Technical Report

Modified Bottom Trawl Net (High Opening Characteristic) of Thailand

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Abstract

Technical Report on Modified Bottom Trawl Net (High Opening Characteristic) of Thailand aims to investigate and update bottom trawl net constructions modified by local Thai fishers, operated in the Gulf of Thailand.

The survey on otter board trawl net designs is conducted at Trat province. The survey on pair trawl net designs is conducted Samutsakhon Province. There are four (4) trawl net designs comprises two (2) otter board trawl nets and two (2) pair trawl nets. With the reference to Fishing gear in Asia I (Thailand) published by SEAFDEC in year 1988 and revised in year 2004, Information collected by survey revealed two bottom otter board trawl and two pair trawl nets are new designs. Trawl fishing technology modification is emphasized on the target species and improvement of fishing performance in particular high opening characteristic.

Key word: Bottom trawl net, High opening characteristic, Thailand

Content

Page

Table Content

Page

Figure Content

Page

Figu **ontent (Continue)**

Page

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Introduction

Trawl fishing has been dominant fishing gear of Thailand since the fishing technology revaluation of Thailand in decade of 1960. Department of Fisheries, Thailand (DOF, Thailand) and Training Department of Southeast Asian Fisheries Development Center (SEAFDEC/TD) has been followed up the modification of fishing gear since 1950, 1969, 1986, 1997, and the latest fishing gear survey conducted in year 2000. Trawl fishing technology in Thailand has been modified regarding to the current situation of fisheries resources. Nowadays marine product by trawl fishery is important not only for human consumption but also for animal meal material. In year 2010, DOF-Thailand has found the modification of bottom pair trawl operated in upper part of Gulf of Thailand. Following by bottom otter board trawl operated in eastern part of Gulf of Thailand. Similarity of both trawl net modification is target species i.e. anchovy. Thus it is also better efficiency to catch trash fish that included with juvenile economic species and may severely impact to fisheries resource.

By this rationale the monitoring of trawl fishing technology has been conducted under bilateral collaboration between DOF, Thailand and SEAFDEC/TD. The survey has separated into two (2) trips. The first survey trip is conducted at Trat province under collaboration with Eastern Marine Fisheries Development Center (EMDEC), Fisheries Administrative Office, Trat Province. Survey was conduct on 16-19 November 2010, at two fishing ports, i.e. Municipal fishing port and Kor Kasemsiri fishing port at Klong-yai District, Trat Province. The second survey trip is conducted at Samutsakhon province under collaboration with Upper Gulf Marine Fisheries Development Center (UMDEC), Fisheries Administrative Office, Samutsakhon Province. Survey was conduct on 16-19 November 2010, at trawl net making factory at Mahachai district and Samutsakhon province.

Information collected by survey revealed two bottom otter board trawl and two pair trawl nets are new designs. Trawl fishing technology modification is emphasized on 2 purposes. The first modification is suitable to target species. The second modification is for better fishing performance.

Objective

1) Investigating bottom trawl net constructions modified by local Thai fishers, operated in the Gulf of Thailand.
2) Updating information and data collection of the design and structure of bottom trawl net of Thailand.

Term of Definition

Bottom trawl net refers to a type of fishing gear what are operated by towing the net on sea bottom. Baranov (1977) define trawl net as fishing gear consisted of a cone-shaped body, closed by bag and cod end and extended at opening by wings. They can be towed by one or two boats and, according to the type, are used on the bottom to catch demersal marine species included with fish, squid and shrimp. Trawl net has been operated beyond several tens or even hundreds of times of the length of fishing path of the gear (up to 1000 times).

Thailand refers to fishing ground within Gulf of Thailand, Thai Waters. Survey has been conducted at Trat Province, eastern part of the Gulf of Thailand and Samutsakhorn Province, upper part of the Gulf of Thailand.

Material and Method

The survey on modified bottom trawl net is a qualitative research. Survey has been carried out by gathering bottom trawl net design and data concerned e.g. catch species landed at fishing port. Rural Rapid Appraisal (or RRA) is applied to gather information for this survey that composed with 3 methods.

Primary data is collected by in-depth interview method. Face to Face interview with unstructured methodology is focus on details

Figure 1 SEAFDEC and DOF, Thailand surveyors interview trawler owner at Kasemsiri fishing port, Klong Yai district, Trat Province

of trawl net and the catches which landed. Personnel who were interviewed were trawl master fishermen, fishermen, trawler owner and trawl net factories. Cost of new trawl net design was interviewed from trawl net factories. (Figure 1)

Direct observation without participation is a method to examine construction and design of modified trawl net. Fishing gear material and other fishing constructed techniques are also interviewed and recorded. (Figure 2)

Review secondary data is a method to emphasize the existed trawl fishing gear and practice operated in Thai Waters. Reports are included with original trawl net designs, that are referred from the report of fishing gear and method of Thailand surveyed and published by Department of Fisheries Thailand (DOF-Thailand) in Year 1950, 1969 and 1997. Context is supplemented by information fishing gear and method of Thailand surveyed by SEAFDEC/TD in Year 1986 and 2004. The background on history of trawl fisheries of Thailand is reviewed and included in order to understand trawl net evolution in Thailand since year 1950. The secondary data is included with the fishing techniques of net construction and design compare with trawl net originated by German and Japanese what investigated by Nomura (1977)

Figure 2 SEAFDEC surveyor is collecting net construction and sketching otter board dimension

Area of Survey

Regarding to the different type of trawl net, i.e. otter trawl and pair trawl, area of survey is separately located into two (2) areas.

1. Otter trawl net is surveyed in the eastern part of the Gulf of Thailand, at the fishing port and trawl net factories in Klong-yai district, Trat Province.

2. Pair trawl net is surveyed in the upper part of the Gulf of Thailand, at the fishing port and trawl net factories in Mahachai District, Samut-sakhorn Province. Location of sites survey is appeared in figure 2.

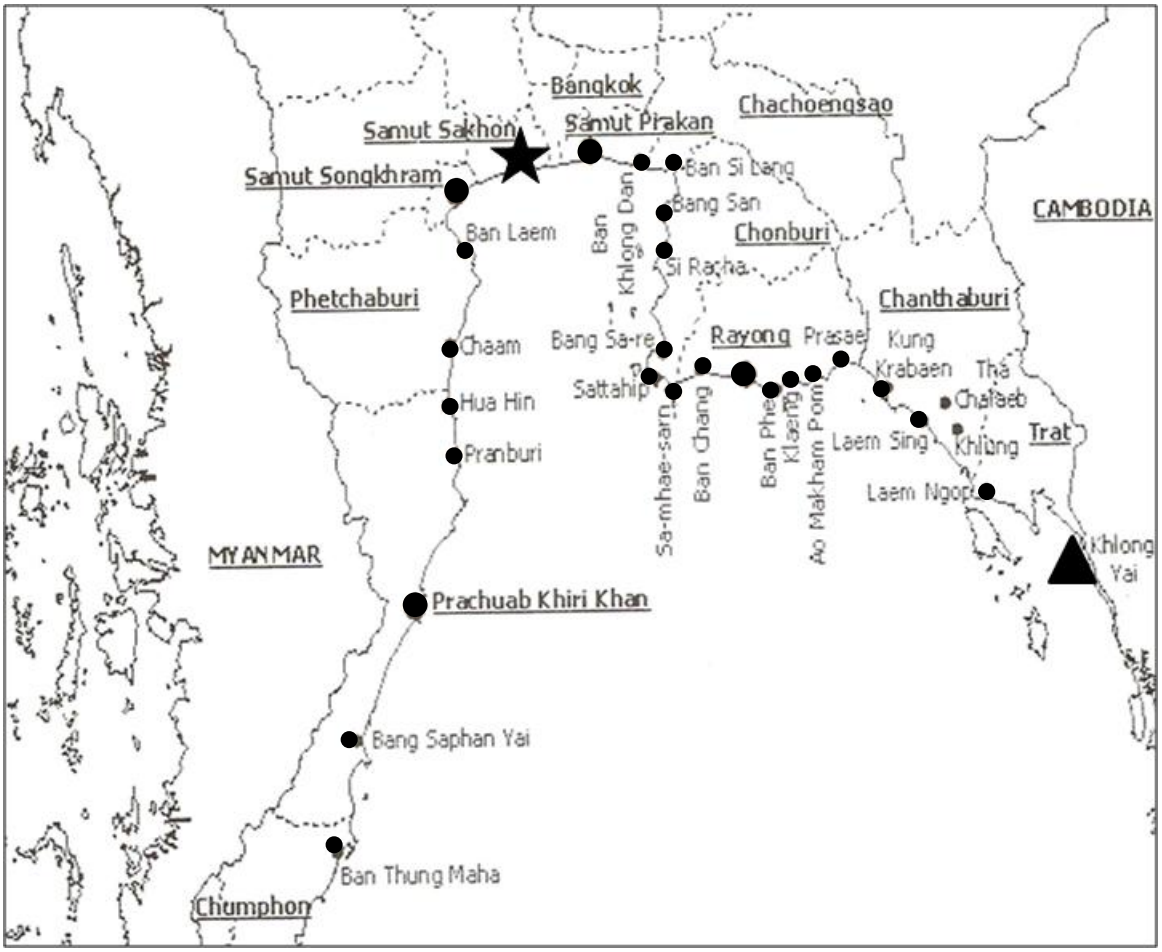

Figure 3 Location where the surveys are carried out

★ : Bottom pair trawl surveyed at Samutsakhon province

▲ : Bottom Otter trawl surveyed at Klong-yai district Trat province

● : Fishing Village or Town

● : Fishing Province (Underline)

Literature Review

Department of Fisheries-Thailand (1950) Trawl net is only design, Sea cucumber drag net, reported in 1950. Referred to Baranov (1977) sea cucumber drag net is a type of trawl net operated by green energy, wind or tidal current. Consideration to fishing mechanism conducted the towing distance is more than five times of net length, thus call trawl. Structure of trawl net body is 10 m in long. Head rope is 4-5 m long and ground rope is 8-9 m long. Net material is cotton No.20 and mesh size id 60 mm. Towing warp is made by coconut rope, diameter is 2.5 m, 50 m in length. The fishing operation is conducted by wind or current energy to drift trawler thus towing mechanism was functioned. Trawler is sailboat 8-10 m in length overall, without engine. Drifting time is around 1 hour. Fishing ground is sandy, 5-20 m in depth. Target catch was Sea cucumber (*Holothuria spp*.)

Tiew K. (1965) has reported the development of marine fisheries through introduction of bottom trawl net fishing in Southeast Asian Countries. The report is a part of trawl fishing experiment under the bilateral agreement between Government of Thailand and Federal of German on the topic of economic and technical. The report is also included with the result of fisheries resources survey in The Gulf of Thailand and proper design of effectiveness bottom trawl fishing net for Thai fishers.

Santa (1968) categorized trawl net of Thailand by net opening methodologies, i.e.

1. Beam trawl

Beam trawl is small trawl operated in Thailand since 2497 by introducing from Southern of China. Beam trawl fishing original trial in Samut-prakarn province for catch shrimp and small demersal fishes. Fishermen modified to use 3 set of beam trawl operated by motor trawler. However beam trawl were replaced by otter board trawl later.

Net material is cotton net No.20/15 ply. Mesh size is 30 mm at wing net and square part and 20 mm at baiting and belly part. Cod-end is assembled with net panel mesh size 15 mm. Total body net length (end of wing to cod-end part) is 5.5 m.

Wooden beam diameter 0.8 inch, 4.0 m in length is employed as beam. Front of beam is fixed with towing bridle rope at both end of beam. The rear beam is joined with two (2)

sweep lined (at left side and right side of beam), made by iron chain 50 cm in length. Each sweep line is attached with the cement ski weight 10 kg. Two (2) wooden bars, length 30 cm, are attached at both wing part of trawl net to open net in vertical direction. Towing warp is rope diameter 12 mm. Trawler is assembled with two (2) fishing booms, 4 m length, on port side and starboard side (sometime call “outriggers”).

2. Shrimp otter trawl

Shrimp otter trawl is introduced since Thai fishermen have discovered fishing ground of massive shrimp in the eastern part of the Gulf of Thailand, around Ko Chang and Ko Kut Island, Trat province. Fishermen reduce scale of original rectangular otter board to smaller proper for trawler 50 to 135 hp. Net construction is bilateral symmetry (similar in left and right side)

Wing part is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 60 m/m. Number of mesh in length is 250 meshes what thread strength is 15 m in length. Baiting part is in parallel with belly part (no square part). Net material is Polyethylene net (PE net). Twine size is 380D/12. Baiting-belly part is composed with 5 portions. Portion No.1 is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 55 mm. Number of mesh in length 82 meshes what thread strength is 4.5 m in length. Number of mesh width of upper part is 310 meshed and lower part is 270 meshes. Portion 1 of baiting-belly part is jointed with square by ratio 1:1 = 310 times, Net cutting pattern at both rim sides of net panel is 6P4B. Portion No.2 is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 55 mm. Number of mesh in length 64 meshes what thread strength is 3.5 m in length. Number of mesh width of upper part is 270 meshed and lower part is 240 meshes. Portion 1 of baiting-belly part is jointed with portion 2 by ratio 1:1 = 270 times, Net cutting pattern at both rim sides of net panel is 5P3B. Portion No.3 is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 50 mm. Number of mesh in length 80 meshes what thread strength is 4.0 m in length. Number of mesh width of upper part is 240 meshed and lower part is 210 meshes. Portion 2 of baiting-belly part is jointed with portion 3 by ratio 1:1 = 210 times, Net cutting pattern at both rim sides of net panel is 1P2B= 25 time and 1P3B=5 time. Portion No.4 is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 45 mm. Number of mesh in length 100 meshes what thread strength is 4.5 m in length. Number of mesh width of upper part is 210 meshed and lower part is 180 meshes. Portion 3 of baiting-belly part is jointed with portion 4 by ratio 1:1 = 180 times, Net cutting pattern at both rim sides of net panel is 7P6B. Portion No.5 is Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 35 mm. Number of mesh in length 58 meshes what thread strength is 2.0 m in length. Number of mesh width of upper part is 180 meshed and lower part is 120 meshes. Portion 3 of baiting-belly part is jointed with portion 4 by ratio 1:1 = 180 times, Net cutting pattern at both rim sides of net panel is approximately 1P2B.

The ground rope is weighted with a chain diameter 0.25 inch. Otter-boards are rectangular and flat, made of wood and iron, 725 cm wide and 170 cm long, with a bridle chain and a back strap. The sweep lines or hand-ropes are10-36 m long, 20 mm in diameter, made of polyethylene, 8 m in length. The warps are 20 mm in diameter, also made of polyethylene.

3. Otter board trawl German design

Since Government of Thailand established the bilateral agreement with Government of Federal Republic of Germany on the topic of economic and technical. Government of Federal Republic of Germany provided the technical experts for devope marine fisheries on Thailand. Finally, otter stern trawl found the most effective for demersal fishing in the Gulf of Thailand. Under the cooperation by private fisheries company, "Ha-rin-sutr Co., Ltd.", trawl net and trawl accessories, e.g. trawl winch, and etc had constructed and finally widely spread in the Gulf of Thailand. Thai fishers generally call this trawl net design is "*German Otter board trawl*" Fishing ground was appropriated in the Gulf of Thailand, from Cape Ca Mao (Vietnam) to east coast of Malaysia Peninsula.

Department of Fisheries-Thailand (1969) separated trawl net into 2 categories regarding to towing characteristic, i.e. 1) towing by man-power and 2) towing by fishing vessel. Trawl what towing by motor vessel is categorized into 5 types regarding to towing mechanism and target species.

1. Towing by man-power

Trawl what operated by man-power is now categorized into drag net, e.g. simple drag net and cucumber drag net. Simple dragnet is named beach seine at present and Sea cucumber drag net is a type of trawl net towed by wind energy referred to Baranov (1977) towing distance is more than five times of net length, thus call trawl. Trawl net structure is 10 m in length. Head rope is 4-5 m in length and ground rope is 8-9 m in length. Net is made by cotton No.20 and mesh size id 60 mm. The fishing operation is conducted by wind or current energy to drift trawler. Drifting time is around 1 hour.

2. Towing by motorized trawler

Trawl what operated by motorized vessel is included with inboard and outboard engine. It can be sub-categorized into is 5 types.

2.1. Otter board trawl

The most popular trawl net design during trawl fisheries initiating in Thailand is otter board trawl net. Main reason is less expense than pair trawl net. Trawl net is little modified

from German design what conducted experiment in 1952. Head rope is 39 m. in length and ground rope is 46.2 m in length. They were made by iron wire diameter 10 mm, wounded by nylon rope diameter 3 mm. Net material is Polyamide (Nylon) net, twine size 210D/24, Mesh size is 120 mm at wing net and proportionally reduce from square part to last belly part as 120, 60, and 40 mm respectively. Cod-end is assembled with net panel mesh size 25 mm. Selvage net is webbed at joint part between head rope and ground rope to wing and lower belly parts. Mesh size is made by Nylon 210D/24 and mesh size is 12 mm Ground rope is assembled with wooden or iron bobbin. Towing warps are made by iron wire, diameter 11 mm, 300 m in length. Two (2) otter boards made by wood and framed by iron bar. It is rectangular shape, size 2 m in length, 1 m in depth and 3 m in thick. Trawler is 24 m in length overall, equipped with a main engine 200-400 hp. Main hauling devices, i.e. two (2) capstan winches and two (2) gallows were installed on working deck. Crews composed with 6-7 fishermen and 5 navigators/engineers.

Fishing operation is regularly operated in daytime and nighttime. Fishing ground is 10 to 50 m in depth. Towing time is 2 hours. Target catches were demersal fishes what categorized in economic fish and trash fish. Economic fish is composed with Threadfin bream (*Nemipterus* spp.), Lizard fish (*Saurida* spp.), (Arius spp.), Squid (*Cephalopoda*) and Shrimp (*Penaeus spp.*). Trash fish is composed with pony fish (*Leiognathus* spp), Goat fish (*Upeneus spp*.) and etc.

2.2. Pair trawl

Japanese fishermen firstly introduced pair trawl before the coming of otter board trawl by German. It is, however, fishermen were not preferred because higher expenses than otter board trawl. Trawl net is 36.2 m in head rope length, 43.8 m in ground rope length. Head rope and ground rope is made by Polyamide (Nylon, PA) rope diameter 23 mm. Net material is Polyamide (Nylon, PA) net, twine size 210D/24, Mesh size is 120 mm at wing net and proportionally reduce from square part to last belly part as 120, 80, 60, and 40 mm respectively. Cod-end is assembled with net panel mesh size 30 mm. Selvage net is webbed at joint part between head rope and ground rope to wing and lower belly parts. Mesh size is made by Polyamide (Nylon, PA) 210D/24 and mesh size is 12 mm Ground rope is assembled with rubber bobbin. Towing warps are made by Polyamide (Nylon, PA) rope diameter 25 mm or iron wire, diameter 11 mm, 300 m in length. Trawler is 23 m in length overall, equipped with a main engine 200-300 hp. Main hauling devices, i.e. two (2) capstan winches and two (2) gallows were installed on working deck. Crews composed with 6-7 fishermen and 3 navigators/engineers.

Fishing operation is regularly operated in daytime and nighttime. Fishing ground is 10 to 50 m in depth. Towing time is 2 hours. Target catches were demersal fishes what

categorized in economic fish and trash fish. Economic fish is composed with Threadfin bream (*Nemipterus* spp.), Lizard fish (*Saurida* spp.), Barracuda (Sphyraena spp.), Pomfret (parastomateus niger), catfish (Arius spp.), Snapper (*Lutjanus* spp.), Trevally (Carang spp.), squid (*Cephalopoda*) and shrimp (*Penaeus spp.*). Trash fish is composed with pony fish (*Leiognathus* spp), Goat fish (*Upeneus spp*.) and etc.

2.3. Beam trawl

The trawl net is similar design with otter board trawl but net is smaller size than otter board trawl, except that a pair of booms are added to the fishing boat. Head rope and ground rope was 25 m in length, made by Polyamide (Nylon) rope diameter 12 mm. Net material is Polyamide (Nylon, PA) net, twine size 210D/21, Mesh size is 45 mm at wing net and proportionally reduce from square part to last belly part as 40, 30, 28, 20 mm respectively. Cod-end is assembled with net panel mesh size 15 mm. Selvage net is Polyamide (Nylon, PA) net, twine size 210D/36, mesh size is 5 0 mm, webbed at joint part between head rope and ground rope to wing and lower belly parts. Mesh size is made by Polyamide (Nylon, PA) twine size 210D/24 and mesh size is 12 mm. A piece of iron chain, 20 kg, is weighted on ground rope. Towing warps are made by Polyamide (Nylon, PA) rope diameter 20 mm, 150 m in length. Trawler is 12 m in length overall, equipped with a main engine 200-300 hp. Main hauling devices, i.e. two (2) capstan winches and two (2) gallows were installed on working deck. Additional 2 fishing booms were, 3 m in length, are installed at mid-ship position. Manual net winch w2as installed on stern deck. Crews are composed with 6 fishermen and 2 navigators/engineers.

Fishing operation is regularly operated in daytime and nighttime. Fishing ground is muddy or muddy-sandy area, 10 to 25 m in depth. Towing time is 2 hours. Target catches were demersal fishes what categorized in economic fish and trash fish. Economic fish is composed with Threadfin bream (*Nemipterus* spp.), Lizard fish (*Saurida* spp.), (Arius spp.), Squid (*Cephalopoda*) and Shrimp (*Penaeus spp.*). Trash fish is composed with pony fish (*Leiognathus* spp), Goat fish (*Upeneus spp*.) and etc.

2.4. Shrimp beam trawl net

The trawl what horizontal net opening is expanded by wooden beam or called beam trawl in present. Wooden beams were 6.5 m in length, diameter 55 mm. Numbers of beam were depended on number of trawl net, usually 2-6 pieces. Each net was attached with 2 cement skies weight 17 kg. Net body is similar design with otter board trawl but smaller size than otter board trawl. Head rope and ground rope was 2.8 m in length, made by Polyamide (Nylon) rope diameter 7 mm. Net material is Polyamide (Nylon, PA) net, twine size 210D/15, Mesh size is

25 mm at wing net to last belly par. Cod-end is assembled with net panel mesh size 15 mm. Selvage net is Polyamide (Nylon, PA) net, twine size 210D/21, mesh size is 4.0 mm, webbed at joint part between head rope and ground rope to wing and lower belly parts. Total length of net (from mouth to cod end) is 3.5 m. Forty (40) pieces of lead, totally 4 kg, is weighted on ground rope. Towing warps are made by Polyamide (Nylon, PA) rope diameter 18 mm, 30-35 m in length. Trawler is 9 m in length overall, equipped with a main engine 10-50 hp. Additional 2 fishing booms were, 3.9 m in length, are installed at mid-ship position. Crews are composed with 4 fishermen and 2 navigators/engineers.

2.5. Acetes beam trawl net

The trawl what horizontal net opening is expanded by wooden beam similar with shrimp beam trawl net. Wooden beam was 5.5 m in length, diameter 50 mm, usually 2-3 pieces. Net body is similar design with shrimp beam trawl net but smaller size than otter board trawl. Head rope and ground rope was 2 m in length, made by Polyamide (Nylon) rope diameter 9 mm. Net material is Polyamide (Nylon, PA), mesh size is 25 mm from wing net to cod-end. Net body was separated into 2 portions, i.e. 1) Opening portion is 2.0 m. width and reduce width to 90 cm. Net body is 3.9 m. 2) belly to cod-end portion was cylindrical shape, 90 cm in diameter, 12 m in net body length. This portion was included with cod-end part what similar net structure. Trawler is 6-9 m in length overall, equipped with a main engine 10-50 hp. Additional 2 fishing booms made by wood, diameter 8 cm, 3.9 m in length, are installed at mid-ship position. Crews are composed with 4 fishermen and 2 navigators/engineers.

Fishing operation is regularly operated at nighttime but occasionary opeate at daytime. Fishing ground is muddy or muddy-sandy area, 2 to 10 m in depth. Towing time is 2 hours. Target catches were Acetes, Small shrimp, Swimming crab and some juvenile fishes.

Bundit C. (1985) refer to Baranov (1977) defines the difference between trawl and other fishin gear of the filtering class, as follow: If the length of fishing path of the gear exceed teh length of the gear itself by few times (not over 5), then it is consider seine type gear. Whather or not the gear in action reaches the surface of water. If the length of fishing part of the gear is several tens or even hundreds of times (up to 1000) longer that the gear itself, this is trawl type gear. Trawl net is also define as a type of fishing gear consisting of bag net that is towed through a mass of water or along the bottom to trap any fish in its path. Bottom trawl can be categorized, regarding to fishing method and construction of trawl net, into 3 main groups, *i.e.* 1) Bottom beam trawl, 2) Bottom otter trawl, and 3) bottom pair trawl.

Nomura (1977) conducted preliminary study of characteristic of trawl net construction in Thailand categorized in 3 type regarded to size of vessel, i.e. 14 m, 14-18 m, 18-20 m, and 20 m. Trawl net is categorized into 2 main structures, i.e. two seam trawl net and four seam trawl net. The investigation of two-seam trawl net is appeared result is described as below;

1. Proportion between total length of net and length of head rope of all type of Thai trawl is 1.23 what smaller than German design as 1.4 but larger than value 1.1 of the Japanese design.

2. Proportion between length of upper wing and length of head rope is 0.485 that almost same as the German and the Japanese trawl net.

3. Proportion between length of baiting and head rope is average as 0.65 in otter board trawl and 0.59 in pair trawl. Its value is larger in the German trawl but smaller in the Japanese trawl.

4. Proportion between cod end and length of head rope is 0.18 on average in Thai trawl however both German and Japanese trawl have bigger value than Thai trawl.

5. Regarding to the observation from 1) to 4), it is suggested that German trawl is long in baiting without flapper. Thai trawl has intermediate long in the baiting and the Japanese trawl has a short baiting with flapper. These conditions are regarded to different kind of target catches and different fishing ground characteristic.

6. The German and the Japanese trawl net have a bigger mesh in wing than the Thai trawl net. And among the Thai trawl net, pair trawl is the biggest mesh and otter board trawl with boom is the smallest net.

7. Almost the same tendency could be shown in the case of cod-end mesh size. Especially, otter board trawl cod-end has a very small mesh size. Pair trawl cod-end is a little bigger than that of otter board trawl. Small mesh size of cod-end will have a bad effect of the resources of fish stock. Therefore greater attention should be strengthened to regulating the mesh size of cod-end of trawl.

The investigation of four-seam trawl net is appeared result is described as below;

Proportion between total length of net and length of head rope of all type of Thai trawl is same as 1.3 what little larger than Japanese four seam pair trawl which has a longer than head rope.

1. Proportion between length of belly and length of head rope, length of cod-end and length of head rope, length of circumference of bosom and length of head rope in Thai trawl (otter board trawl, pair trawl and otter board with boom trawl)are fairly larger than value of Japanese four-seam pair trawl.

2. Proportion between length of wing (hanging ration = 0.85) and head rope in Thai trawl which shows a constant value according to the size of boat is smaller than that of the Japanese four-seam pair trawl. It means that the latter has a longer wing as compare with a length of head rope.

3. Consequently the Japanese four-seam pair trawl has a loner wing and a longer head rope which will make a wider trawling area and will maintain a high opening mouth of net.

4. In the other hand Thai trawl net in both two seams net and four seams net have a rather long body of webbing to prevent the catches escape from the net in spite of low net towing speed.

5. For the purpose of catching shrimp or prawn, the trawl net should have a wide but flat net mouth, and it is not necessary to have long body net. But for catching swimming fish should have long head rope to take in the big volume of water caused by high opening mouth of net.

6. From the above point of view, the Thai trawl generally seems to aim both fish and shrimp aim its net construction.

7. As for the mesh size, it is so small that one must give attention to the preservation of fish stock which was aforementioned discussed.

SEAFDEC/TD (1986 and 2004) category trawl net, into 4 main groups, *i.e.* 1) Bottom beam trawl, 2) Bottom otter trawl, 3) Bottom otter trawl with boom and 4) bottom pair trawl.

1. Bottom beam trawl

The beam trawl was the forerunner of all trawl gear designs known today. Its main feature is a beam whose purpose is to spread the netting. Most beams are made of iron and are between two to four meters long. Sometimes a heavy beam is supported by steel shoes at each end which run over the sea bed. A ground rope and a head rope are joined together to the cement ski that works as a bobbin. The weight of the cement ski is about 10 to 15 kilograms for small-size beam and about 40 to 45 kg for big size beam trawl. The skies are connected with the beam by a length of chain. The towing bridle consists of two or three ropes, one from each shoe and one from the center of the beam. These come together and are shackled directly to the towing warp. The principal catch of beam trawl are shrimps, therefore the mesh size is relatively small. The mesh size of beam trawl also depends on the catch.

Fishing grounds of beam trawl are in shallow waters with muddy bottom. This kind of fishing is very common in the south of Thailand such as Nakhon si thammarat Province, Suratthani Province, Chumphon Province. Fishing goes on throughout the year.

2. Bottom otter trawl

The most popular form of trawl fishing in Thailand is by otter trawl, in which otter boards are used for horizontal spreading of the net mouth. Most otter trawl nets consist of two panels; this is called a “two-seam net”. The mouth is oval-shaped when viewed from front. Two wings stretch out to increase the swept area and to guide fish in the net’s path down to the cod-end. There are two typed of otter trawl: one for shrimps and the other for fish.

The otter trawl target for shrimp is usually operated from small trawler, size 8-16 m in length overall and equipped with a low to medium power of the main engine, 30-120 hp. Trawl net is constructed by Polyethylene (PE) net, 30-60 mm mesh-size, twine size is 250D/6 or 380D/6-12 for the wings, upper panel and the belly, and 20-25 mm mesh-size polyethylene 380D/9-15 for the cod-end. In most cases, the triangular piece of netting at the top wings of both panels is omitted. The size of net depends on the power of the fishing boat; the head-rope varies from 11-23 m and the ground-rope from 13-24 meters. The difference between them is 1-2 meters. Both are made of Polyethylene or Polypropylene (PP) material. The ground rope is weighted with a chain, or with lead sinkers. Otter-boards are rectangular and flat, made of wood and iron, 50-100 cm wide and 100-200 cm long, with a bridle chain and a back strap. The sweep lines or hand-ropes are10-36 m long, 14-26 mm in diameter, made of polyethylene, polypropylene or a combination rope.

Towing warp size is 14-28 mm in diameter, made of polyethylene or polypropylene. A capstan winch is used for hauling warps and lifting the catch in the cod-end onto the foredeck of the fishing boat. The net is pulled by hand at stern. Four to eight fishermen take part in a fishing operation. The shrimp otter trawls are mostly operated in the fishing ground from Nakhon sri thammarat Province to Songkhla Province, and the catches consist of shrimps and trash-fish.

The fish otter trawls are the largest single fishery in Thailand. Most vessels used in this case are comparatively big, from 15 to over 30 m in length, with the main engines powered from 100-500 hp. The fishing expeditions take one or two weeks, sometimes even longer. The two-seam type of net is used, 120-180 mm mesh-size, Polyethylene (PE) twine size 700D/12-21 netting for the wings, square, upper panel and belly, and 20-30 mm mesh-size Polyethylene (PE) 380D/9-15 netting for the cod-end. This net differs from the shrimp otter trawl net in that it has a triangular piece of netting at the top wings of both panels. The head rope is 28-40 m, and the ground rope 30-46 m long. The difference in their lengths is 2-6 metres. Both ropes are made of

wire and combination rope. Wooden and rubber rollers, sometimes covered with spherical plastic capsule are attached on the ground rope for weighting and nothing. Otter-boards are rectangular and flat, 1-2 m wide, 1.2 x 2.4 m long, made of wood and iron. They have a fixed bracket and a bridle chain or fixed iron holders, and sometimes 1-5 plastic floats are attached at the front top part of the boards, so as to prevent the sinking of the boards into the muddy sea bed. Gallows, which are necessary for this type of trawl, are fixed at the stern of the boat. The deck machineries and hauling devices for this bottom trawl is fixed at the stern of the trawler. The sweep lines or hand-ropes are 35-80 m long, 22-32 mm thick combination ropes. The warps are 14-18 mm thick wires, coiled on the warp drum winches on both sides of the boat, or in the middle of a stern trawler. Warps are hauled by a warp drum winch and the net is pulled by a capstan winch, and passes through a y on the crane boom at the fore-deck (or stern-deck of a stern trawler). The cod-end is hauled in the same way. Ten to twenty men are needed for a fishing operation. The main catches are demersal fishes and trash-fish. The major fishing ports are Samutprakan Province, Samutsakhon Province, Songkhla Province and Phuket Province.

3. Bottom otter trawl with boom

This fishing gear is similar to the bottom otter trawl, except that a pair of wooden booms is added to the fishing boat. The purpose of the booms is to increase the horizontal spreading of otter boards. Twin booms are arranged, hinging outward from the middle of fishing boat to provide outboard towing point for the towing warps. The operation of this gear is the same as for an ordinary otter-trawl, but a boom increases the spreading of otter boards.

The gear can be found in the inner Gulf of Thailand, from Trat Province to Chumphon Province. Most of the catches consist of shrimps.

4. Bottom pair trawl

Pair trawling means that the net is towed by two boats. It both boats are small, less than 18 m long and with main engines of up to 150 hp, it is a small pair trawl. A medium pair trawl combines towing of a boat of over 18 m in length and with a main engine of more than 150 hp, with a small fishing boat. If both vessels are large, it is known as a large pair trawl. This fishing method was introduced in Thailand in the 1960s by Japanese fishermen. However Japanese pair trawl was originated by Taiwan.

In pair trawling, the net mouth is kept open by outward towing of the two boats, which always try to keep the same distance between them during operation. Otter boards are not necessary, the arrangement of gear is simplified, the warp is connected directly to the sweep lines

whose other and is joined to a triangular iron frame at the end of bridles from each wing of the net.

A pair trawl is usually operated in the day-time. Fishing grounds are in the Gulf of Thailand and the Andaman Sea at the depth of water up to 40 meters. Most catches consist of demersal fishes, trash fish, squid, and cuttlefish. The major landing ports are Samutsakhon Province, Samutsongkhram Province, Songkhla Province, Ranong Province and Phuket Province.

Department of Fisheries, Thailand (1997) explains the definition of bottom trawl net; is a cone-shaped net and fishing method is; to continuously tow forward by one or two boats, with beam or otter board to hold the trawl net open in a horizontal direction. Classification of trawl fishing is categorized into three (3) main types, *i.e.*

1. Pair trawl

Pair trawl net is opened net mouth in a horizontal direction by 2 trawlers. Trawl net is 32-38 m in head rope length, 36-48 m in ground rope length and total body net length (end of wing to cod-end part) is 48-55 m. Mesh size is 180-200 m/m at wing net and proportionally reduce from square part to last belly part as 160, 120, 80, 60, and 40 m/m respectively. Cod-end are assembled with net panel mesh size 20, 25 or 30 m/m. Floats diameter 14-20 cm, 25-50 pieces are attached at head rope. Ground rope is made by iron wire assembled with wooden or iron bobbin. Sweep line is 50-60 m in length and warp length is 300-600 m.

Fishing operation is regularly operated in daytime from sunrise to sunset. However nighttime operation is sometime observed in particular full moon period. Fishing ground is 5 to 60 m in depth. Speed of towing is 4 to 5 knot and both trawler keep distance 100 to 300 m. towing time is 3 to 4 hours and operation is conducted 3 hauls a day.

Regular size of trawler is 18-25 m installed with main engine 60-550 hp. Crew members are 18-22 fishermen. Mostly catches are demersal fishes and squid however none of target record of shrimp. There is, however, some pelagic fish, e.g. Indo-Pacific mackerel, Carangid, and Spanish mackerel are caught by pair trawl.

Provincial bases of pair trawl are observed in the Gulf of Thailand, i.e. Samutprakarn Province, Samutsakhon Province, Samutsongkram Province, Prachaub kirikarn Province, Chumphon Province, Songkla Province and in Andaman Sea, i.e. Phuket Province.

2. Otter board trawl

The most popular form of trawl fishing in Thailand is by otter trawl, in which otter boards are used for horizontal spreading of the net mouth. Otter-boards are rectangular and flat, made of wood and iron, with a bridle chain and a back strap. While trawl fishing operation is conducted, water resistance makes otter board expanded and two wings stretch out to increase the swept area and to guide fish in the net's path down to the cod-end.

Small trawler of Thailand or call shrimp trawler is little different fishing accessories on-board trawler in fishing area. Small trawlers from Trat Province (Eastern part of the Gulf of Thailand) to Suratthani Province (Central-southern part of the Gulf of Thailand), are mostly assembled with 2 fishing booms, on port side and starboard side (sometime call "outriggers"). Booms make by wooden or iron pipes, 10-13 cm in diameter and 3 to 5 meter in length. They are always installed in front of wheel-house and foldable to keep while alongside at jetty. However trawlers based from Nakhon si thammarat Province southwardly to Narathiwat Province (Southern part of the Gulf of Thailand), and trawlers what length overall is longer than 18 m, mostly not to assembled with any fishing booms. Otter board trawl net is categorized into 4 sub-types, i.e.

2.1. Otter board fish trawl

Observe in trawler size bigger than 14 m length overall. Regarding to target catches is same as pair trawl, construction of trawl net is almost similar with pair trawl. Trawl net is 25-44 m in head rope length, 29-48 m in ground rope length and total body net length (end of wing to cod-end part) is 40-50 m. Net material is polyethylene net, twine size 380D/15 or 700D/21, Mesh size is 80-180 mm at wing net and proportionally reduce from square part to last belly part as 120, 100, 80, 60, and 40 mm respectively. Cod-end is assembled with net panel mesh size 20, 25 mm. Ground rope is made by combination rope (wire wounded by rope) assembled with wooden or iron bobbin. Warp length is made by rope but large trawler always employs iron wire length 200-600 m.

Fishing operation is regularly operated in daytime from sunrise to sunset. Fishing ground is 5-60 m deep. Towing time is 3-6 hours and 7-25 days a trip.

2.2. Otter board shrimp trawl

Otter board shrimp trawl are always observed by trawler size 6-14 m length overall. Twine size and mesh size is smaller than otter fish trawl. Trawl net is 25-44 m in head rope length, 29-48 m in ground rope length and total body net length (end of wing to cod-end part) is 40-50 m. Net material is polyethylene net, twine size 380D/6 or 380D/15, Mesh size is 60, 50 or 40 mm at wing net and net body. Cod-end is assembled with net panel mesh size 20, 25 mm. Ground

rope is made by rope diameter 10-20 mm. assembled with chain diameter 3 mm, weight 10-40 kg attached throughout the ground rope. Warp length is made by rope, length 100-400 m.

Fishing operation is regularly operated in nighttime started from sunset. However daytime operation is sometime observed in particular season of banana shrimp. Fishing ground is 5-30 m in depth. Towing time is 3-5 hours and one-night trip regularly but some trawlers operate 7-15 days/trip. Regular size of trawler is 14-18 m in length overall.

2.3. Acetes trawl

Acetes are always observed by trawler length overall size smaller than 14 m at Nakhon si thammarat Province and Songkla Province. Trawl net is modified from shrimp trawl and operated in Acetes season for 2 month. Trawl net construction is similar with shrimp trawl however fisherman replace net body with polyethylene knotless net mesh size 6-7 mm. Cod-end net used knotless net, fine mesh 2x2 mm, cover with PE net mesh size 20 mm. Total body net length (end of wing to cod-end part) is 17-20 m. Warp length is made by rope, length 100-150 m.

Fishing operation is regularly operated in daytime started by observe school of Acetes through color of seawater. Towing time is 2 to 3 hours in circle direction. Fishing ground is 4 to 6 m in depth.

2.4. Jelly fish trawl

Jelly fish trawl is limited to operate in Rayong Province and Chanburi Province in the eastern part of the Gulf of Thailand. Trawl net is modified from shrimp or fish trawl by replace cod-end part by net mesh size 90 mm and extends length of cod-end from 3-6 m to 20 m in order to contain large quantity of jelly fish. Head rope is 17-24 m long, and ground rope is 18-25 m long. Total net body length (end of wing to cod-end part) is 40-60 m. Net material is polyethylene net, twine size 380D/12 or 700D/18,

Fishing operation is regularly operated in daytime. Operation is one-haul a day. Fishing ground is 6 to 18 m in depth.

3. Beam trawl

Beam trawl net is trawl net what horizontal open by iron beam. There are two (2) trawl net are set during fishing operation. Beam trawl was limited only longtail-outboard engine trawler in the past however otter board trawlers are modified to use beam trawl at present. Beam trawl is categorized into 2 sub-types regarding to target catches, i.e.

3.1. Shrimp beam trawl

Shrimp beam trawl is able to operate by longtail trawler to general trawlers what modified from otter board trawl or surf clam dredge length size from 9 to 20 m in length overall. Net construction of trawl net is 2-9 m in head rope and ground rope length. Total body net length (end of wing to cod-end part) is 3.5 to 8 m. Net material is Polyethylene (PE) net, twine size 380D/9 or 380D/15, Mesh size is 35-40 mm at wing net and proportionally reduce from square part to last belly part as 30, and 25 mm. Cod-end is assembled with net panel mesh size 15 or 20 or 25 mm. Head rope have no float or only float is fixed at center of head rope. Numbers of lead, length 9 cm are fixed with ground rope.

Iron pipe diameter 0.75-1.0 inch, 1.30-4.50 m in length is employed as beam. Front of beam is fixed with towing bridle rope at both end of beam, length if 2 time if beam length. The rear beam is joined with 2 pieces of sweep line (at left side and right side of beam), made by rope or chain 40-75 cm in length. Each sweep line is attached with the cement ski weight 12-30 kg. A ground rope and a head rope, length 20-50 cm, are joined together to the cement ski. Two (2) Iron bars are attached at both wing part of trawl net to open net in vertical direction. Towing warp is rope diameter 10-20 mm length 50-150 m.

Fishing operation is able to conduct in daytime and nighttime. Fishing ground is 1-15 m deep. Towing time is 30 minutes to 1 hour. Dominant catch is various species of shrimp, flounder, whiting fish and cuttlefish.

3.2. Jelly fish beam trawl

Fishing operation is conducted only in daytime. Operation is conducted one haul a day. Trawl net is cut in to triangular shape, 4 pieces, size 10-24 m length and 3-10 m in width what depended to the frames. Net material is Polyethylene net, twine size 700D/15, mesh size 80-90 mm. Iron frame size 3x3 m or 10x10 m depended on the size of trawler is made by iron pipe diameter 2.5-5 cm. Net is joined at frame and floats, 6 inches diameter, are fixed at head rope, interval is 2 m. Piece of chain is fixed through ground rope. The other design of Jelly fish beam trawl is no rectangular frame. Fishermen use only iron pipe attached with rectangular trawl net opening at ground rope. Numbers of float, 6 to 8 inches diameter, are fixed at head rope, interval is 2 m.

Fishing ground is 6-18 m deep however trawl net is deployed at mid-water level. Catch is focused only jelly fish.

Mala and Pongpat (2010) describes the fishing efforts of trawlers in gross ton, related to size of fishing boats are measured as follow:

1. Otter board trawler

1.1. The small size trawler with Length Overall (LOA) is less than 14 m., has an average as 9 gross tonnage;
1.2. The medium-small size trawler with LOA is between 14-18 m., has an average 27 gross tonnage;
1.3. The medium-large size trawler with Length is between 18-25 m., has an average 56 gross tonnage
1.4. The large size trawler with LOA is bigger than 25 m., has an average 180 gross ton.

2. Pair trawler

2.1. The small size trawler with Length Overall (LOA) is less than 14 m., has an average 15 gross ton;
2.2. The medium-small size trawler with LOA is between 14-18 m., has an average 29 ;
2.3. The medium-large size trawler with Length is between 18-25 m., 18-25 m has an average 59 gross ton and
2.4. The large size trawler with LOA is bigger than 25 m., has an average 118 gross ton.

3. Beam trawler

3.1. The large size trawler with LOA is bigger than 25 m., 14 m has an average 11 gross ton;
3.2. The medium-small size trawler with LOA is between 14-18 m., has an average 22 gross ton and BT 18-25 m has an average 45 gross ton.

FAO (1990) definite trawl nets are tow nets consisting of a cone-shaped body, closed by bag and cod end and extended at opening by wings. They can be towed by one or two boats and, according to the type, are used on the bottom of in mid-water. In certain cases, as in trawling for shrimp or flatfish, the trawler can be specially rigged with outriggers to tow up to four trawls at the same time (double rigging). Trawling in mid-water trawl is more complex than bottom trawling because of the requirement in maneuver the trawl vertically and horizontally to intercept fish school.

SEAFDEC (2002) reported the bottom trawl net target for fish and cuttlefish. Mesh size of wing part is 1.6 m and cod end mesh size is 35 mm. Length of ground rope is 43 m and length of ground rope is 38.5 m. Upper wing net is 11.8 m and lower wing is 15.2 m. Total net body length is

62.69. Trawler equips with main engine 135 Hp. Survey area is Hai Hua, Nam Dinh Province, Northern part of Viet Nam.

FAO (1990), Department of Fisheries, Thailand (1997), and **SEAFDEC (2004)** has different trawl net classification. The comparison is presented as follow;

Table 1 Classification of trawl net

FAO	SEAFDEC	DOF
1. Bottom Trawls	1. Beam Trawls	1. Pair Trawls
1.1. Beam Trawls	2. Bottom Otter Trawls	2. Otter Board Trawls
1.2. Bottom Otter Trawls	3. Bottom otter trawl with boom	2.1. Otter board fish trawl
1.3. Bottom Pair Trawls	4. Bottom Pair Trawls	2.2. Otter board shrimp trawl
2. Midwater Trawls		2.3. Acetes trawl
2.1. Midwater Otter Trawls		2.4. Jelly-fish trawl
2.2. Midwater Pair Trawls		3. Beam Trawls
2.3. Otter Twin Trawls		3.1. Shrimp Beam Trawl
		3.2. Jelly-fish Beam trawl

Result of Survey

Trawl net sample No.1
Hybrid otter board trawl net

Hybrid otter board trawl is new named for bottom trawl what investigate at Kor Kasemsiri Fishing Port, Klongyai District, Trat province. Hybrid otter board trawl is definition of trawl net what cover target catch by fish and shrimp. Bottom otter board trawl operated in Thailand mostly separated into 4 types regarding to target catch, i.e. fish trawl and shrimp trawl acetes trawl and jelly fish trawl (DOF, 1997) Focus on 2 main bottom otter board trawl, fish trawl and shrimp trawl. The different between each trawl net is mesh size. Mesh size at wing part of fish trawl net is varied from 80 mm to 180 mm. Whereas mesh size at wing part of shrimp trawl net is varied from 30 mm to 60 mm. Trawl net found in survey area is mesh size in between fish trawl and shrimp trawl net, 76 mm at wing net. It's targeted for catching Cuttlefish (*Sepia* spp.), Octopus (*Octopus* spp.), Banana shrimp (*Penaeus merguensis*), School shrimp (matapenaeus spp.) and demersal fishes e.g. Threadfin bream (*Nemipterus* spp.), Lizard fish (*Saurida* spp.), Snapper (*Lutjanus* spp.), Emperor fish (Letrinus sp.), Spinefoot (*Siganus* spp), Crocker (*Johnius* spp.) and Scallop (*Amusium* sp.). Trash fish observed at landing site is composed is regular trash fish, e.g. pony fish (*Leiognathus* spp), cardinal fish (*Apogon* spp.) and juvenile economic fishes, e.g. Threadfin bream, Crocker, Lizard fish, and etc. Authors observed that small shrimp, e.g. Whiskered velvet shrimp (*Metapenaeopsis barbata*) and Fiddler shrimp (*Metapenaeopsis stridulans*) was not landed. It may regard to bigger mesh size at wing part of trawl net webbed together with the big selvage net at ground rope.

Figure 4 Catches by Hybrid bottom trawl

Figure 5 Selvage net of bottom wing part constructed at Fishing workshop, Klongyai, Trat Province

Categories of trawlers installed with this hybrid bottom trawl net is Length Overall (LOA) less than 14 m and LOA is between 14-18 m. Trawlers are assembled with 2 fishing booms (starboard side and port side; outrigger), 3-4 m in length, purpose for expanding sweep area. Some observed trawlers had no name labeled onboard, assumed that trawlers came from Cambodia.

Information by the interview, they have fishing licenses both in Thai and Cambodia Waters, however trawlers registered at Sihanouk Ville, Cambodia and all crews are Cambodians. Fleet manager is Thai and catches regularly landed in Klongyai District, Trat Province because better market price than landing at Cambodia although marine products were caught in unidentified fishing ground, Cambodia or Thai Waters.

Specification of trawler is wooden trawl 14-18 m in length overall, installed with a 165 in-board engine. Fish finder and Global Positioning Seattleite (GPS) systems are installed on-board. Trawlers' trip is from three (3) days to one week trip with 4 fishermen included fishing master, chief engineer. Regarding to the limited space to examine trawl net on trawler, Investigators need to check net plan at trawl net making factory in downtown of Klongyai District.

Figure 6 Trawler size under 14 m. observed at Kor kasemsiri fishing port

Figure 7 (Right) Trawler boom with otter board (Left) Otter board

Fishing gear construction

Bottom trawl net is 2 seams structure, upper panel and lower panel. Each seam composed with portions that different in net material and net specification (mesh size and twine size). Bottom trawl net design is detailed as below;

1. Upper net panel

Upper net panel is composed of six (6) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Head line is a polypropylene (PP), cross rope, diameter 12 m/m. Length of head line is 25.5 m.

1.2. Upper triangle-wing parts are composed with 3 net panels, i.e.;

a) Main net is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Numbers of meshes in length are 39.5 meshes what thread strength is 30.0 m.

b) Sub-selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width. Mesh size is 120 mm. Sub selvage net is joined with main net by ratio 1: 4 (One bar of sub-selvage mesh joined with four bars of triangle upper-wing meshes).

c) Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width. Mesh size is 600 mm. Selvage net is joined with sub selvage net by ratio 1: 5 (One bar of selvage mesh joined with five bars of sub-selvage meshes).

Total thread strength of Upper triangle-wing part (composed with selvage and sub-selvage) is 4.1 m. Length of head line attached with wing-end panel is 4.1 m. Net cutting pattern at head line, inside and outside (included with selvage and sub-selvage net) is all bar-cut (AB-Cut).

1.3. Upper-wing parts are composed with 3 net panels. Materials are same as the part of upper triangle-wing, i.e.

a) Main net is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Number of mesh in length is 96.5 meshes what thread strength is 7.3 m.

b) Sub-selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width. Mesh size is 120 mm. Sub selvage net is joined with main net by ratio 5:8 (five bar of sub-selvage mesh joined with eight bars of upper-wing meshes)

c) Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width. Mesh size is 600 mm. Selvage net is joined with sub selvage net by ratio 1: 5 (One bar of selvage mesh joined with five bars of sub-selvage meshes).

Total thread strength of Upper wing part (composed with selvage and sub-selvage) is 7.3 m. Length of head line attached with wing-end panel is 7.3 m. Net cutting pattern at head line (included with selvage and sub-selvage net) is composed with all bar-cut (AB-Cut) at inside net opening and 1P3B at outside net opening.

1.4. Square part of upper panel is composed with 3 net panels. Materials are same as the part of upper triangle-wing and upper wing parts, i.e.

a) Main net is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Numbers of mesh in length are 41.5 meshes what thread strength is 3.2 m. Length of head line attached with upper bosom is 2.7 m and numbers of hanging mesh at bosom is 15 meshes (Mesh size is 600 mm then stretch length is 9.0 m therefore hanging ratio (E) is 0.3). Numbers of meshes at upper side of square part consisted of 286 meshes of mesh size 76 mm, and 15 meshes of mesh size 600 mm. And lower side of square part is 429 meshes of mesh size 76 mm. Net cutting pattern at both rim sides of net panel is 1P1B.

b) Sub-Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width and 15 meshes in length. Mesh size is 120 mm. Sub selvage net is joined with main net by ratio 5:8 (One bar of sub-selvage mesh joined with four bars of square meshes).

c) Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 600 mm webbed by fifteen (15) meshes in width and three (3) meshes in length. Selvage net is joined with sub selvage net by ratio 1: 5 (One bar of selvage mesh joined with five bars of sub-selvage meshes).

1.5. Baiting part (or Upper belly part) is composed with 5 portions.

a) Portion No.1 is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Numbers of meshes in length are 51 meshes what thread strength is 3.8 m. Numbers of meshes at upper side of portion No. 1 are 429 meshes, and lower side is 395 meshes. Portion No.1 of baiting part is jointed with square part by ratio 1:1 = 429 times. Net cutting pattern at both rim sides of net panel is 1P1B.

b) Portion No.2 is constructed by Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 51 mm (2 inches). Numbers of meshes in length are 56 meshes what thread

strength is 2.9 m. Numbers of meshes at upper side of portion No.2 are 395 meshes and lower side is 357 meshes. Portion No.1 of baiting part is jointed with Portion No.2 by ratio 1:1 = 395 times. Net cutting pattern at both rim sides of net panel is 1P1B.

c) Portion No.3 is constructed by Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 44 mm. Numbers of meshes in length are 72 meshes what thread strength is 3.2 m. Numbers of meshes at upper side of portion No.3 is 357 meshed and lower side is 309 meshes. Portion No.2 of baiting part is jointed with Portion No.3 by ratio 1:1 = 357 times. Net cutting pattern at both rim sides of net panel is 1P1B.

d) Portion No.4 is constructed by Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 38 mm. Numbers of meshes in length are 81 meshes what thread strength is 3.1 m. Numbers of meshes at upper side of portion No.4 is 309 meshes and lower side is 255 meshes. Portion No.3 of baiting part is jointed with Portion No.4 by ratio 1:1 = 309 times. Net cutting pattern at both rim sides of net panel is 1P1B.

e) Portion No.5 is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 32 mm. Numbers of meshes in length are 157 meshes what thread strength is 5.0 m. Numbers of meshes at upper side of portion No.5 are 255 meshes and lower side is 150 meshes. Portion No.4 of baiting part is jointed with Portion No.5 by ratio 1:1 = 255 times. Net cutting pattern at both rim sides of net panel is 1P1B.

1.6. Cod-end part of upper panel is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 22 mm. Numbers of meshes in length are 182 meshes what thread strength is 4.0 m. Numbers of meshes at upper and lower side of cod-end part is 150 meshes. Portion 5 of baiting part extended with cod-end by ratio 1:1. = 150 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

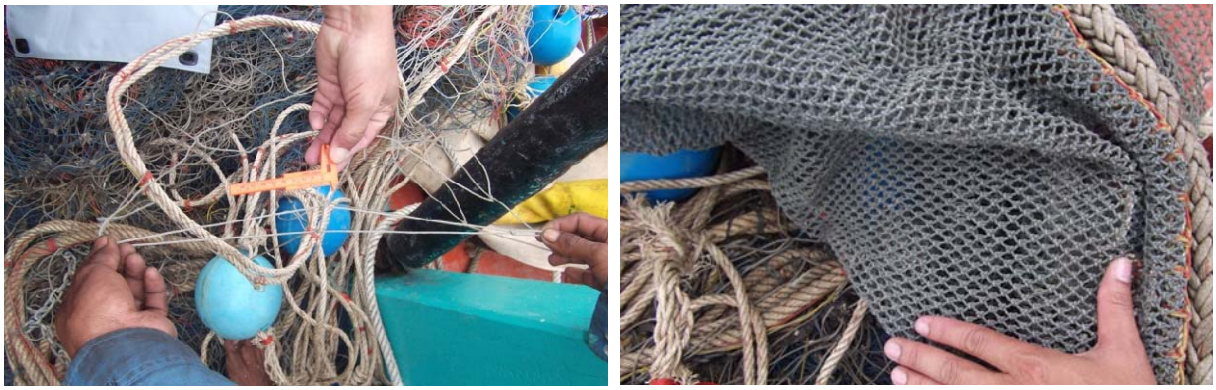

Figure 8 (Right) mesh size of wing part (Left) mesh size of cod end

Figure 9 Selvage net of bottom wing part constructed at Fishing workshop, Klongyai, Trat Province

2. Lower panel

Lower net panel is composed of five (5) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

2.1. Ground rope is a polypropylene (PP), cross rope, diameter 12 m/m. Length of ground rope is 32 m. Ratio in length between ground rope and head rope is 1.25 time.

2.2. Lower triangle-wing part is composed with 3 net panels, i.e.; a) Main net, b) Sub-selvage net, and c) Selvage net. Material, specification and net construction is similar to upper triangle-wing part.

2.3. Lower-wing part is composed with 3 net panels, Material is similar to upper triangle-wing part, i.e.

a) Main net is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Number of mesh in length is 138 meshes what thread strength is 10.5 m.

b) Sub-selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width. Mesh size is 120

mm. Sub selvage net is joined with main net by ratio 5:8 (five bar of sub-selvage mesh joined with eight bars of upper-wing meshes)

c) Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 600 mm, three (3) meshes in width. Selvage net is joined with sub selvage net by ratio 1: 5 (One bar of selvage mesh joined with five bars of sub-selvage meshes).

Total thread strength of Upper wing part (composed with selvage and sub-selvage) is 10.5 m. Length of ground rope attached with wing-end panel is 10.5 m. Net cutting pattern at head rope (included with selvage and sub-selvage net) is composed with all bar-cut (AB-Cut) at inside net opening and 1P3B at outside net opening.

2.4. Lower belly part is composed with 5 portions.

a) Portion No.1 composed with 3 net panels, i.e.;

a.1) Main net is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 76 m/m (3 inches). Numbers of mesh in length are 50.5 meshes what thread strength is 3.8 m. Length of ground rope attached with lower bosom is 2.8 m and numbers of hanging mesh at bosom is 15 meshes (Mesh size is 600 mm then stretch length is 9.0 m therefore hanging ratio (E) is 0.3). Numbers of meshes at upper side of square part consisted of 268 meshes of mesh size 76 mm, and 15 meshes of mesh size 600 mm. And lower side of square part is 395 meshes of mesh size 76 mm. Net cutting pattern at both rim sides of net panel is 1N1B.

a.2) Sub-Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm, three (3) meshes in width and 15 meshes in length. Mesh size is 120 mm. Sub selvage net is joined with main net by ratio 5:8 (One bar of sub-selvage mesh joined with four bars of square meshes).

a.3) Selvage net is constructed by Polypropylene net (PP net), yellow color. Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 600 mm webbed by fifteen (15) meshes in width and three (3) meshes in length. Selvage net is joined with sub selvage net by ratio 1: 5 (One bar of selvage mesh joined with five bars of sub-selvage meshes).

b) Portion No.2 to portion No.5 is constructed by Polyethylene net (PE net). Material, specification and net construction is similar to portion No.2 to portion No.5 of baiting part at upper net panel.

2.5. Cod-end part of upper panel is constructed by Polyethylene net (PE net). Material, specification and net construction is similar to cod-end part of baiting part at upper net panel.

Otter-boards are similar design as SEAFDEC survey in year 1986 and 2004. It is and flat trapezoid shape, made of wood and framed by iron stripes, 70 cm wide and 160 cm in length at upper side and 130 cm in length at lower side, with a bridle chain and a back strap. The sweep lines or hand-ropes are 50 m long, 25 mm in diameter, made of a combination rope. The warps are 14-28 mm in diameter, also made of polyethylene or polypropylene. A capstan winch is used for hauling warps and lifting the catch in the cod-end onto the foredeck of the fishing boat. The net is pulled by hand at stern. Four fishermen take part in a fishing operation.

General conclusion that Hybrid otter board trawl, observed at Klong-yai, Trat Province, has head rope 27 m in length and ground rope is 32 in length. Total trawl net body length is 36.54 m. Referred to *Prodo* (1990) approximated horizontal spread between end of wings is equal half of head rope = 13.5 m however such trawlers regularly installed with 2 booms (port and starboard side) 3-5 m in length. Thus horizontal spreads between both ends of wings are approximated 19.5-23.5 m in width and approximated vertical opening is 3.3-3.9 m in height.

TRAWL	Vessel	Location
Bottom, Otter	Loa 14-18	Klongyai
Squid, Shrimp, Fish	hp 190-345	Trat

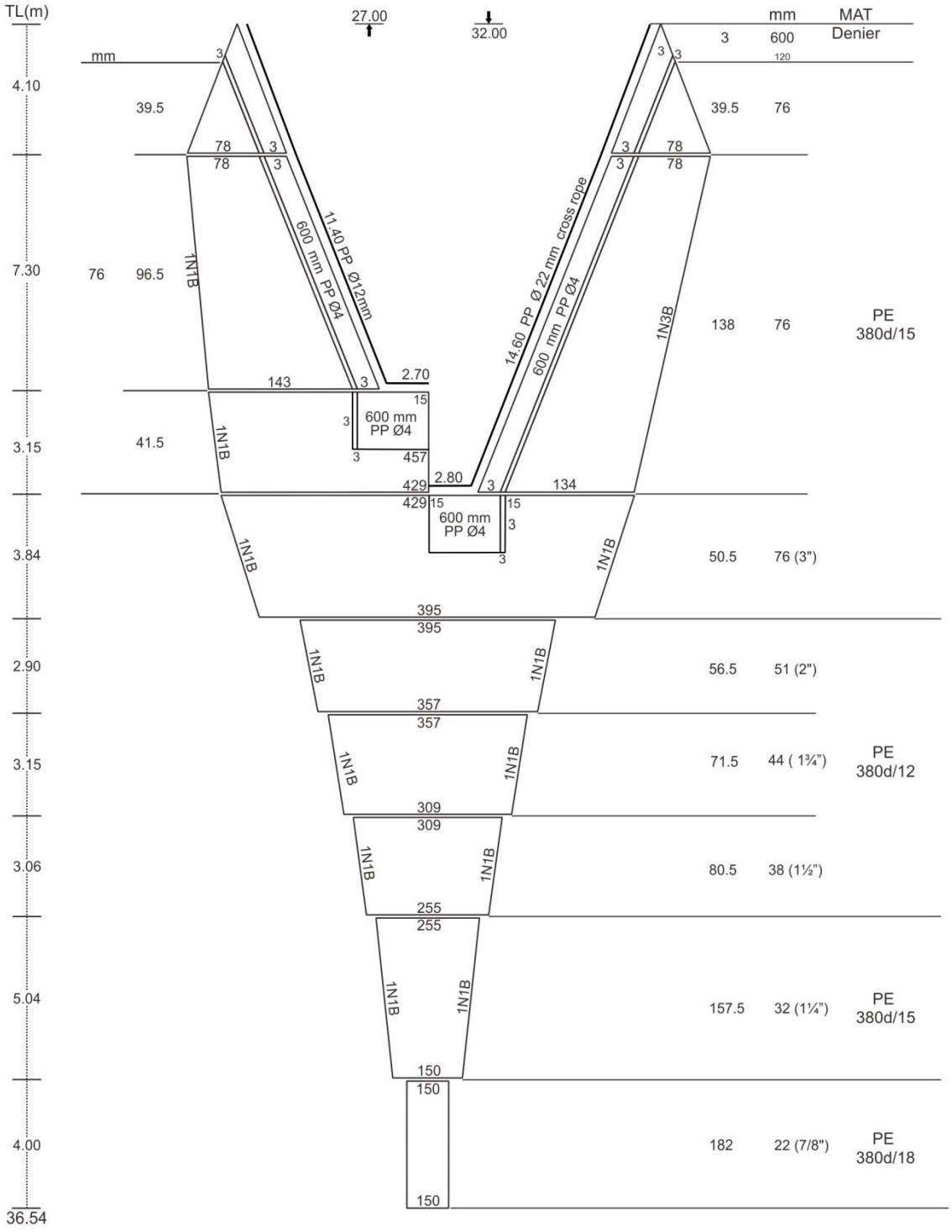

Figure 10 Trawl net sample No.1 Hybrid otter board trawl net, Klongyai, Trat Province

Table 2 Partial details of Trawl net sample No.1 Hybrid otter board trawl net, Klongyai, Trat Province

Name of parts	Twine size (Denier)	Mesh size (mm) (Stretch length)	Number of mesh			Baiting rate	Length (m)	
			Upper edge	Lower edge	Depth		Depth	Width/2
Upper triangle wing (R)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	1 + 1 (Sub-selvage) + 1 (Selvage)	78 +3 (Sub-Selvage) + 3 (Selvage)	40 + 3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: AB	4.10	NA
Upper triangle wing (L)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	1 + 1 (Sub-selvage) + 1 (Selvage)	78 +3 (Sub-Selvage) + 3 (Selvage)	40 + 3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: AB	4.10	NA
Lower triangle wing (R)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	1 + 1 (Sub-selvage) + 1 (Selvage)	78 +3 (Sub-Selvage) + 3 (Selvage)	40 + 3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: AB	4.10	NA
Lower triangle wing (L)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	1 + 1 (sub-selvage) + 1 (Selvage)	78 +3 (Sub-Selvage) + 3 (Selvage)	40 + 3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: AB	4.10	NA
Upper wing (R)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	78 + 1 (Sub-selvage) + 3 (Selvage)	143 + 1 (Sub-selvage) + 3 (Selvage)	97 +3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: 1N1B	7.30	NA
Upper wing (L)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	78 + 1 (Sub-selvage) + 3 (Selvage)	143 + 1 (Sub-selvage) + 3 (Selvage)	97 +3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: 1N1B	7.30	NA
Lower wing (R)	380D/15 +	76 mm + 120 mm	78 + 1 (Sub-	134 + 1 (Sub-	138 +3 (Sub-	Inner: AB	10.45	NA

	PP 4 mm	(Sub-selvage) + 600 mm (Selvage)	selvage) + 3 (Selvage)	selvage) + 3 (Selvage)	selvage) + 3 (Selvage)	Outer: 1N3B		

Name of parts	Twine size (Denier)	Mesh size (mm) (Stretch length)	Number of mesh			Baiting rate	Length (m)	
			Upper edge	Lower edge	Depth		Depth	Width/2
Lower wing (L)	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	78 + 1 (Sub-selvage) + 3 (Selvage)	134 + 1 (Sub-selvage) + 3 (Selvage)	138 +3 (Sub-selvage) + 3 (Selvage)	Inner: AB Outer: 1N3B	10.45	NA
Square	380D/15 + PP 4 mm	76 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	286 + 6 (Sub-selvage) + 30 (Selvage)	429	42	Left: 1N2B Right: 1N2B	3.15	NA
Baiting - belly (1) -Upper	380D/15	50.5 mm	429	395	51	Left: 1N2B Right: 1N2B	3.84	
Baiting - belly (1) -Lower	380D/15 + PP 4 mm	50.5 mm + 120 mm (Sub-selvage) + 600 mm (Selvage)	268 + 6 (Sub-selvage) + 30 (Selvage)					
Baiting - belly (2)	380D/12	51	395	357	57	1N2B	2.9	
Baiting - belly (3)	380D/12	44	357	309	72	1N2B	3.15	
Baiting - belly (4)	380D/12	38	309	255	81	1N2B	3.06	
Baiting - belly (5)	380D/15	32	255	150	158	1N2B	5.04	
Cod-end	380D/18	22	150	150	182	AP	4.00	

Table 3 Proportion of partial details of Trawl net sample No.1 Hybrid otter board trawl net, Klongyai, Trat Province

Code	Part	Length (m)	Proportion	Value
l	Head line	27	l/m	0.84
m	Ground rope	32	l/b	0.74
b	Total length	36.54	m/b	0.86
a	Stretched circumference of net mouth	71.33	a/b	1.95
c	Upper wing	11.4	c/b	0.78
d	Lower wing	14.6	d/b	0.31
e	Baiting or Belly	21.99	e/b	0.60
f	Cod-end	4.00	f/b	0.11
d-c	Square	3.15	(d-c)/b	0.09

Trawl net sample No.2

Large mesh otter board trawl

Large mesh otter board trawl is new named for bottom trawl what investigate at Kor Kasemsiri fishing port Klongyai District, Trat province. Large mesh otter board trawl is definition of trawl net what target catch is some demersal and in particular anchovy. Regarding to aforementioned details of bottom otter board trawl operated in Thailand. Large mesh otter board trawl has been categorized to fish trawl. Generally mesh size at wing part of fish trawl net is varied from 80 mm to 180 mm whereas mesh size of trawl net of wing and square part found in survey area is 4,000 mm (4 m.). Large mesh otter board trawl is also categorized to high opening otter board trawl. The characteristic of high opening make the target catch is anchovy and juvenile economic fishes. Regarding to the interview, large mesh otter board trawl is limited to operate only in the nighttime. Fishermen claim that this net design is ineffective to operate in daytime because catch is far lower than regular trawl net design.

Figure 11 (Up) Economic fished caught by large mesh trawl net (Down) Trash fish landing

Trawlers what observed to install with large mesh otter trawl net is size between14-18 m and 18-25 m. Some trawlers are assembled with 2 fishing booms (starboard side and port side; outrigger), 3-5 m long purpose for expanding sweep area. Some observed trawlers had Thai name labeled onboard and owners are Thai. From the interview, they have fishing licenses both in Thai and Cambodia Waters, however trawlers registered at Sihanouk Ville, Cambodia and all crews are Cambodians. Fleet manager is Thai and catches regularly landed in Klongyai District, Trat Province because better market price than landing at Cambodia although marine products were caught in

unidentified fishing ground, Cambodia or Thai Waters. Remarkably catch is massive quantity of anchovy. They are not sufficient preservation process on-board thus most of anchovy was delivered to animal meal factories located at Trat and adjacent province

Specification of trawler is wooden trawl, installed with a 190-350 in-board engine. Fish finder and Global Positioning Seattleite (GPS) systems are installed on-board. Trawler is 1-2 weeks trip with 8-10 fishermen included fishing master.

Figure12 Otter board trawler size 14-18 m length overall (LOA) at Kor Kasemsiri fishing port Klongyai, Trat Province

Figure 13 (Left) Otter board (Right) Bobbin at otter board pendant

Because of the limited space to examine trawl net on trawler, Investigators need to check net plan at trawl net making factory in downtown of Klongyai District. Bottom trawl net is 2

seams structure, upper panel and lower panel. Each seam composed with portions that different in net material and net specification (mesh size and twine size). Bottom trawl net design is detailed as below;

Fishing gear construction

1. Upper panel

Upper net panel is composed of six (6) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Head line is a polypropylene (PP), cross rope, diameter 12 m/m. Length of head line is 65.5 m.

1.2. Upper triangle-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 4,000 mm (4 m). Numbers of meshes in length are 5 meshes what total thread strength of lower triangle-wing part is 18.0 m in length. Length of head line attached with wing-end panel is 18.0 m. Net cutting pattern at head line, inside and outside net opening is all bar-cut (AB-Cut).

1.3. Upper-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 4,000 mm (4 m). Numbers of meshes in length are 3 meshes what total thread strength of lower triangle-wing part is 12.0 m in length. Length of head line attached with wing-end panel is 10.0 m. Net cutting pattern at head line is composed with 1T1B at inside net opening and 1P1B at outside net opening.

1.4. Square part of upper panel is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 4,000 mm (4 m). Number of mesh in length is 1 mesh what thread strength is 4.0 m in length. Length of head rope attached with upper bosom is 5.0 m and numbers of hanging meshes at bosom are 5 meshes (Mesh size is 4,000 mm then stretch length is 20.0 m therefore hanging ratio (E) is 0.3). Numbers of meshes at upper side and lower side of square part are 35 meshes. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

1.5. Baiting part is composed with 20 portions.

a) Portion No.1 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 4,000 mm (4 m). Number of mesh in length is 1 mesh what thread strength is 4.0 m in length. Numbers of meshes at upper side and lower side of

portion No. 1 are 35 meshes. Portion No.1 of baiting part is jointed with square part by ratio 1:1 = 35 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

b) Portion No.2 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 3,200 mm (3.2 m). Numbers of meshes in length are 1.5 meshes what thread strength is 4.8 m in length. Numbers of meshes at upper side and lower side of portion No. 2 is 35 meshes. Portion No.1 of baiting part is jointed with portion No.2 by ratio 1:1 = 35 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

c) Portion No.3 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 2,400 mm (2.4 m). Numbers of meshes in length 1.5 meshes what thread strength is 3.6 m in length. Numbers of meshes width of upper part and lower part is 35 meshes. Portion No.1 of baiting part is jointed with portion No.2 by ratio 1:1 = 35 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

d) Portion No.4 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 1,600 mm (1.6 m). Numbers of meshes in length are 1.5 meshes what thread strength is 2.4 m in length. Numbers of meshes width of upper part and lower part are 40 meshes. Portion No.3 of baiting part is jointed with Portion No.4 by ratio 1:1 = 30 times and 1:2 = 5 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

e) Portion No.5 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 800 mm (80 cm). Numbers of meshes in length are 2.5 meshes what thread strength is 2.0 m in length. Numbers of meshes width of upper part and lower part are 80 meshes. Portion No.4 of baiting part is jointed with Portion No.5 by ratio 1:2 = 40 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

f) Portion No.6 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 400 mm (40 cm). Number of meshes in length is 5.5 meshes what thread strength is 2.2 m in length. Numbers of meshes width of upper part and lower part are 160 meshes. Portion No.5 of baiting part is jointed with Portion No.6 by ratio 1:2 = 80 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

g) Portion No.7 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 300 mm (30 cm). Numbers of meshes in length are 15 meshes what thread strength is 4.5 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.5 of baiting part is jointed with Portion No.6 by ratio 2:3 = 80 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

h) Portion No.8 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 200 mm (20 cm). Number of meshes in length is 6 meshes what thread strength is 1.2 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.5 of baiting part is jointed with Portion No.6 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

i) Portion No.9 is constructed by Polyethylene net (PE). Twine size is 700D/15. Mesh size is 180 mm (18 cm). Numbers of meshes in length are 7 meshes what thread strength is 1.3 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.8 of baiting part is jointed with Portion No.9 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut

j) Portion No.10 is constructed by Polyethylene net (PE). Twine size is 700D/15. Mesh size is 160 mm (18 cm). Numbers of meshes in length are 7 meshes what thread strength is 1.1 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.9 of baiting part is jointed with Portion No.10 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

k) Portion No.11 is constructed by Polyethylene net (PE). Twine size is 700D/15. Mesh size is 140 mm (14 cm). Numbers of meshes in length are 9.5 meshes what thread strength is 1.5 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.10 of baiting part is jointed with Portion No.11 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

l) Portion No.12 is constructed by Polyethylene net (PE). Twine size is 700D/12. Mesh size is 120 mm (12 cm). Numbers of meshes in length are 10.5 meshes what thread strength is 1.2 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

m) Portion No.13 is constructed by Polyethylene net (PE). Twine size is 700D/12. Mesh size is 100 mm (10 cm). Numbers of meshes in length are 13 meshes what thread strength is 1.3 m in length. Numbers of meshes width of upper part and lower part are 240 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 1:1 = 240 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

n) Portion No.14 is constructed by Polyethylene net (PE). Twine size is 380D/12. Mesh size is 76 mm (3 inches). Numbers of meshes in length are 18 meshes what thread strength is 1.4 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion

No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

o) Portion No.15 is constructed by Polyethylene net (PE). Twine size is 380D/9. Mesh size is 64 mm. Numbers of meshes in length are 20 meshes what thread strength is 1.3 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

p) Portion No.16 is constructed by Polyethylene net (PE). Twine size is 380D/9. Mesh size is 38 mm. Numbers of meshes in length are 40 meshes what thread strength is 1.5 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

q) Portion No.17 is constructed by Polyethylene net (PE). Twine size is 380D/6. Mesh size is 32mm. Numbers of meshes in length are 47 meshes what thread strength is 1.5 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

r) Portion No.18 is constructed by Polyethylene net (PE). Twine size is 380D/6. Mesh size is 25 mm. Numbers of meshes in length are 68 meshes what thread strength is 1.7 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

s) Portion No.19 is constructed by Polyethylene net (PE). Twine size is 380D/6. Mesh size is 22 mm. Numbers of meshes in length are 100 meshes what thread strength is 2.2 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 6:5 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

t) Portion No. 20 is constructed by Polyethylene net (PE). Twine size is 380D/6. Mesh size is 19 mm. Numbers of meshes in length are 229 meshes what thread strength is 4.4 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.19 of baiting part is jointed with Portion No.12 by ratio 1:1 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

u) Portion No. 21 is constructed by Polyethylene net (PE). Twine size is 380D/6. Mesh size is 21 mm. Numbers of meshes in length are 187 meshes what thread strength is 2.8 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 1:1 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

v) Portion No. 22 is constructed by Polyethylene net (PE). Twine size is 380D/9. Mesh size is 15 mm. Numbers of meshes in length are 138 meshes what thread strength is 2.1 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion No.11 of baiting part is jointed with Portion No.12 by ratio 1:1 = 200 times. Net cutting pattern at both rim sides of net panel is all-point (AP) cut.

1.6. Cod-end part of upper panel is constructed by Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 15 mm. Numbers of meshes in length are 270 meshes what thread strength is 4.0 m in length. Numbers of meshes width of upper part and lower part are 200 meshes. Portion 3 of baiting part extended with cod-end by ratio 1:1. = 200 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

2. Lower panel

Lower net panel is composed of five (5) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Ground rope is two (2) A polypropylene (PP) cross rope, diameter 12 m/m, is assembled to head rope. Length of Head rope is 73.0 m.

1.2. Lower triangle-wing part is constructed by Polypropylene net (PP). Twine size is 4 mm diameter. Mesh size is 4,000 mm (4 m). Numbers of meshes in length are 5 meshes what thread strength is 18.0 m in length. Length of ground rope attached with wing-end panel is 18.0 m. Net cutting pattern at head rope, inside and outside is all bar-cut (AB-Cut).

1.3. Bottom-wing part is constructed by Polypropylene net (PP). Twine size is 4 mm diameter. Mesh size is 4,000 mm (4 m). Numbers of meshes in length are 3 meshes what thread strength is 16.0 m in length. Length of ground rope attached with wing-end panel is 11.0 m. Net cutting pattern at ground rope at inside net opening is all bar cut (AB-Cut) and 1T1B cut and outside net opening is 1P1B.

1.4. Belly part is composed with 22 portions. Portion No. 1-22 is Polyethylene net (PE net). Material, specification and net construction is similar with portion No.1-22 of baiting part at upper net panel.

1.5. Cod-end part of lower panel is constructed by Polyethylene net (PE net). Twine size is 380D/12. Mesh size is 15 mm. Material, specification and net construction is similar with cod-end part at upper net panel.

Otter-boards are rectangular shape and flat, made of wood and framed with iron stripe, 80 cm wide and 2.2 cm in total length, with a bridle chain and a back strop. The sweep lines or hand-ropes are 50 m long, 24 mm in diameter, made by a polypropylene rope (PP). Net pendants are 50 m long, 24 mm in diameter, made of a polypropylene rope (PP). Towing warps are 24 mm in diameter, also made of polyethylene. A capstan winch is used for hauling warps and lifting the catch in the cod-end onto the foredeck of the fishing boat. The net is pulled by hand at stern. Four to eight fishermen take part in a fishing operation.

Figure14 Otter board trawl net on trawler size 14-18 m length overall (LOA) at Kor Kasemsiri fishing port Klongyai, Trat Province

Figure15 Rectangular otter board design

Figure16 Otter board trawler size 14-18 m length overall (LOA) at Kor Kasemsiri fishing port Klongyai, Trat Province

Generally conclusion that large mesh trawl net, observed at Klong-yai, Trat Province, has head rope length 65 m and ground rope is 73 in length. Referred to Prodo (1990) approximated horizontal spread* between end of wings is half of head rope = 32.5 m however such trawler regularly install with booms (port and starboard size) 3-5 m in length. Thus horizontal spreads between both ends of wings are expandable to 36.5-42.5 m and approximated vertical opening is 14 m.

TRAWL	Vessel	Location
Bottom, otter		Loa 14-18
Klongyai		
Demersal fish, Anchovy	hp 190-345	Trat

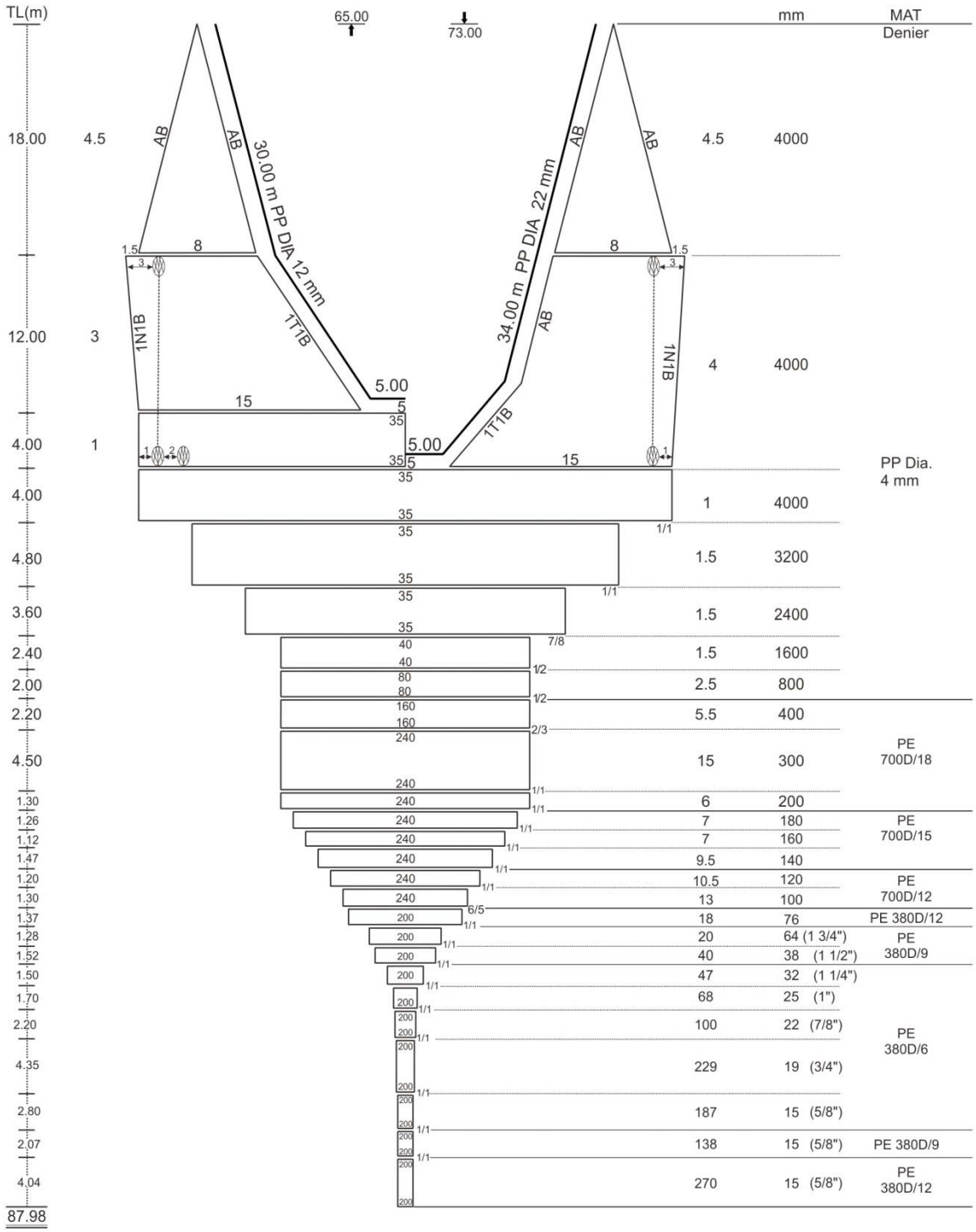

Figure17 Trawl net sample No.2 Large mesh otter board trawl Klongyai, Trat Province

Table 4 Partial details of trawl net sample No.2 Large mesh otter board trawl Klongyai, Trat Province

Name of parts	Twine size (Denier)	Mesh size (mm) (Stretch length)	Number of mesh			Baiting rate	Length (m)	
			Upper edge	Lower edge	Depth		Depth	Width/2
Upper triangle wing (R)	PP 4mm	4000	1	8	4.5	AB	18	NA
Upper triangle wing (L)	PP 4mm	4000	1	8	4.5	AB	18	NA
Lower triangle wing (R)	PP 4mm	4000	1	8	4.5	AB	18	NA
Lower triangle wing (L)	PP 4mm	4000	1	8	4.5	AB	18	NA
Upper wing (R)	PP 4mm	4000	1	15	3	Inner: 1T1B Outer: 1N1B	12	NA
Upper wing (L)	PP 4mm	4000	1	15	3	Inner: 1T1B Outer: 1N1B	12	NA
Lower wing (R)	PP 4mm	4000	1	15	4	Inner: AB, 1T1B Outer: 1N1B	16	NA
Lower wing (L)	PP 4mm	4000	1	15	4	Inner: AB, 1T1B Outer: 1N1B	16	NA
Square	PP 4mm	4000	35	35	1	AP	4	NA
Baiting - belly (1)	PP 4mm	4000	35	35	1	AP	4	280.0
Baiting - belly (2)	PP 4mm	3200	35	35	1.5	AP	4.8	224.0
Baiting - belly (3)	PP 4mm	2400	35	35	1.5	AP	3.6	168.0
Baiting - belly (4)	PP 4mm	1600	40	40	1.5	AP	3.6	128.0
Baiting - belly (5)	PP 4mm	800	80	80	2.5	AP	2.0	64.0

Baiting - belly (6)	700D/18	400	160	160	5.5	AP	2.2	64.0
Baiting - belly (7)	700D/18	300	240	240	15	AP	4.5	72.0
Baiting - belly (8)	700D/18	200	240	240	6.5	AP	1.3	48.0
Baiting - belly (9)	700D/15	180	240	240	7	AP	1.26	43.2
Baiting - belly (10)	700D/15	160	240	240	7	AP	1.12	38.4
Baiting - belly (11)	700D/15	140	240	240	9.5	AP	1.47	33.6
Baiting - belly (12)	700D/12	120	240	240	10.5	AP	1.3	28.8
Baiting - belly (13)	700D/12	100	240	240	13	AP	1.3	24.0
Baiting - belly (14)	380D/12	76	200	200	18	AP	1.37	15.2
Baiting - belly (15)	380D/9	64	200	200	20	AP	1.28	12.8
Baiting - belly (16)	380D/9	38	200	200	40	AP	1.52	7.6
Baiting - belly (17)	380D/6	32	200	200	47	AP	1.50	6.4
Baiting - belly (18)	380D/6	25	200	200	68	AP	1.70	5.0
Baiting - belly (19)	380D/6	22	200	200	100	AP	2.20	4.4
Baiting - belly (20)	380D/6	19	200	200	229	AP	4.35	3.8
Cod-end -1	380D/6	15	200	200	187	AP	2.80	3.0
Cod-end -2	380D/9	15	200	200	138	AP	2.07	3.0
Cod-end -3	380D/16	15	200	200	270	AP	4.04	3.0

* Baiting-Belly is only upper panel

** Coend 2 is Double Twine PE 380D/15

Table 5 Proportion of partial details of trawl net sample No.2 Large mesh otter board trawl Klongyai, Trat Province

Code	Part	Length (m)	Proportion	Value
l	Head line	65	l/m	0.89
m	Ground rope	73	l/b	0.74
b	Total length	88	m/b	0.83
a	Stretched circumference of net mouth	280	a/b	3.18
c	Upper wing	30	c/b	0.34
d	Lower wing	34	d/b	0.39
e	Baiting or Belly	53.98	e/b	0.61
f	Cod-end	8.91	f/b	0.10
d-c	Square	4	(d-c)/b	0.05

Trawl net sample No.3

Large mesh Pair trawl (High Opening Design II)

Large mesh pair trawl is newly named for bottom pair trawl what had been investigated at fishing port Mahachai District, Samutsakhon province. Large mesh pair trawl is definition of trawl net what target catch is some demersal and in particular anchovy, same as trawl net sample No.2. Generally mesh size at wing part of regular pair trawl net is varied from 140 mm to 180 mm whereas mesh size of trawl net of wing and square part found in survey area is 960 mm (96 cm.). Large mesh otter board trawl is also categorized to high opening otter board trawl. The characteristic of high opening make higher composition of by-target catch, i.e. anchovy and juvenile economic fishes. Regarding to the interview, large mesh pair trawl is limited to operate only in the nighttime, same as large mesh otter trawl. Fishermen claim that this net design is ineffective to operate in daytime because catch is far lower than regular trawl net design.

Referred to interview pair trawl fisherman at Laem Ngob fishing port, Trat Province and Samaesarn Village, Cholburi province, large mesh pair trawl design has been transferred from Vietnam Fishermen. Some pair trawlers has been traded and operated in Vietnam Waters has been installed large mesh pair trawl several years ago. While Thai fishing company bought pair trawler back from Vietnam, trawl net was store into cargo hold then Thai pair trawl fishers had trial large mesh pair trawl net and found it was excellent high opening performance and higher catch on anchovy. At present, large mesh pair trawl has been dispersedly operated throughout the Gulf of Thailand.

Trawlers what observed to install with large mesh otter trawl net appear length overall between 18-25 m and over 25 m. In pair trawling, the net mouth is kept expand by outward towing of the two boats, which always try to keep the same distance between them during operation. Otter boards are not necessary. Observed to F.V. Ariyasin, pair trawler based at Samut songkram province but operated in Trat and adjacent province, eastern part of the Gulf of Thailand, appeared that dominant catches by large mesh pair trawl net is mixed by demersal and pelagic resources. There are some demersal fishes e.g. Crocker, Flathead (*Platycephalus* sp.), some

rocky fishes, e.g. Grouper (*Epinehelus* spp.), emperor fish (*Letrinus* spp.) and some pelagic fish, e.g. Bonito (*Euthynnus* sp.), Sardine, etc. Remarkably catch is massive quantity of anchovy. They are not sufficient preservation process on-board thus most of anchovy was delivered to feed meal factories located at Trat and adjacent province. However some anchovies had been delivered to animal meal factories at the Central of Thailand as well. Catch result observed from pair trawl have shown the efficiency of gear what perform by the high opening characteristic. Therefore the most update design of pair trawl net in the Gulf of Thailand is high opening what will be effect to abundant of marine resources in the Gulf of Thailand soon regarding to catch low tropic level fish, i.e. anchovy.

Figure 18 Economic pelagic species caught by pair trawl

Figure 19 Economic demersal species caught by pair trawl

Specification of trawler is wooden trawl, installed with a 350-550 hp in-board engine. Fish finder and Global Positioning Seattleite (GPS) systems are installed on-board. Trawler is 1-2 weeks trip with 20-24 fishermen included fishing master.

Regarding to the limited space to examine trawl net on trawler, Investigators need to check net plan at trawl net making factory in downtown of Mahachai District, Samutsakhon Province. Pair trawl net is two (2) seams construction, upper panel and lower panel. Each seam composed with portions that different in net material and net specification (mesh size and twine size). Large mesh pair trawl net design is detailed as below;

Fishing gear construction

1. Upper panel

Upper net panel is composed of five (5) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Head rope is a polypropylene (PP) cross rope, diameter 24 m/m. Length of Head rope is 81 m.

1.2. Upper triangle-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshed in length are 14.5 meshes what thread strength is 13.9 m in length. Length of head rope attached with wing-end panel is 13.9 m. Net cutting pattern at head rope, inside and outside net opening is all bar-cut (AB-Cut).

1.3. Upper-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 25 meshes what thread strength is 24.0 m in length. Length of head rope attached with upper-wing

net panel is 24.1 m. Net cutting pattern at head rope, inside net opening is all bar-cut (AB-Cut) and outside net opening is 1N4B.

1.4. Square part of upper panel is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 6 meshes what thread strength is 5.8 m in length. Length of head rope attached with upper bosom is 5.0 m and numbers of hanging meshes at upper bosom are 54 meshes (Mesh size is 960 mm then stretch length is 51.8 m therefore hanging ratio (E) is 0.1). Numbers of meshes in upper side of square part are 126 meshes and lower side is 120 meshes. Net cutting pattern at both rim sides of net panel is 1N2B.

1.5. Baiting part is composed with 9 portions.

a) Portion No.1 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 6 meshes what thread strength is 5.8 m in length. Numbers of meshes at upper side of portion No. 1 are 120 meshes, and lower side is 114 meshes. Portion No.1 of baiting part is jointed with square part by ratio 1:1 = 120 times. Net cutting pattern at both rim sides of net panel is 1N2B.

b) Portion No.2 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 480 mm (48 cm). Numbers of meshes in length are 10 meshes what thread strength is 4.8 m in length. Numbers of meshes at upper side of portion No.2 are 228 meshes, and lower side is 218 meshes. Portion No.1 of baiting part is jointed with portion No.2 by ratio 1:2 = 114 times. Net cutting pattern at both rim sides of net panel is 1N2B.

c) Portion No.3 is constructed by Polyethylene net (PE). Twine size is 700D/24. Mesh size is 480 mm (48 cm). Numbers of meshes in length are 22 meshes what thread strength is 5.3 m in length. Numbers of meshes at upper side of portion No.3 are 436 meshes, and lower side is 414 meshes. Portion No.2 of baiting part is jointed with portion No.3 by ratio 1:2 = 218 times. Net cutting pattern at both rim sides of net panel is 1N2B.

d) Portion No.4 is constructed by Polyethylene net (PE). Twine size is 700D/24. Mesh size is 200 mm (20 cm). Numbers of meshes in length are 22 meshes what thread strength is 4.4 m in length. Numbers of meshes at upper side of portion No.4 are 497 meshes, and lower part is 475 meshes. Portion No.3 of baiting part is jointed with portion No.4 by ratio 1:1 = 331 times and 1:2 = 83 times. Net cutting pattern at both rim sides of net panel is 1N2B.

e) Portion No.5 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 160 mm (16 cm). Numbers of meshes in length are 22 meshes what thread strength is 3.5 m in length. Numbers of meshes at upper side of portion No.5 are 594 meshes, and lower part

is 572 meshes. Portion No.4 of baiting part is jointed with portion No.5 by ratio 1:1 = 356 times and 1:2 = 119 times. Net cutting pattern at both rim sides of net panel is 1N2B.

f) Portion No.6 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 120 mm (12 cm). Numbers of meshes in length are 51 meshes what thread strength is 6.12 m in length. Numbers of meshes at upper side of portion No.6 are 572 meshes, and lower part is 521 meshes. Portion No.5 of baiting part is jointed with portion No.6 by ratio 1:1 = 572 times. Net cutting pattern at both rim sides of net panel is 1N2B.

g) Portion No.7 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 76 mm. Numbers of meshes in length are 51 meshes what thread strength is 3.8 m in length. Numbers of meshes at upper side of portion No.6 are 521 meshes, and lower part is 470 meshes. Portion No.5 of baiting part is jointed with Portion No.6 by ratio 1:1 = 521 times. Net cutting pattern at both rim sides of net panel is 1N2B.

h) Portion No.8 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 51 mm. Numbers of meshes in length are 70 meshes what thread strength is 3.57 m in length. Numbers of meshes at upper side of portion No.6 are 470 meshes, and lower part is 400 meshes. Portion No.7 of baiting part is jointed with Portion No.8 by ratio 1:1 = 470 times. Net cutting pattern at both rim sides of net panel is 1N2B.

i) Portion No.9 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 38 mm. Numbers of meshes in length are 150 meshes what thread strength is 5.7 m in length. Number Numbers of meshes at upper side of portion No.6 are 400 meshes, and lower part is 300 meshes. Portion No.8 of baiting part is jointed with Portion No.9 by ratio 1:1 = 400 times. Net cutting pattern at both rim sides of net panel is 1N2B.

1.6. Cod-end part is composed with 2 portions, i.e.

a) Pre cod-end part is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 25 mm. Numbers of meshes in length are 720 meshes what thread strength is 18.0 m in length. Numbers of meshes at upper side and lower side of pre cod-end part are 300 meshes. Pre cod-end part jointed with Portion No.9 of baiting by ratio 1:1 = 300 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

b) Cod-end part is constructed by Polyethylene net (PE net) double twines. Twine size is 380D/15. Mesh size is 25 mm. Numbers of meshes in length are 240 meshes what thread strength is 6.0 m in length. Numbers of meshes at upper side and lower side of cod-end part are 300 meshes. Actual cod-end jointed with Pre cod-end part by ratio 1:1 = 300 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

2. Lower panel

Lower net panel is composed of five (5) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Ground rope is a polypropylene (PP) cross rope, diameter 24 mm. Length of Head rope is 91.4 m.

1.2. Lower triangle-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 14.5 meshes what thread strength is 13.9 m in length. Length of ground rope attached with wing-end panel is 13.9 m. Net cutting pattern at head rope, inside and outside net opening is all bar-cut (AB-Cut).

1.3. Lower-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 31 meshes what thread strength is 31.8 m in length. Length of ground rope attached with bottom wing panel is 29.7 m. Net cutting pattern at ground rope, inside net opening is all bar-cut (AB-Cut) and outside net opening is 1N4B.

1.4. Belly part is composed with 9 portions.

a) Portion No. 1 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are 6 meshes what thread strength is 5.76 m in length. Length of ground rope attached with lower bosom is approximately 4 m and numbers of hanging mesh at bottom bosom are 44 meshes (Mesh size is 960 mm then stretch length is 42.2 m therefore hanging ratio (E) = 0.1). Numbers of meshes at upper side of portion No. 1 are 120 meshes, and lower side is 114 meshes. Net cutting pattern at both rim sides of net panel is 1N2B.

b) Portion No. 2 to portion No.9 of bottom belly part is constructed by Polyethylene net (PE net). Material, specification and net construction is similar to portion No.2 to portion No.9 of baiting part at upper net panel.

1.5. Cod-end part is composed with 2 portions both portions are similar material specification and net construction to upper net panel.

Generally conclusion that pair trawl net, observed at Mahachai district, Samutsakhon Province, has head rope length 81 m and ground rope is 91.4 in length. Referred to Prodo (1990)

approximated horizontal spread* between end of wings is half of head rope more than 40 m. and approximated vertical opening is 12-14 m.

Figure 21 Wooden, rubber and stainless steel bobbin of pair trawl are assembled at ground rope

Figure 22 Ground rope, selvage net, wing net and net body of trawl net

Figure 23 Wooden, rubber and stainless steel bobbin of pair trawl are assembled at ground rope

TRAWL	Vessel	Location
Bottom, pair	Choke-udomsin	Mahachai,
Squid, demersal fish	Loa 18-25	Maung Samutsakhon
	hp 500	

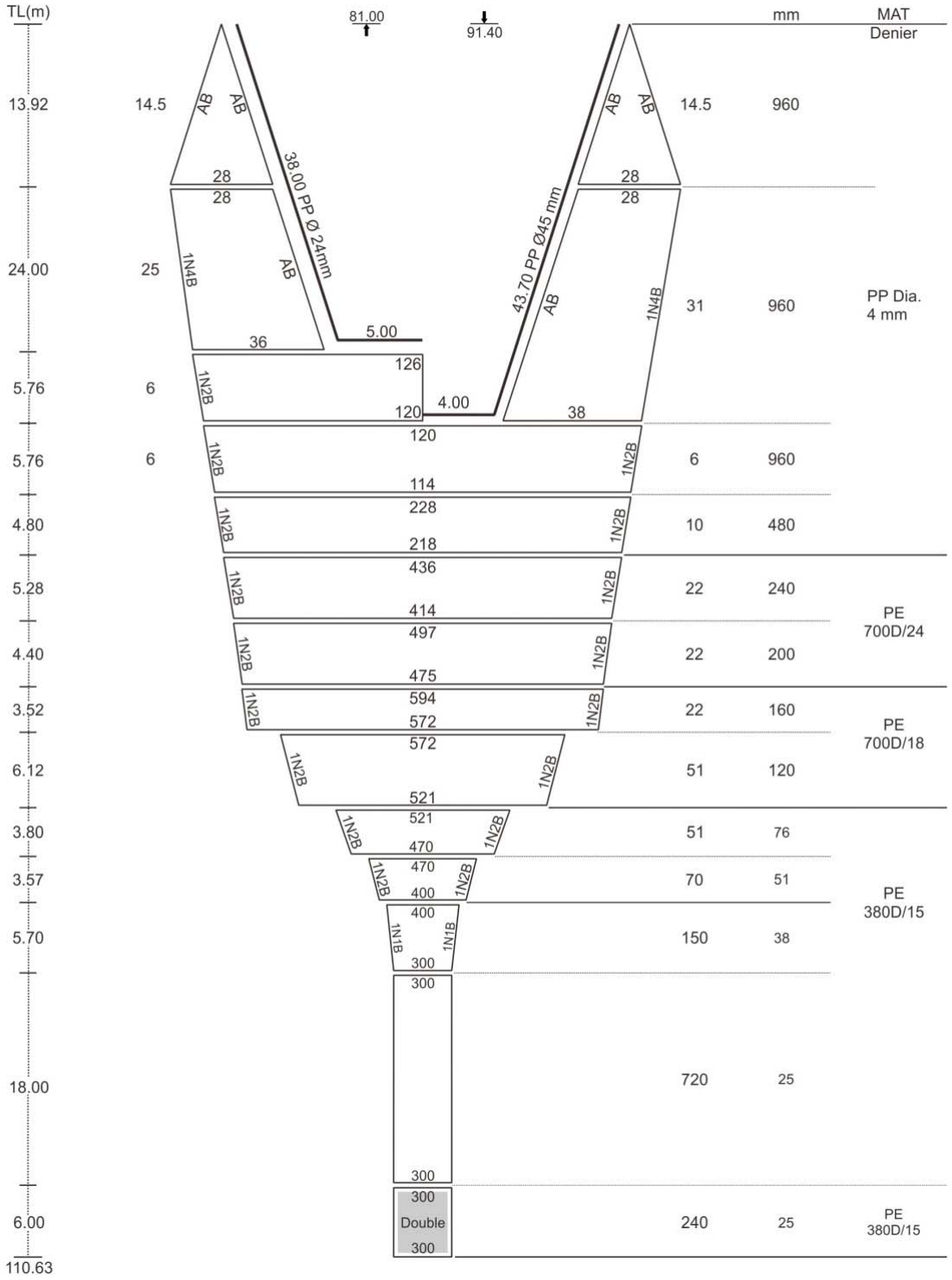

Figure 24 Trawl net sample No.3 Large mesh Pair trawl (High Opening Design II)

Table 6 Partial details of trawl net sample No.3 Large mesh Pair trawl (High Opening Design II)

Name of parts	Twine size (Denier)	Mesh size (mm) (Stretch length)	Number of mesh			Baiting rate	Length (m)	
			Upper edge	Lower edge	Depth		Depth	Width/2
Upper triangle wing (R)	PP 4mm	960	1	28	14.5	AB	13.92	NA
Upper triangle wing (L)	PP 4mm	960	1	28	14.5	AB	13.92	NA
Lower triangle wing (R)	PP 4mm	960	1	28	14.5	AB	13.92	NA
Lower triangle wing (L)	PP 4mm	960	1	28	14.5	AB	13.92	NA
Upper wing (R)	PP 4mm	960	28	36	25	Inner: AB Outer: 1N4B	24	NA
Upper wing (L)	PP 4mm	960	28	36	25	Inner: AB Outer: 1N4B	24	NA
Lower wing (R)	PP 4mm	960	28	38	31	Inner: AB Outer: 1N4B	31.76	NA
Lower wing (L)	PP 4mm	960	28	33	31	Inner: AB Outer: 1N4B	31.76	NA
Square	PP 4mm	960	126	120	6	1N2B	5.76	NA
Baiting - belly (1)	PP 4mm	960	120	114	6	1N2B	5.76	115.20
Baiting - belly (2)	PP 4mm	480	228	218	10	1N2B	4.80	109.44
Baiting - belly (3)	PE 700D/24	240	436	414	22	1N2B	5.28	104.64
Baiting - belly (4)	PE 700D/24	200	497	475	22	1N2B	4.40	99.40
Baiting - belly (5)	PE 700D/18	160	594	572	22	1N2B	3.52	95.04

Baiting - belly (6)	PE 700D/18	120	572	521	51	1N2B	6.12	68.64
Baiting - belly (7)	PE 380D/15	76	521	470	51	1N2B	3.8	39.60
Baiting - belly (8)	PE 380D/15	51	470	400	70	1N2B	3.57	23.97
Baiting - belly (9)	PE 380D/15	38	400	300	120	1N1B	5.70	15.20
Name of parts	**Twine size (Denier)**	**Mesh size (mm) (Stretch length)**	**Number of mesh**			**Baiting rate**	**Length (m)**	
			Upper edge	**Lower edge**	**Depth**		**Depth**	**Width/2**
Cod-end -1	PE 380D/15	25	300	300	720	AP	18.00	7.50
Cod-end -2**	PE 380D/15	25	300	300	240	AP	6.00	7.50

* Baiting-Belly is reported only upper panel

** Cod-end 2 is Double Twine PE 380D/15

Table 7 Proportion of partial details of trawl net sample No.3 Large mesh Pair trawl (High Opening Design II)

Code	Part	Length (m)	Proportion	Value
l	Head line	81.00	l/m	0.89
m	Ground rope	91.40	l/b	0.73
b	Total length	110.63	m/b	0.83
a	Stretched circumference of net mouth	115.20	a/b	1.04
c	Upper wing	24.00	c/b	0.22
d	Lower wing	31.76	d/b	0.29
e	Baiting or Belly	42.95	e/b	0.39

f	Cod-end	24.00	f/b	0.22
d-c	Square	5.76	(d-c)/b	0.05

Trawl net sample No.4

Large mesh Pair trawl (High Opening Design III)

Large mesh pair trawl is also newly named for bottom pair trawl what had been investigate at fishing port Mahachai District, Samutsakhon province. Large mesh pair trawl is definition of trawl net what target catch is some demersal and in particular anchovy, same as trawl net sample No.2 and No.3. However mesh size at wing part of large mesh pair trawl net, sample No.4 is 1,920 mm (1.92 m), twice times larger of large mesh pair trawl net sample No.3 mm (960 mm). Other details of large mesh pair trawl net sample No.4 are similar to sample No. 3

Figure 25 Anchovy caught by pair trawl and supply to fishmeal industry

Fishing gear construction

1. Upper panel

Upper net panel is composed of six (6) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

1.1. Head rope is a polypropylene (PP), cross rope, diameter 24 m/m. Length of Head rope is 83.8 m.

1.2. Upper triangle-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Numbers of meshes in length are 7.5 meshes what thread strength is 14.4 m in length. Length of head rope attached with upper triangle wing-end panel is 14.4 m. Net cutting pattern at head rope, inside and outside net opening is all bar-cut (AB-Cut).

1.1. Upper-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Numbers of meshes in length are 13 meshes what thread strength is 24.96 m in length. Length of head rope attached with upper wing-end panel is 25 m. Net cutting pattern at head rope, inside net opening is all bar-cut (AB-Cut) and outside net opening is 1N4B.

1.2. Square part of upper panel is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Numbers of meshes in length are 2.5 meshes what thread strength is 4.8 m in length. Length of head rope attached with upper bosom is 5.0 m and numbers of hanging meshes at upper bosom are 27 meshes (Mesh size is 1920 mm then stretch length is 51.8 m therefore hanging ratio (E) is 0.1). Numbers of meshes at upper side of square part are 63 meshes and lower part is 60 meshes. Net cutting pattern at both rim sides of net panel is 1N2B.

1.3. Baiting part is composed with 10 portions.

a) Portion No.1 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Numbers of meshes in length are 2.5 meshes what thread strength is 4.8 m in length. Numbers of meshes at upper side of portion No.1 are 60 meshes, and lower part is 57 meshes. Portion 1 of baiting part is jointed with square part by ratio 1:1 = 60 times. Net cutting pattern at both rim sides of net panel is 1N2B.

b) Portion No.2 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 960 mm (96 cm). Numbers of meshes in length are

5.5 meshes what thread strength is 5.3 m in length. Numbers of meshes at upper side of portion No.2 are 114 meshes, and lower part is 108 meshes. Portion No.1 of baiting part is jointed with portion No.2 by ratio 1:2 = 57 times. Net cutting pattern at both rim sides of net panel is 1N2B.

c) Portion No.3 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 4.0 mm. Mesh size is 480 mm (48 cm). Numbers of meshes in length are 10 meshes what thread strength is 4.8 m in length. Numbers of meshes at upper side of portion No.3 are 216 meshes, and lower part is 206 meshes. Portion 2 of baiting part is jointed with portion No.3 by ratio 1:2 = 108 times. Net cutting pattern at both rim sides of net panel is 1N2B.

d) Portion No.4 is constructed by Polyethylene net (PE). Twine size is 700D/24. Mesh size is 240 mm (24 cm). Numbers of meshes in length are 12 meshes what thread strength is 2.9 m in length. Numbers of meshes at upper side of portion No.4 are 412 meshes, and lower part is 400 meshes. Portion 3 of baiting part is jointed with portion No.4 by ratio 1:2 = 206 times. Net cutting pattern at both rim sides of net panel is 1N2B.

e) Portion No.5 is constructed by Polyethylene net (PE). Twine size is 700D/24. Mesh size is 200 mm (20 cm). Numbers of meshes in length are 22 meshes what thread strength is 4.4 m in length. Numbers of meshes at upper side of portion No.5 are 480 meshes, and lower part is 458 meshes. Portion 4 of baiting part is jointed with portion No.5 by ratio 1:1 = 320 times and 1:2 = 80 times. Net cutting pattern at both rim sides of net panel is 1N2B.

f)Portion No.6 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 160 mm (16 cm). Numbers of meshes in length are 22 meshes what thread strength is 3.5 m in length. Numbers of meshes at upper side of portion No.6 are 572 meshes, and lower part is 550 meshes. Portion 5 of baiting part is jointed with portion No.6 by ratio 1:1 = 344 times and 1:2 = 114 times. Net cutting pattern at both rim sides of net panel is 1N2B.

g) Portion No.7 is constructed by Polyethylene net (PE). Twine size is 700D/18. Mesh size is 120 mm (12 cm). Numbers of meshes in length are 50 meshes what thread strength is 6.0 m in length. Numbers of meshes at upper side of portion No.7 are 550 meshes, and lower part is 500 meshes. Portion 6 of baiting part is jointed with portion No.7 by ratio 1:1 = 550 times. Net cutting pattern at both rim sides of net panel is 1N2B.

h) Portion No.8 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 76 mm. Numbers of meshes in length are 50 meshes what thread strength is 3.8 m in length. Numbers of meshes at upper side of portion No.8 are 500 meshes, and lower part is 450 meshes. Portion No.7 of baiting part is jointed with portion No.8 by ratio 1:1 = 500 times. Net cutting pattern at both rim sides of net panel is 1N2B.

i) Portion No.9 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 51 mm. Numbers of meshes in length are 50 meshes what thread strength is 2.6 m in length Numbers of meshes at upper side of portion No.9 are 450 meshes, and lower part is 400 meshes. Portion No.8 of baiting part is jointed with portion No.9 by ratio 1:1 = 450 times. Net cutting pattern at both rim sides of net panel is 1N2B.

j) Portion No.10 is constructed by Polyethylene net (PE). Twine size is 380D/15. Mesh size is 38 mm. Numbers of meshes in length are 150 meshes what thread strength is 5.7 m in length. Numbers of meshes at upper side of portion No.10 are 400 meshes, and lower part is 300 meshes. Portion No.8 of baiting part is jointed with Portion No.9 by ratio 1:1 = 400 times. Net cutting pattern at both rim sides of net panel is 1N2B.

1.4. Cod-end part is composed with 2 portions, *i.e.*

a) Pre cod-end part is constructed by Polyethylene net (PE net). Twine size is 380D/15. Mesh size is 25 mm. Numbers of meshes in length are 720 meshes what thread strength is 18.0 m in length. Numbers of meshes at upper side and lower side of pre cod-end part are 300 meshes. Pre cod-end part jointed with Portion No.9 of baiting by ratio 1:1 = 300 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

b) Cod-end part is constructed by Polyethylene net (PE net) double twines. Twine size is 380D/15. Mesh size is 25 mm. Numbers of meshes in length are 240 meshes what thread strength is 6.0 m in length. Numbers of meshes at upper side and lower side of cod-end part are 300 meshes. Cod-end jointed with Pre cod-end part by ratio 1:1 = 300 times. Net cutting pattern both rim sides of net panel is all-point cut (AP).

2. Lower panel

Lower net panel is composed of five (5) main parts. Each part is different of material and net specification. Details of net parts are listed as below;

2.1. Ground rope is a polypropylene (PP) cross rope, diameter 45 mm. Length of ground rope is 98.0 m.

2.2. Lower triangle-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Number of mesh in length is 7.5 meshes what thread strength is 14.4 m in length. Length of head rope seized with wing-end panel is 14.4 m. Net cutting pattern at head rope, inside and outside is all bar-cut (AB-Cut).

2.3. Lower-wing part is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Number of mesh in length is 15.5 meshes what thread strength is 29.8 m in length. Length of ground rope attached with bottom wing panel is 32.6 m. Net cutting pattern at ground rope, inside net opening is all bar-cut (AB-Cut) and outside net opening is 1N4B.

2.4. Belly part is composed with 10 portions.

a) Portion No. 1 is constructed by Polypropylene net (PP). Net is handy webbed by PP twine. Diameter is 5.0 mm. Mesh size is 1,920 mm (1.92 m). Number of mesh in horizontal 2.5 meshes what thread strength is 4.8 m in length. Length of ground rope attached with lower bosom is approximately 4 m and numbers of hanging mesh at bottom bosom are 21 meshes (Mesh size is 1920 mm then stretch length is 40.32 m therefore hanging ratio (E) = 0.1). Number of mesh in upper part is 60 meshes, and lower part is 57 meshes. Net cutting pattern at both rim sides of net panel is 1N2B.

b) Portion No. 2 to portion No.10 of bottom belly part is constructed by Polyethylene net (PE net). Material, specification and net construction is similar to portion No.2 to portion No.10 of baiting part at upper net panel.

2.5. Cod-end part is composed with 2 portions both portions are similar material specification and net construction to upper net panel.

Generally conclusion that pair trawl net, observed at Mahachai District, Samutsakhon Province, has head rope length 83.8 m and ground rope is 98.0 in length. Referred to Prodo (1990) approximated horizontal spread* between end of wings is half of head rope more than 42 m. and approximated vertical opening is 12-14 m.

Figure 26 Pair trawler “Ariyasin” is landing catches at Laem-ngob fishing port, Trat Province

TRAWL	Vessel	Location
Bottom, pair	Choke-udomsin	Mahachai,
Demersal fish, Anchovy	Loa 18-25	Maung Samutsakhon
	hp 500	

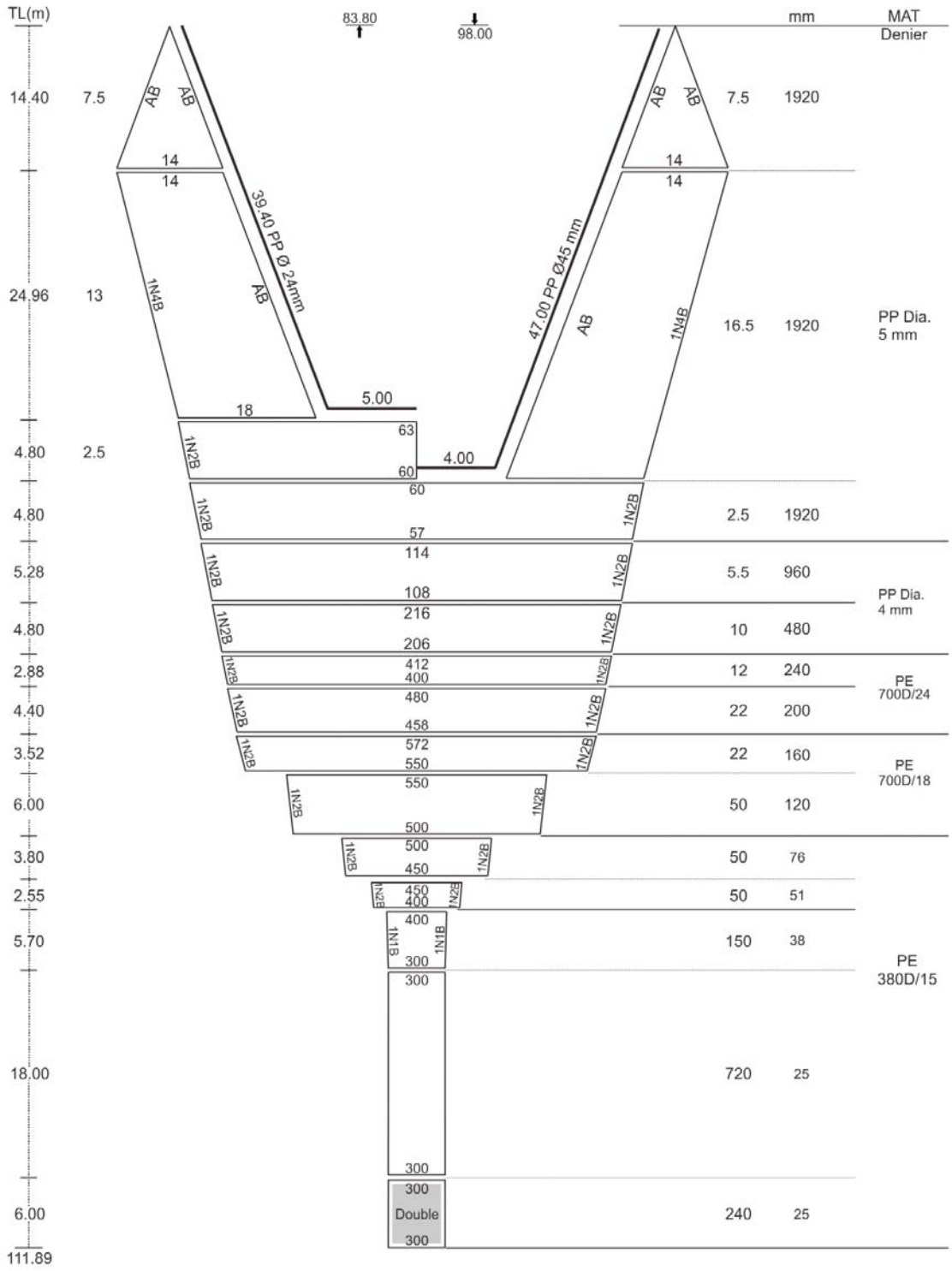

Figure 29 Trawl net sample No.4 Large mesh Pair trawl (High Opening Design III)

Table 8 Partial details of trawl net sample No.4 Large mesh Pair trawl (High Opening Design III)

Name of parts	Twine size (Denier)	Mesh size (mm) (Stretch length)	Number of mesh			Baiting rate	Length (m)	
			Upper edge	Lower edge	Depth		Depth	Width/2
Upper triangle wing (R)	PP 4mm	1920	1	14	7.5	AB	14.40	NA
Upper triangle wing (L)	PP 4mm	1920	1	14	7.5	AB	14.40	NA
Lower triangle wing (R)	PP 4mm	1920	1	14	7.5	AB	14.40	NA
Lower triangle wing (L)	PP 4mm	1920	1	14	7.5	AB	14.40	NA
Upper wing (R)	PP 4mm	1920	14	18	13	Inner: AB Outer: 1N4B	14.40	NA
Upper wing (L)	PP 4mm	1920	14	18	13	Inner: AB Outer: 1N4B	14.40	NA
Lower wing (R)	PP 4mm	1920	14	20	15.5	Inner: AB Outer: 1N4B	24.96	NA
Lower wing (L)	PP 4mm	1920	14	20	15.5	Inner: AB Outer: 1N4B	24.96	NA
Square	PP 4mm	1920	63	60	2.5	1N2B	4.80	NA
Baiting - belly (1)	PP 4mm	1920	60	57	2.5	1N2B	4.80	NA
Baiting - belly (2)	PP 4mm	960	114	108	5.5	1N2B	5.28	109.44
Baiting - belly (3)	PE 700D/24	480	216	206	10	1N2B	4.80	103.68
Baiting - belly (4)	PE 700D/24	240	412	400	12	1N2B	2.88	98.88
Baiting - belly (5)	PE 700D/18	200	480	458	22	1N2B	4.40	96

Baiting - belly (5)	PE 700D/18	160	572	550	22	1N2B	3.52	91.52
Baiting - belly (6)	PE 700D/18	120	550	500	50	1N2B	6.0	66
Baiting - belly (7)	PE 380D/15	76	500	450	50	1N2B	3.8	38
Name of parts	**Twine size (Denier)**	**Mesh size (mm) (Stretch length)**	**Number of mesh**			**Baiting rate**	**Length (m)**	
			Upper edge	**Lower edge**	**Depth**		**Depth**	**Width/2**
Baiting - belly (8)	PE 380D/15	51	450	400	50	1N2B	2.55	22.95
Baiting - belly (9)	PE 380D/15	38	400	300	150	1N1B	5.7	15.2
Cod-end -1	PE 380D/15	25	300	300	720	AP	18.00	7.5
Cod-end -2**	PE 380D/15	25	300	300	240	AP	6.00	7.5

* Baiting-Belly is reported only upper panel

** Cod-end 2 is Double Twine PE 380D/15

Table 8 Proportion of trawl net sample No.4 Large mesh Pair trawl (High Opening Design III)

Code	Part	Length (m)	Proportion	Value
l	Head line	83.8	l/m	0.86
m	Ground rope	98	l/b	0.75
b	Total length	111.89	m/b	0.88
a	Stretched circumference of net mouth	109.44	a/b	0.98
c	Upper wing	39.4	c/b	0.35
d	Lower wing	47	d/b	0.42

e	Baiting or Belly	43.73	e/b	0.39
f	Cod-end	24	f/b	0.21
d-c	Square	4.8	(d-c)/b	0.04

Discussion and Recommendation

Lessen learn by the fishing gear survey has shown that fishing technology has been obviously developed or modified suitable for specific purpose, such as target catch, fisheries resources and better practices. Hence fishing technology information is necessary to update regularly.

Trawl net sample No.1 (Hybrid otter board trawl)

Trawl net sample No.1 (Hybrid otter board trawl) is categorized into bottom single trawl target for fish notified by material and specification of head rope and ground rope, length and engine of trawler and catch result. However Codend net material and mesh size is only similarity design with the original trawl design surveyed in year 1986 and 2004. Codend net is Polyethylene net mesh size 20-25 mm (dominant mesh size is 20 mm.). The extended net length of width behind square part indicates the high opening design of trawl net is same as original trawl net in Thailand what almost of them found less than 60 m. Trawl net sample No.1 has been obviously developed for vigorous net structure for particular fishing operation and fishing ground. Thus, there are few modifications different from trawl design surveyed in year 1986 and 2004. Details are described as followed;

1) Mesh size

Original bottom trawl net design in Thailand is constructed with net panel mesh size of wing and square pert as 140-180 mm. But mesh size at wing and square part of trawl net sample No.1 or Hybrid otter board trawl is 75 mm. It reflects that; 1) Target catch of trawl net sample No.1, *i.e.* cuttlefish, Banana shrimp and general fishes is different from the original bottom trawl as only fish. 2) Average size of catches at present smaller than in last decade years.

2. Selvage net

Few original fish trawl net designs assembled with selvage net what regularly made by polyethylene net, 700d/12, double twine, mesh size 120-160 mm. Trawl net sample No.1 or Hybrid otter board trawl is assembled with selvage net polypropylene twine size 4 mm diameter

and mesh size is 600 mm. It presumes the trawl net operated in soft bottom fishing ground. Soft muddy is able to pass through with large mesh size and prevent net broken. As cuttlefish and banana shrimp is main target catch of trawl net sample No.1 or Hybrid otter board trawl, ground rope of trawl net must be enough heavy to expose surface of sea bottom and frighten target catches what stay on or bury under surface of sea bottom.

It is very important to gather the information of trawl net, not only the mesh size but also structure, material and design of ground rope in order to recognizable the magnitude of the impact to sea bottom.

Trawl net sample No.2 (Large-mesh otter board trawl)

The most distinctive structure of trawl net sample No.2 (Large-mesh otter board trawl) is mesh size at wing square and 1st belly parts as 4000 mm. Trawl net is categorized in bottom single trawl target for fish with high opening design. Character of high opening is observed by length of net width behind square is very large, 280 m, compare with trawl net sample No.1 (Hybrid otter board trawl) is 65.2 m and original Thai trawl nets are less than 60 m. Trawl net sample No.2 has been developed for target species i.e. anchovy. Trawl net is not necessary to severely drag on sea bottom thus ground rope is not assembled with selvage and sinker is made by chain with obviously lighter weight than trawl net sample No.1. It prevents trawl net damage by reducing abrasion between ground rope and sea bottom. Although ground rope and head rope is 65 m and 75 m in length, assembling with large mesh size at net opening section can reduce hydro resistance and allows trawler can operate with higher towing speed. Regarding to the target catch is anchovy, codend is constructed by very fine polyethylene net, mesh size is 15 mm. Thus trawl net sample No.2 is necessary to monitor on the exact fishing ground, catching efficiency in particular Catch Per Unit Effort (CPUE) of anchovy. Biological impact focus on juvenile economic species and other low value fish as bycatch must be urgently investigated concurrently with fishing technology performance e.g. net height, net opening and etc.

In addition the improvement of anchovy handing onboard trawler must be significantly and urgently undertaken. Observed at landing port, the quality of anchovy unloaded from trawler is none of ice supplying. Anchovy condition caught by these trawlers become

became decomposed with less hygienic condition. It is perform irresponsible fishing manner of trawler fishers and directly impact to fisheries management in term of export in the future

Trawl net sample No.3 (Large mesh bottom pair trawl net I)

Trawl net sample No.3 (Large mesh bottom pair trawl net I) is categorized into bottom pair trawl target for fish with high opening design. Obviously that trawl net sample No.3 has been modified for better fishing operation performance in particular net opening expansion and faster towing speed. Character of high opening is observed by extended net length of width behind square is very large, 230.4 m, compare with original bottom pair trawl net is approximately less than 100 m. Assembling with large mesh at wing square and 1st belly parts, 96 cm which can reduce hydro resistance, trawler is perform with high speed towing operation, observed by the pelagic catch e.g. bonito, travelly. However massive demersal species e.g. grouper, snapper, croaker, pomfret and etc, is also caught by this trawl type. Thus, trawl net sample No.3 is necessary to monitor the catching efficiency, catch per unit effort of all catch (CPUE) in particular the pelagic species. Biological impact focus on juvenile economic species and other low value fish as bycatch must be urgently investigated in concurrently with fishing technology performance e.g. net height, net opening, operational techniques, and etc.

Trawl net sample No.4 (Large mesh bottom pair trawl net II)

Trawl net sample No.4 (Large-mesh bottom pair trawl net II) is categorized as bottom pair trawl target for fish both demeral and pelagic, with high opening design. High opening characteristic is observed by length of net width behind square part, is very large as 230.4 m, compare with original bottom pair trawl net is approximately less than 100 m. Regarding to assemble with large mesh at wing square and 1st belly parts as 192 cm, trawl net can reduce hydro resistance and well perform with high speed towing operation, hence very good efficiency to catch anchovy in the night time. Obviously that trawl net sample No.4 has been modified for certain target species.

Thus this trawl net sample No.4 is needed to monitor same detail as trawl net sample No.2 i.e. fishing ground, catching efficiency in particular catch per unit effort of anchovy. Biological impact, focused on juvenile economic species and other low value fish as bycatch must be

urgently investigated in concurrently with fishing technology performance e.g. net height, net opening and etc. In addition the improvement of anchovy handing onboard trawler must be significantly and urgently undertaken. Observed at landing port, the quality of anchovy unloaded from trawler is none of ice supplying. Anchovy condition caught by these trawlers become became decomposed with less hygienic condition.

Other issues

Referred to the interview, all of trawl net designs are introduced from neighbored countries. Responsible agencies should develop the appropriate monitoring process at transboundary landing place such fishing ports at Klong-yai district, Pak-ba-ra fishing port at Satun province, Songkla fishing port, Pattani fishing port, where fishing technologies are able to transfer among neighboring countries.

Strengthen on the precautionary of destructive fishing technology in the region, fishing gear technologist should be exchange their fishing ear information through the event e.g. meeting, workshop, seminar or network.

The study on the impact of fishing gear and practices should be undertaken concurrently with the other fishing technology research and development. It may facilitate to fisheries managers to legislate appropriated measures for sustainable fishing practices.

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