale (but not commercial) fishermen turned to anchovy falling net with luring light.

Fishing vessels

As reported in the marine fisheries inter-census survey in 2000, the total fishing fleet of 58,119 vessels comprised 72.7% with outboard engines, the majority of which are long-tail boats. The remaining 22.8% were fishing vessels with inboard engines, and 4.5% with no engines.

Fishing grounds

Thailand's EEZ spans over an area of 420,280 km²: 304,000 km² in the Gulf of Thailand and 116,280 km² in the Andaman Sea. Five major fishing grounds can be identified in the Gulf of Thailand, *i.e.* the Eastern, Inner Gulf, Upper Western, Lower Western, and the Mid-Gulf. The fishing grounds in the Andaman Sea are largely around the various islands and continental shelves (Fig. 42).

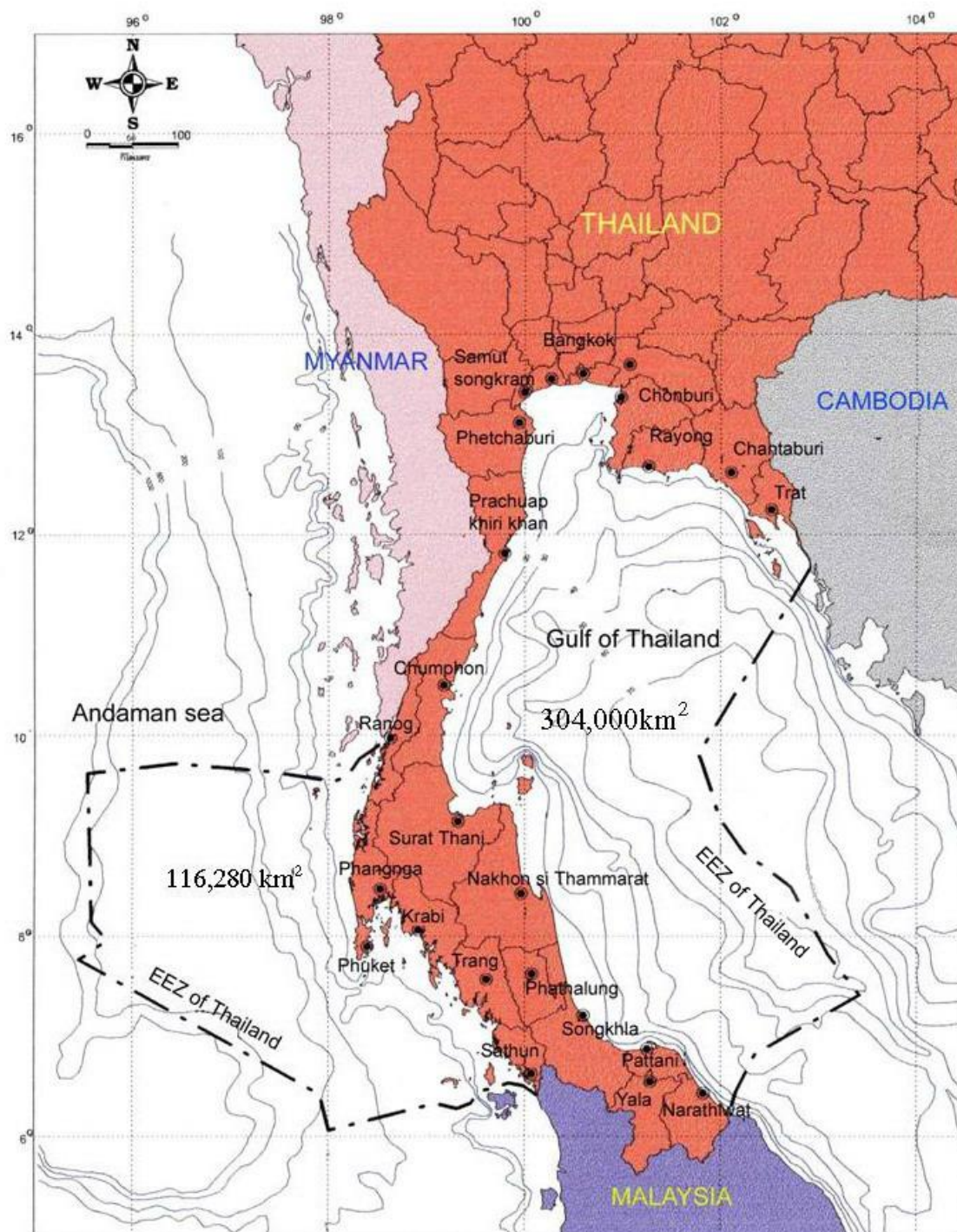


Fig 42. Thailand EEZ
Sopana Boonyapiwat, et.al. (2008)

Appendix 2. Statistics on marine catch by purse seines (1955-2006)

Source: Department of Fisheries of Thailand (1964-2009)

Year	Catch by Purse seine					Annual catch
	Thai Purse seine	Anchovy purse seine	Chinese Purse seine	Tuna Purse Seine	Total	
1957						170,900
1958						145,000
1959						147,770
1960						146,470
1961						233,275
1962						269,709
1963						323,374
1964						494,196
1965						529,483
1966						635,165
1967						762,187
1968						1,004,058
1969						1,179,595
1970						1,335,690
1971						1,470,289
1972						1,548,157
1973						1,548,157
1974	128,185	11,676	11,151		151,012	1,351,590
1975	153,053	7,506	13,572		174,131	1,394,608
1976	282,546	5,870	4,956		293,372	1,551,792
1977	427,540	2,100	7,504		437,144	2,067,533
1978	353,931	4,046	3,721		361,698	1,957,785
1979	279,207	9,174	4,460		292,841	1,813,185
1980	235,276	5,755	3,591		244,622	1,674,953
1981	315,752	6,441	4,586		326,779	1,488,978
1982	302,556	16,298	13,986		332,840	1,577,334
1983	400,267	40,000	29,208		469,475	1,651,882
1984	406,058	87,824	23,052		516,934	1,653,266
1985	471,211	88,651	11,055		570,917	2,057,751
1986	550,780	48,969	2,606		602,355	2,348,572
1987	610,056	29,945			640,001	2,601,929
1988	571,728	60,740			632,468	2,337,215

Appendix 2 (Cont.)

Year	Catch by Purse seine					Annual catch
	Thai Purse seine	Anchovy purse seine	Chinese Purse seine	Tuna Purse Seine	Total	
1989	568,440	105,613			674,053	2,539,237
1990	611,831	145,681			757,512	2,555,417
1991	617,303	120,508			737,811	2,709,051
1992	675,252	161,554			836,806	2,965,723
1993	701,540	152,850			854,390	2,754,486
1994	769,509	155,405			924,914	3,150,233
1995	771,698	147,034			918,732	2,827,400
1996	709,167	146,539			855,706	2,786,125
1997	658,773	143,850			802,623	2,679,500
1998	642,986	143,438			786,424	2,708,968
1999	626,353	126,808			753,161	2,725,207
2000	577,976	134,951			712,927	2,773,665
2001	541,303	135,537			678,840	2,631,700
2002	554,558	141,385			695,943	2,643,711
2003	558,659	152,248			710,907	2,651,223
2004	599,480	157,151			756,631	2,635,969
2005	609,796	159,735		11,937	781,468	2,615,565
2006	536,145	151,720		22,622	710,487	2,484,893

Appendix 3: Number of purse seiners (1955-2006)

Source: Department of Fisheries of Thailand (1964-2009)

Year	Number of Purse Seiners			Total
	Thai Purse seiner	Anchovy purse seiner	Chinese Purse seine	
1955	175		139	314
1956	196		185	381
1957	116		117	233
1958	188		179	367
1959	198		196	394
1960	171		193	364
1961	141		165	306
1962	112		92	204
1963	112		126	238
1964	91		127	218
1965	58		160	218
1966	84		159	243
1967	224		100	324
1968	347		53	400
1969	363		35	398
1970	475		35	510
1971	477		31	508
1972	344		64	408
1973	515	103	54	672
1974	554	82	39	675
1975	567	40	18	625
1976	651	58	17	726
1977	665	19	22	706
1978	707	31	15	753
1979	615	51	15	681
1980	735	12	34	781
1981	787	32	14	833
1982	771	56	13	840
1983	731	97	16	844
1984	790	55	16	861
1985	819	197	17	1,033
1986	836	143	17	996
1987	1,043	117	14	1,174

Appendix 3 (Cont.)

1988	1,241	199	16	1,456
1989	1,079	348	16	1,443
1990	1,262	367	12	1,641
1991	1,243	347	24	1,614
1992	1,128	324	0	1,452
1993	1,173	336	0	1,509
1994	1,163	348	0	1,511
1995	1,022	375	0	1,397
1996	905	422	0	1,327
1997	999	503	0	1,502
1998	966	323	0	1,289
1999	1138	416	0	1554
2000	990	514	0	1,504
2001	1,071	378	0	1,449
2002	1,260	426	0	1,686
2003	1,313	324	0	1,637
2004	1,135	344	0	1,479
2005	1,186	359	0	1,545
2006	1,164	326	0	1,490

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