



Undulated Surf Clam (*Paphia* spp.) Dredge Fishing of Thailand 1

-Overview-

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Undulated Surf Clam (*Paphia* spp.) Dredge Fisheries of Thailand

Part 1: Overview

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Abstract

The review report of undulated surf clam (*Paphia* spp.) by iron dredge fishing of Thailand is comprised with the classification and general biology of undulated surf clam (*Paphia undulata*) found in Thailand. Biological information is detailed with growth coefficient, length at the first mature, length at the first capture in related with iron dredge slit interval, reproductive information and significant of fishing ground around Gulf of Thailand and Andaman Sea. Statistic record on the undulated surf clam production including with the processing of undulated surf clam of Thailand is investigated and review.

Development of fishing practices and fishing started from handy dredge in late of 1970 decade. Undulated surf clam develop to commercial fishery by using iron dredge has the first record in year 1969. Nowadays three main dredge size 120 cm, 120-240 and 300-350 cm in width (length of entrance), are operated in Thailand by using fishing boat from outboard engine class to inboard engine size 18 m length over all . Dredge fisher operate iron dredge what construction of dredge slit interval 2 sizes, i.e. 8 mm and 12 mm. The modification to narrower dredge slit from 12 mm to 8 mm is major cause to massive damage undulated surf clam before mature size and direct impact to undulated surf clam resources to spend few years for restocking population.

Keywords: Undulated Surf Clam, Dredge Fisheries

Introduction

Undulated Surf Clam, *Paphia spp.* (Born, 1778), is one of the important marine resources for fisheries economic of Thailand more than few decades. Department of Fisheries, Thailand (Department of Fisheries) has initially reported the harvesting of Undulated surf clam since 1973. During the early statistical recording, undulating surf clam was not much favorite marine seafood for Thai consumer. However after the undulating surf clam product processing industrials, e.g. canning, frozen, etc., targets for the export, has been developed in 1977, undulating surf clam has become higher demand mainly for raw material. In year 2009 undulated surf clam is harvested 17,763 metric ton, value is approximate 7 million US Dollar¹ and export value of processing product approximate 20 million US Dollar.

Fishing technology to harvest undulated surf clam has been initiated reported by manual practicing, diving, digging including with the use of handy dredge with pole without fishing boat before year 1957. Fishing technology development from handy dredge to iron dredge operate with motorized fishing vessel has firstly reported since 1969. Nowadays undulating surf clam fishing grounds are widely spread through both Gulf of Thailand and Andaman Sea. Fishermen delimited fishing efficiency of dredge fishing by increasing number of fishing vessels and size of engine. As well as expanding dredge size, reducing dredge slit interval.

At present, the most serious problem of undulated surf clam dredge fishing in Thailand is the fluctuated landing in particular the production for processing industrial. The problem caused by massive damage of parental stock, catching pre-juvenile clam for material of cannery production then impact to whole consumers. Regarding to the negative impact of dredge fishing operation to marine ecosystem and environment, confliction between undulated surf clam dredge fishers and local fishers who harvest other fisheries resources in the same fishing ground is obviously occurred, consequence to the social impact and economic impact to the coastal fishers. It may cause by the conventional management measures of coastal area what less effective to manage the coastal fisheries resources.

Undulated Surf Clam (*Paphia spp.*) Dredge Fishing of Thailand is separated into 3 main volume. The first volume is the overview part of Undulated Surf Clam fishery in Thailand. Context is contained with the biological of Undulated Surf Clam (*Paphia spp.*), significant fishing ground of Thai Waters both Gulf of Thailand and Andaman Sea including with environmental of fishing ground, Statistical of Undulated Surf Clam production since 1976, fishing technology and fishing vessel. The Second volume is environment impacts of Undulated Surf Clam fishing operation to habitat case study in Paknam Pranburi Estuary, Prachaub Khiri Khan Province, Thailand. Third volume is catches by Undulated Surf Clam iron dredging.

¹ Exchange rate in year 2012: 1 US Dollar = 30 Baht

Author wishes to distribute the information of Undulated Surf Clam fishing by iron dredging in order to enhance better understanding for fisheries manger both positive impact and negative impact of dredging to ecosystem. It is including with the benefit of Undulated Surf Clam to fisher both marine capture and processing industrial. It is in order to support the development of dredge fisheries management measure for sustainable utilization. The management measure of dredge fisheries including with effective coastal fisheries management will be benefited from the study not only fisheries manager but also anyone who interested in dredge fisheries. For any countries what Clam resources have not any utilized yet, information can support of fisheries manager to strengthen management by precautionary approach before open resources to fishers.

Objective

Compiling the undulated surf calm dredge fisheries of Thailand, for preparing the study of environmental impact of undulated surf calm fishing

Research Methodology

The methodology of research work use Qualitative Research as major research tools. Rural Rapid Appraisal (RRA methodology) by reviewing the secondary data and in-depth interview concerned on undulated surf clam dredge fishing in Thailand and Participation Rural Appraisal (PRA methodology) by participatory observation of fishing gear and fishing boat included with its accessories.

1. Primary data collection method through in-depth interview

The face-to-face interview using unstructured questionnaire focused on the details of the fishing technology. Since the targeted fishing gears had already been recognized, some details related to the fishing practices, fishing seasons, fishing grounds and cost of dredge fishing gear were also gathered during the interview with master fishermen, fishermen and fishing boat owners in coastal provinces, namely: 1) Samut Prakarn Province 2) Samut Sakhon Province and 3) Petchburi Province.

2. Direct and actual observation without participation

This approach was adopted to examine the construction and design of the iron dredge. The materials used for constructing the fishing gear and other fishing techniques were also recorded, which were gathered through actual observation in the fishing port and found in fishing boats. The survey area is located along the coastal of upper part of the Gulf of Thailand, three (3) coastal provinces, namely: 1) Samut Prakarn Province 2) Samut Sakhon Province and 3) Petchburi Province. The location of the fishing communities in the survey area is shown in Figure 2.

3. Review of secondary data

The review focused on the existing information in related with Undulating surf calm dredge fisheries of Thailand. The biological and physiology information of undulated surf clam within various topics, e.g. classification, environmental, ecological and physiological, was sourced and concluded from the research papers published by Department of Fisheries, Thailand (e.g., Sunan et al. (1985), Sunan (1987), Païroh and Sunan (1992), Somsiri (1999), and Jintana (2000)

Information of undulated surf clam resources, i.e. fishing grounds, abundance, distribution, by-catch, and the experiment for initiating the conservative measures, was sourced and concluded from the fisheries research papers, published by Department of Fisheries, Thailand. (e.g., Tien et al, (1983), Sunan et al. (1985),

Bamroongsak and Wannakiat (1989), Mickmin (1990), Saramit (1993), Palma J. and Others (2003), Mala and Jintana (2005), and Department of Fisheries (1992, 2005)

Fishing gear and fishing techniques information was sourced and concluded from the fisheries research public papers published by Department of Fisheries, Thailand and SEAFDEC/TD, i.e. Department of Fisheries (1943, 1953, 1969 and 1997), Mickmin (1990), SEAFDEC (1989, and 2007).

Statistic of undulated surf clam product since 1957 to 2004 was reviewed from fisheries statistic document published by Department of Fisheries, Thailand. The export quantity was collected from statistic document published by Department of Custom and Department of Fisheries, Thailand.

Information of undulated surf clam utilization in commercial interests were reviewed from two (2) fisheries economic research documents published by Raungrai et al. (1985) and Bamrungsak (1993)



Figure 1 Area of survey and study: 1) Samut Prakarn Province 2) Samut Sakhon Province and 3) Petchburi Province.

Result

Biological and Classification of Undulated surf clam in Thailand

Classification of Undulated surf clam found in Thailand

undulated surf clam is common name of bivalve, *Paphia* spp. few common names of undulated surf clam are found, e.g. undulated clam, Short-necked surf, Surf clam, Carpet clam and Venus shell. Processing Industry calls Baby clam for commercial name and Asari for export product recorded by Custom Department. Classification of Undulated surf clam is described as below;

Phylum Mollusca
Class Bivalvia or Pelecypoda
Order Eulamellibranchiata
Family Verneridae
Genus *Paphia*

Undulated surf clam *Paphia* spp. found in Thailand has 3 species i.e. *Paphia undulata* (Born, 1778), *P. alapapilionis* (Röding, 1798) and *P. crassisulca* (Lamarck, 1818) (Figure 2).

Dominant economic species of Thailand is *Paphia undulata* (Born, 1778)

General physiology of undulated surf clam

Undulated surf clam is species of bivalve. Shell is egged-shape, brownish, thin and symmetry between upper and lower of shell. Periostracum of shell is waxed-like feature. There are dark-brownish net pattern cover all of Periostracum. Umbro or Beak is slightly oblique to the front and appearance to asymmetry on each individual side of shell or call Inequilateral (compare between center to upper side and lower side). Rear of Umbro is escutcheon feature. Inside the shell is white color and there is a hinge to joint between each shell side. (Jintana, 2000)

Undulated surf clam is a plankton feeder or suspended feeder species. Their diet is plankton, suspended solid and other microorganism. Some biologists categorize undulated surf clam into Plankton Feeder or Planktivore. Feeding behavior is filter feeding by suction water with food through filtered organs. So that undulated surf clam has develop the gill for efficiency functions on filtered and gas exchanging call *Lamellibranch*. Type of gill also use for classify Genus of bivalve. (Wantana, 1998)



(A)



(B)



(C)

Figure 2 Undulated surf clam (A) *Paphia undulata* (Born, 1778) (B) *P. alapapilionis* (Röding, 1798) and (C) *P. crassisulca* (Lamarck, 1818)

Source: (A); (B) R. Vega-Luz (2005)
(C) G. Poope and P. Poope (2012)

Biological growth of undulated surf clam in Thailand

Growth and reproductive biological studies by Bumrungsak (1983), Sunan et.,al (1984, 1987), Pairaw and Sunan (1993) and Jintana (2000) reveals that biological information, growth and reproductive is different in regarding to habitat. Surathani Porvince is found the highest growth coefficient 1.74 per year but the other area is almost same as 0.9 per year. Details of each habitat is appeared in table 1

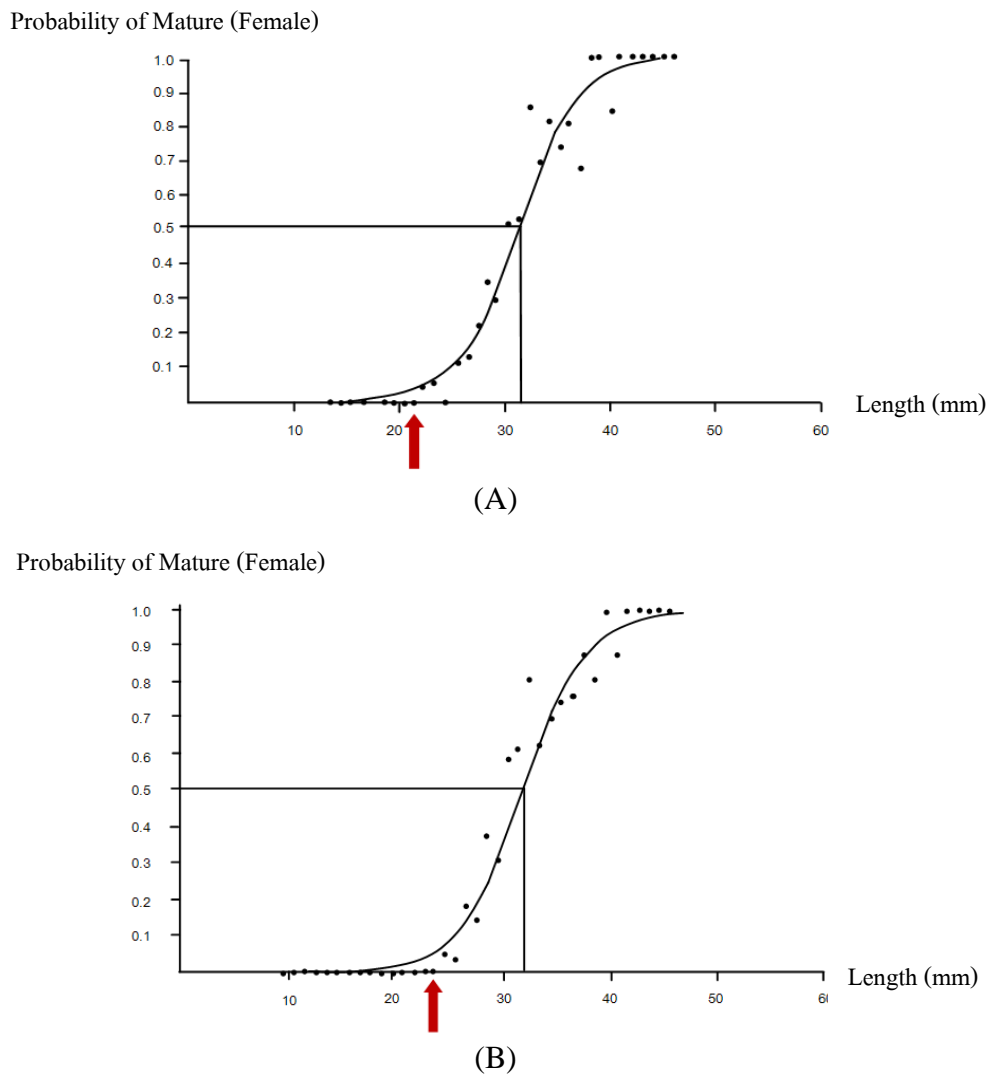


Figure 3 Length at the first mature (L_0) of undulated surf clam; (A) Male, (B) Female

Source: Jintana (2000)

Table 1 Growth Coefficient (K) and Maximum length of Undulated surf clam (L_{∞})

Fishing ground	K	L_{∞}	Sources
Ao Trat Bay, Trat Province	0.94	6.35	Bumrungsak, 1983
Mahachai Bay, Samutsakhon Province	0.98	5.9	Jintana, 2000
Ban-don Bay, Suratthani Province	1.74	5.3	Jintana 2000
Phangha Bay, Phangna Province	0.92	6.3	Pairaw and Sunan, 1993

Source: Bumrungsak, 1983; Jintana, 2000; and Pairaw and Sunan, 1993

Length of the first mature (L_0) is measured by length of shell. L_0 of undulated surf clam in Thailand collected from habitat around Trat Province shows the highest range in Thai waters, i.e. 40.1-47.0 mm in male, and 42.5 – 46.4 in female. Habitat of Ao Mahachai Bay, Samut Sakhon Province is found the shortest as 23.0 mm in male and 24.0 in female. Other habitat is appear in Table 2

In general, reproductive season of undulated surf clam in Thailand has found two periods in years, February-May and August-November (Table 3). Jintana (2000) reports the undulated surf clam habitat around Ao Mahachai Bay, Samut Sakhon Province is only period a year, August-October. It is different reproductive season from other habitats. Researchers presume that the phenomenon of Ao Mahachai Bay, Samut Sakhon Province is occurred by the massive freshwater runoff from Tachin River during November annually and cause massive undulated surf clam died. Furthermore the less parental stock is not sufficient for reproducing in the period of February-May. (Table 3)

Table 2 Length at the first mature (L_0)

Fishing ground	Length at the first mature (mm)		Sources
	Male	Female	
Trat Province	40.1	42.5	Bumrungsak, 1983
Mahachai Bay, Samutsakhon Province	23.0	23.8	Jintana, 2000
Ban-don Bay, Suratthani Province	29.1	30.6	Jintana 2000
Phangha Bay, Phangna Province	14.3 (Without sex classification)		Pairaw and Sunan, 1993

Source: Bumrungsak, 1983; Jintana, 2000; and Pairaw and Sunan, 1993

Table 3 Reproductive Season of Undulated surf clam in Gulf of Thailand and Andaman Sea

Fishing ground	Reproductive Season		Sources
	First period	Second period	
Trat Province	April-May	August-November	Bumrungsak, 1983
Mahachai Bay, Samut-sakhon Province	None	August-October	Jintana, 2000
Ban-don Bay, Suratthani-Province	January-March	September-November	Sunan et.al. 1987
Phangha Bay, Phangna-Province	March-May	August-November	Pairaw and Sunan, 1993

Source: Bumrungsak, 1983; Jintana, 2000; and Pairaw and Sunan, 1993

Jintana (2000) studies the growth rate of undulated surf clam in Ao Mahachai Bay, Samut Sakhon Province. The study summarized that after metamorphosis process, the length of shell increases to the maximum length of undulated surf clam (L_{∞}) within 2 years. Length of shell on the first month is 4.0 mm. Third month is 12.4 mm. Sixth month is 22.0 mm and twelfth month is 36 mm and Twenty fourth month is 50 mm. Department of Fisheries Thailand (1992) concludes the range of L_{∞} of Undulated surf clam in Thailand is 53.0-64.0 mm. Whereas Ban-don Bay, Suratthani Province is the shortest as 53.0 mm and Trat Bay, Trat Province is the longest as 64.0 mm.

Undulated surf clam has not been commercially cultured in Thailand yet. However the studies on breeding and nursery have been carried out by Department of Fisheries-Thailand. Nuanmanee (1988) conducted the breeding and nursery from juvenile to the size for releasing to the natural, 10-30 mm in shell length. The development after fertilization to swimming blastula stage (Celia development) spends 2:30 hours. The development after fertilization to Trochophore stage spends 5 hours. The development after fertilization to D-shape stage spends 12 hours. The development after fertilization to Umbo stage spends 120 hours (5 days). The development after fertilization to Pediveliger stage (Foot is developed for crawl onto seabed) spends 8 days. The development after fertilization through metamorphosis process to spat or seed stage spends around 12 days. Length of juvenile shell age 1 month is 1.7-2.4 mm (average 2.4 mm) and 3 months is 7.0-13.0 mm. (average 10 mm)

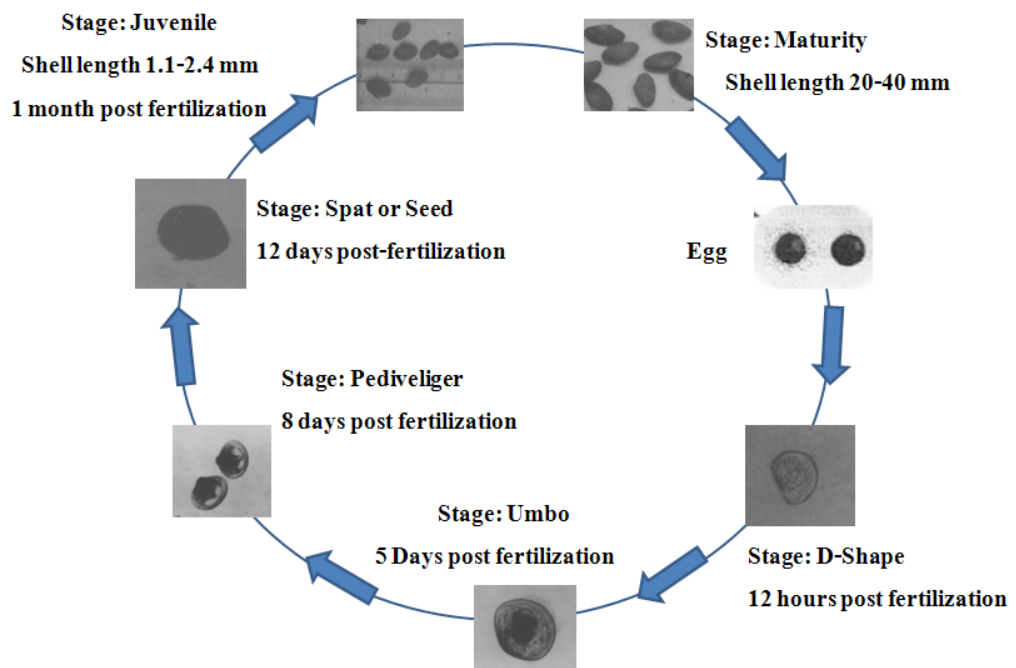


Figure 4 Life cycle of Undulated surf clam

Source: Re-drawing from Nuanmanee (1988)

Undulated surf clam fishing ground in Thailand

Undulated surf clam is a benthic organism categorized into Infauna or Endofauna, lives from bottom surface to 20 cm deep under bottom surface. Sea bottom characteristic is soft-muddy (Jittima, 2001). Undulated surf clam habitats are found around the estuary and river mouth of Thailand and sea depth is between 3-15 m.

Sunan et.al (1985) analyses sediment samples of fishing at Trat Province. The investigation reveals that bottom sediment which habitat of Undulated surf clam is high enrichment. Average percentage of Total Organic Matter is 2.06-3.23% (Natural Tom is 2.0-2.5%) Composition of bottom sediment is (Silt) 44.35% (Clay) 38.19% and (Sand) 17.12%

Department of Fisheries-Thailand (Department of Fisheries) explored the fishing ground of undulated surf clam in The Gulf of Thailand and Andaman Sea by using research vessels and landing catch survey (Department of Fisheries, 1992 and 2005) Details are described as below;

Fishing ground in the Gulf of Thailand

1) Fishing ground around Trat Province

Fishing ground around Trat Province is separated into 3 significant area. Total fishing area is approximately 132 Sq.km. The first fishing ground is around Ao Trat Bay. Area is covered from eastern part of Laem sorg Cape to eastern part of Koh Mai-si-lek Island. Area is approximately 40 Sq.km. This fishing ground is original fishing ground since year 1971. The second fishing ground is the front of Klong-yai District. Area is contiguous area of fishing ground around Ao Trat Bay. It is covered from Kao Hau-meaw Hill, along coastline to the front of Had Lek Sub-District, Klong Yai District. Area is approximately 90 Sq.km. The third fishing ground is around Laem Ngob District. This is new fishing ground, covered from Ao Thammachart Bay to fishing port of Laem Ngob District. Area is approximately 2 Sq.km

Training Department of Southeast Asia Fisheries Development Center: SEAFDEC/TD (2003) reports the appearance of undulated surf clam dredge fishing gear at Koh Kong Island. It is presumed that fishing ground Fishing ground around Trat Province is contiguous into Cambodia Exclusive Economic Zone (EEZ) but the fishing is conducted by Cambodia Fisherman at Koh Kong Island

Tien et.,al. (1983) reports catch rate of undulated surf clam resources survey in year 1981 separated into 2 periods, i.e. 1) January to April and 2) September. Catch per unit effort (CPUE) results 630-1,312 kg/day/fishing boat. February is highest catch, 1,312 kg/day/fishing boat and September is the lower catch, 630 kg/day/fishing boat. Result of survey from fishing ground around Laem, Ngob District in year 1988, is approximately 1,500 kg/day/fishing boat.



Figure 5 Undulated surf clam fishing ground 1) Ao Trát Bay 2) Laem Ngob District 3) Klong yai District

Source: Developed from information of Bamrungsak and Wannakiet (1989)

Department of Fisheries (1992) reports undulated surf clam resources survey around Ao Trát Bay in year 1987 and 1989. The result shows the deteriorated fishing ground condition caused by heavily harvested during fishing season in year 1986 and 1988. Abundance of undulated surf clam around Ao Trát Bay in year 1987 around Ao Trát Bay decreases to 1.4 kg/sq.km and 38.7 kg/sq.km in year 1989.

Undulated surf clam resources survey around Klong-yai District shows the deteriorated fishing ground condition same as Ao Trát Bay fishing ground. Results of the resources survey shows abundant of Undulated surf clam is 27.0 kg/sq.km in year 1987 and 75.6 kg/sq.km in year 1989. The result of resources survey around Kho Hau-maew in year 1989 when the fishing ground had not affected by commercial dredging in year 1986 found abundance 1,624.5 kg/sq.km

Bamrungsak and Wannakiet (1989) conducts undulated surf clam survey by using iron dredge around Laem Ngob District in year 1989. Abundance of Undulated surf clam is approximately 4,190 kg/Sq.km However, the survey by grab is different result. Undulated surf clam abundance is found approximately 27,000 kg/sq.km by using grab. Researchers assume that fishing ground of Laem Ngob District is not wide area. While the surveys are conducted by iron dredge, dredging path may cover less abundance area of undulated surf clam. Under estimation of undulated surf clam biomass may be occurred by using iron dredge conducted the survey in the light resource intensity.

2) Fishing ground around Samut Prakarn Province

The fishing ground around Samut Prakarn Province is covered from Bangpra-kong Estuary to Chao-phra-ya Estuary. (Figure 5) Total area is approximately 144 Sq.km The importance fishing ground is located around Klong-darn District and Bangbor District, sea depth is between 3-12 m.

Department of Fisheries surveys undulated surf clam resources around fishing ground in Samut Prakarn Province in year 1987 and 1988. The surveys result that CPUE of fishing ground where shallower than 4 m is 15 kg/hr and fishing ground where depth between 4-10 m is 5-15 kg/hr. The survey in year 1988-1990 results that the highest CPUE is approximately 1,000-4,975 kg/day/fishing boat is recorded during January to February. The lowest CPUE is approximately 228-590 kg/day/fishing boat, recorded during May to June.



Figure 6 Prohibited zone around Ao Mahachai Bay, Samut Sakhon Province

Source: Modified from Jindalikit (2000)

3) Fishing ground around Samut Sakhon Province

The fishing ground around Samut Sakhon Province covers from western of Chao-pra-ya Estuary to Ao Mahachai Bay. (Figure 5) Total area is approximately 32 Sq.km Depth of fishing ground is between 3-12 m.

Department of Fisheries surveys undulated surf clam resources around fishing ground in Samut Sakhon Province in year 1987 and 1988. The surveys result that CPUE of fishing ground where shallower between 4-6 m on the western of the province is approximate 10-15 kg/hr and fishing ground where depth between 6-8 m on the narrow area in front of Ban Saha-korn is approximately 15.0-20.0 kg/hr but at the same depth in the eastern part of province is less than 5.0 kg/hr. Fishing ground in front of Ban-mai, depth between 8-10 m, is approximately 10.0-15.0 kg/hr.

The survey in year 1988-1990 results that the highest CPUE is approximately 1,000-4,975 kg/day/fishing boat is recorded during January to February. The lowest CPUE is recorded during May to June, is approximately 228-590 kg per day per fishing boat.

Regarding to Ao Mahachai Bay area is nursery ground of bivalve, dredge fishing by using iron dredge has been prohibited by the announcement of Ministry of Agriculture and Cooperative on 17 June 1975. The details are concerned to prohibit iron dredges and all lookalike fishing methods with motorized vessel conducts bivalve species in the prohibited area. (Figure 4)

4) Fishing ground around Samut Songkram Province and Petchaburi Province

The fishing ground around Samut Songkram Province covers area from Mae Klong Estuary to Hard Chao-sam-ran Beach. (Figure 5) Total area is approximately 56 Sq.km. Samut Songkram Province is one of the undulated surf clam important landing site of Thailand.

Department of Fisheries conducts the landing survey of undulated surf clam resources around fishing ground in Samut Songkram Province and Petchaburi Province in year 1988-1990. Results of survey reveal the highest CPUE is approximately 112-2,720 kg/day/fishing boat is recorded during January to February. The lowest CPUE is approximately 80-115 kg/day/fishing boat, recorded during March to May.

5) Fishing ground around Prachaub Khiri Karn Province

Department of Fisheries (1992) demarcates fishing ground around Prachaub Khiri Karn Province is covered area from Paknam Pranburi Estuary to Southern of Sattakud Island. (Figure 5) Total area is approximately 61.5 Sq.km. None of report on the undulated surf clam resources survey has conducted in this area by Department of Fisheries.

Isara (2011) estimate the density of undulated surf clam around Paknam Pranburi, Prachaub Khiri Karn Province in pre clam fishing season of year 2007 is 2.5 mt./sq.km. Density of clam is reduced by destructive dredging to 4.8 km/sq.km. around the fish ground and 14.5 km around conservation area of Paknam Pranburi coastal community. Restocking need at least 3 year to recover regarding to parental stock has been destroy.

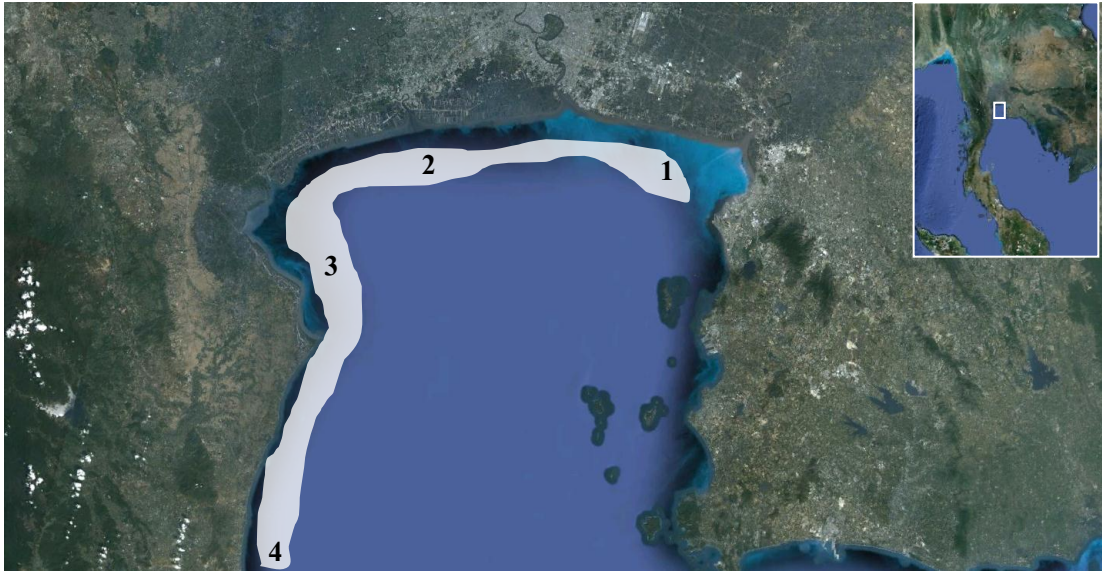


Figure 7 Undulated surf clam fishing ground around Upper Gulf of Thailand
 1) Samut Prakarn Province and contiguous area of Chachoengsao province
 2) Samut Sakhon Province 3) Samut Songkram Province and Petchaburi Province 4) Prachaub Khiri Karn Province

Source: Modified from Department of Fisheries (1992)

6) Fishing ground around Surat Thani Province

Fishing ground around Surat Thani Province has vast area, totally 180.8 Sq.km Department of Fisheries identifies area of fishing ground covered Moo Koh Anghthong Archipelago is 44.8 Sq.km, Tachana District is 112 Sq.km, and Chiya District is 24 Sq.km (Figure 6) These fishing ground is remain significant potential at present.

Department of Fisheries investigates CPUE conducted by fisheries research vessels in year 1987 and 1988. Result of survey around Ao Bandon Bay reveals that CPUE is less than 15 kg/hr in 1987. The CPUE is increased to 46.8 kg/hr around Tachana District and 65.4 kg/hr around central of Ao Bandon Bay. Department of Fisheries reports undulated surf clam maximum and minimum production surveyed from fishing vessel from 1985-1991. Result of survey is between 1,944-4,831 kg/day/fishing boat. The maximum production is appeared in March 1986 and 1987, October 1988, August 1990 and January 1991. The minimum production is between 358-1,790 kg/day/fishing boat December found in every years of survey.

Since year 2010, Surat Thani Province Office has announced the zoning management for utilization of fishing ground around Surat Thani Province. Details is appeared in Annex 1

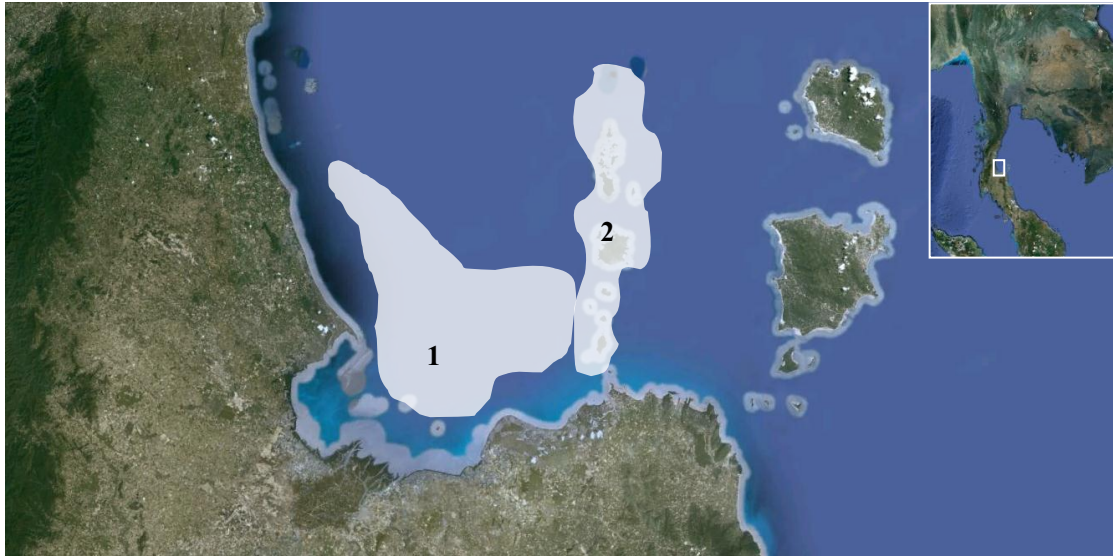


Figure 8 Undulated surf clam fishing ground around Suratthani Province
 1) Ao Ban-don Bay and 2) Moo Koh Anghong Archipelago

Source: Modified from Department of Fisheries (1992)

7) Fishing ground around Nakhon Si Thammarat Airport Province

Department of Fisheries (1992) demarcates fishing grounds around Nakhon Si Thammarat Province is covered area of Ao Nakhon Si Thammarat Bay (from Tasala District to Pakpaying District) and off Laem Talumpuk Cape. Distance from coastline 2-5 km, depth is 10-14 m. (Figure 7) Total area is around 80 Sq.km

Department of Fisheries investigates CPUE conducted by fisheries research vessels in year 1986. Result of survey around Ao Nakhon Si Thammarat Bay (from Ta-sa-la District to Pak-pa-ying District) reveals that resource is definitely deteriorated by dredge fishing operation. However in Year 1987, Department of Fisheries discovers a new fishing ground off off Laem Ta-lum-puk Cape, depth is 10-12 m. The CPUE is less than 1 kg/hr. Further investigation in 1990, CPUE of this area is increased to 25.2 kg/hr and 51.6 in year 1991. There is not any recording of fishing season and abundance of undulated surf clam resources in this fishing ground. However the fishing season may assume by the conflicts between local fishers and undulated surf clam dredge fishers that occurs during September 2007 to January 2008.



Figure 9 Undulated surf clam fishing ground around Nakhon Si Thammarat Province
 1) Ao Nakhon Si Thammarat Bay (from Tasala District to Pakpayang District) and 2) off Laem Talumpuk Cape

Source: Modified from Department of Fisheries (1992)

8) Fishing ground around Songkla Province

The fishing ground around Songkla Province is in the lower Gulf of Thailand covered area from Satingpra District to Singha Nakhon District. Distance from coastline is 5-7 km and sea depth is 10-14 m. (Figure 8) Total fishing area is around 48 Sq.km.

Result of resources survey conducted by Department of Fisheries research vessels around northern Koh Maew Island reveals the CPUE is 2.5 kg/hr. Fishing activities by using iron dredges start in 1991 but all fishing activities has been stopped later because conflict with local fishers. None of the record on the fishing season and abundance of undulated surf clam resources in this fishing ground.

9) Fishing ground around Pattani Province

The fishing ground around Pattani Province is covered area around Ao Pana-re Bay. Distance from coastline 1-3 km, depth is 7-14 m. (Figure 8) Total area is around 15 Sq.km

There are not fishing activities in this fishing ground because of conflict between with local fishers and dredge fishers. None of the record on the fishing season and abundance of undulated surf clam resources in this fishing ground.

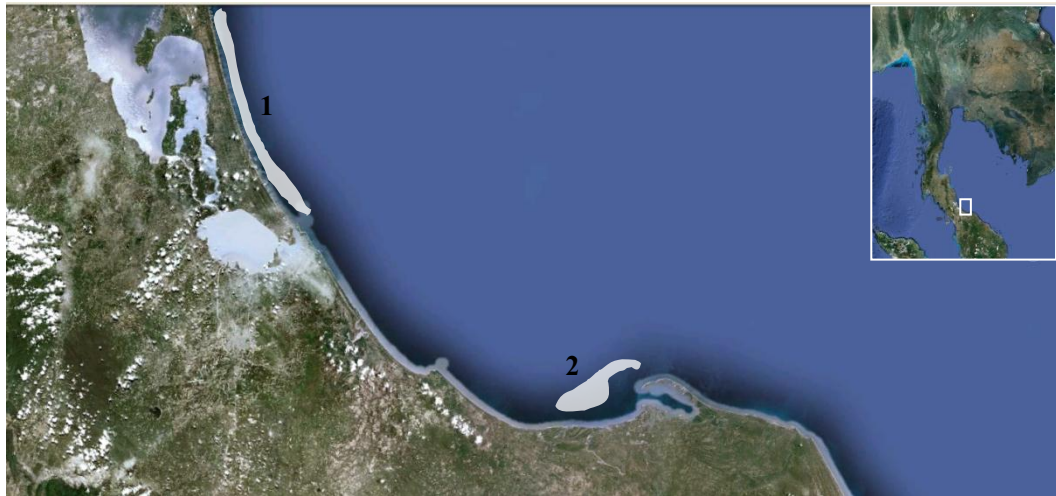


Figure 10 Undulated surf clam fishing ground 1) Songkla Province and 2) Pattani Province

Source: Modified from Department of Fisheries (1992)

Fishing ground in Andaman Sea

1) Fishing ground around Ranong Province

The fishing ground around Ranong Province is covered area around western of Koh-kam Island, Ka-pur District. (Figure 9) Total area is around 8 Sq.km None of the record on the fishing season and abundance of undulated surf clam resources in this fishing ground.



Figure 11 Undulated surf clam fishing ground in Andaman Sea, Ranong Province

Source: Modified from Pairaw and Sunan (1993)

2) Fishing ground around Phangna Province

Pairaw and Sunan (1993) reports fishing activities by iron dredge during 1982-1983 is covered around Koh Plong Island and Koh Yaw Island. Sea depth is 1.8-3.6 m. (Figure 10) Total area of fishing is approximately 10.2 Sq.km After year 1984-1989, Fishing ground is expanded to area around Ko Mark Island, Koh Batang Island, Koh Boy Island and Koh Roy Island. Total area is approximately 56.2 Sq.km Fishing ground also included with area around Koh Plong Island and Chong Lard Striate. Total area of fishing is approximately 56.2 Sq.km (Figure 10)

Department of Fisheries investigates CPUE by using fisheries research vessels southern of Koh Batang Island, western of Koh Roy Island and eastern of Koh Thong Island. Result reveals that CPUE is 16.0-20.0 kg/hr and abundance around this fishing ground is approximately 4,000-5,100 kg/Sq.km Resource survey around fishing ground of Hin Mod Deang Rock, western of Koh Batang Island, Northern of Koh Boiy Noi Island and Northern of Koh Yaw Noi Island, shows CPUE 20.6-39.4 kg/hr and abundance around this fishing ground is approximately 5150-9,850 kg/Sq.km

Fishing ground on the eastern part of Ao Phangna Bay, Koh Pha-nak Island, Koh Yai Island eastern and western of Koh Mark island and northern of Koh Yaw Noi Island, shows CPUE less than 0.4 kg/hr and abundance around this fishing ground is approximately 975-2,262 kg/Sq.km Fishing ground around the western of Koh Yaw Yai Island, Laem Here Cape, Koh Soub Island, Koh Labu Island shows low abundance, 3.8-99.25 kg/Sq.km and CPUE is 0.04-9.05 kg/hr. The survey around Chong Lard Striate (between Koh Yaw Noi Island and Koh Yaw Yai Island) after habitat is recovered in year 1987 is found CPUE is 0.2-3.4 kg/hr and resources abundance is approximately 49.5-850.0 kg/Sq.km

Referred to the research works by Department of Fisheries, there is not any production recorded by landing survey of fishing vessels. None of the record on the fishing season and abundance of undulated surf clam resources in this fishing ground.

3) Fishing ground around Phuket Province

Pairaw and Sunan (1993) reports fishing ground along the coast of Phangna Bay, around Phuket Island. Fishing ground is northern of Laem Yang Cape, Ao Ta Rau Bay (or Ao Sapum bay), Laem Abu Cape, Koh Ma Praw Island and Laem Nga Cape (Koh Si-re Island). Sea depth is 1.8-4.8 m. (Figure 10) Total area of fishing is approximately 6.5 Sq.km Result of survey shows CPUE 0.1-1.3 kg/hr and abundance around this fishing ground is approximately 13.2-315.9 kg/Sq.km

Referred to the research works by Department of Fisheries, there is not any production recorded by landing survey of fishing vessels. None of the record on the fishing season and abundance of undulated surf clam resources in this fishing ground.

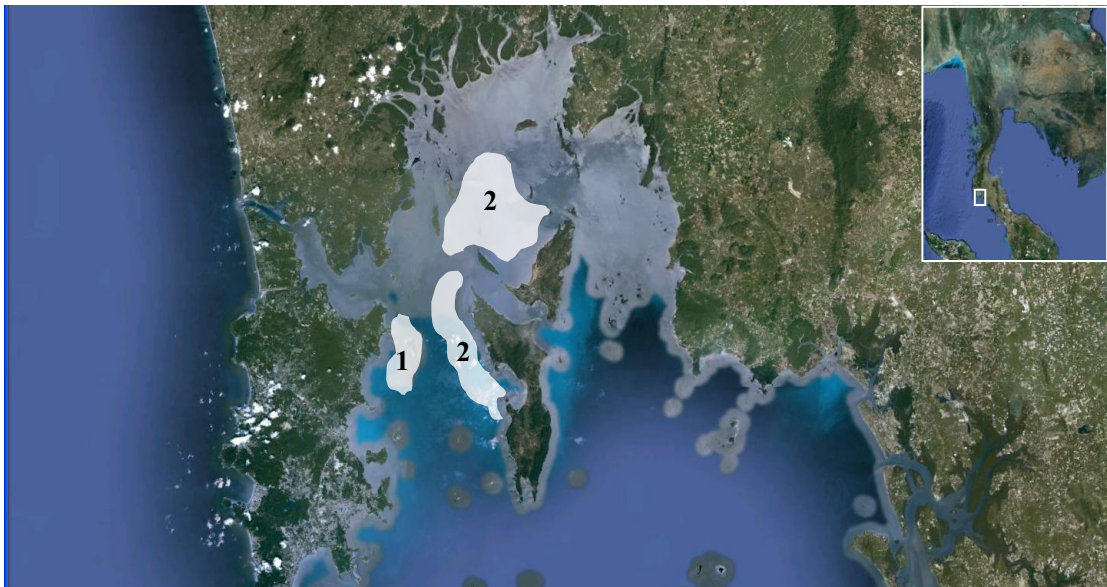


Figure 12 Undulated surf clam fishing ground around Ao Phangna Bay in Andaman Sea 1) Phuket Province and 2) Phangna Province

Source: Modified from Pairaw and Sunan (1993)

4) Fishing ground around Krabi Province

Pairaw and Sunan (1993) reports fishing ground of iron dredge in year 1983, is along the coast of Phangna Bay, around Koh Ngai Island and Koh Lanta Yai Island. Total area of fishing is approximately 20.5 Sq.km Fishing ground in year 1984, is around Koh Kulong Island, Koh Nhui Island and Koh Por Island. Total area of fishing is approximately 24.3 Sq.km Fishing ground during year 1985-1991, is around Koh Por Island, Koh Klang Island and off Klong Phon canal. Total area of fishing is approximately 18.0 Sq.km (Figure 11)

Result of survey around Cape of Laem Daeng, Koh Talu Island and Koh Bongbong Island shows CPUE 0.1-1.8 kg/hr and resources abundance around this fishing ground is approximately 12.3-441.0 kg/Sq.km The fishing ground around Koh Klui Island, Leam Sak District shows CPUE 9.3-19.0 kg/hr and abundance around this fishing ground is approximately 2336.3-4750.0 kg/Sq.km Referred to the research works by Department of Fisheries, undulated surf clam production from fishing ground around Krabi Province is reduced to 1,000 kg during year 1984-1988, undulated surf clam production is increase to 234,000 kg in year 1989.

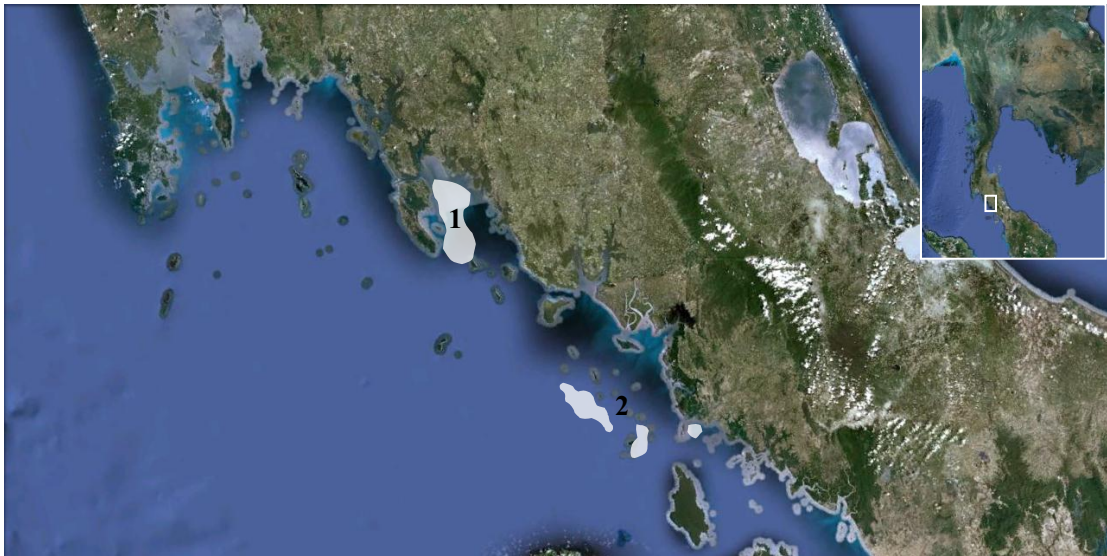


Figure 13 Undulated surf clam fishing ground in Andaman Sea 1) Krabi Province and 2) Trang Province and Satun Province

Source: Modified from Pairaw and Sunan (1993)

5) Fishing ground around Trang Province and Satun Province

Pairaw and Sunan (1993) reports fishing ground of iron dredge in year 1984, is around Koh Petra Island and Koh Tabai Island, Trang Province. Sea depth is 10-14 m. The other fishing ground is between Koh Tong-ku Island and Koh Bu-lon-le Island, Satun Province. Sea depth is 15-17 m. (Figure 11) Total area of fishing is approximately

18.0 Sq.km It remarks that fishing ground around Trang and Satun Province is deeper than the others. Under surf clam production is less than other fishing ground but size of clam is bigger.

Referred to the research works by Department of Fisheries, there is not any production recorded by landing survey of fishing vessels and resources survey by Department of Fisheries research vessels. None of the record on the fishing season and abundance of Undulated surf clam resources in this fishing ground.

SEAFDEC (1995) reports the appearance of iron dredge for harvesting Undulated surf clam at Peris Estuary, Peris State. Department of Fisheries (1992) reports the fishing ground of Undulated surf clam is contiguity around Langawi Island, Kedah State and around Payak Island, Peris State and area of Triburi State, Malaysia EEZ

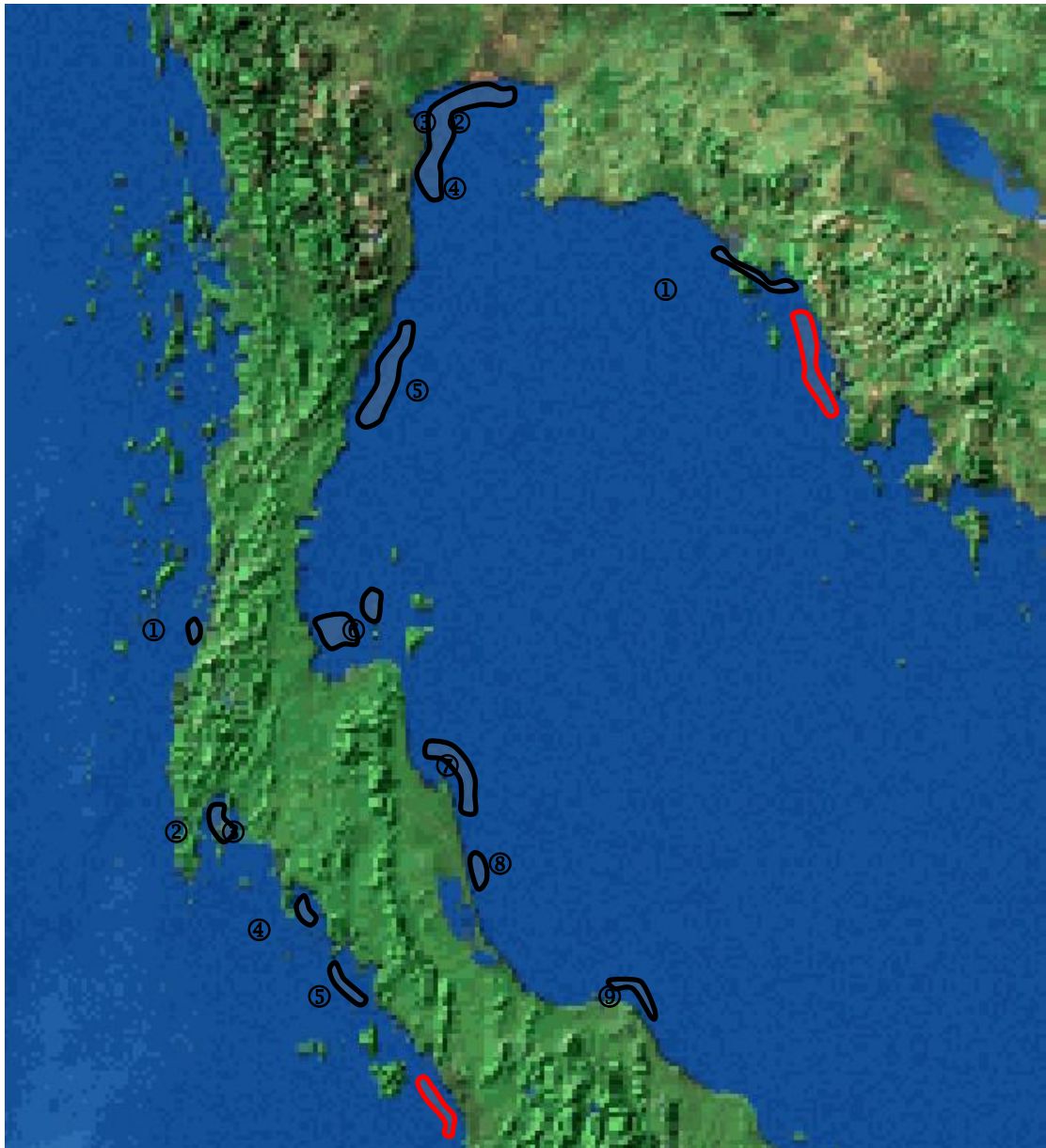


Figure 14 Undulated surf clam fishing ground of Thailand: *Gulf of Thailand* 1) Trat Province 2) Samutprakarn Province 3) Samut sakhon Province 4) Samut songkram Province and Petchburi Province 5) Prachaub kirikhan Province 6) Suratthani Province 7) Nakhon Sri Thummarat Province 8) Songkla Province 9) Pattani Province; *Andaman Sea* 1) Ranong Province 2) Phangna Province 3) Phuket province 4) Krabi Province and 5) Trang and Satun Province; *Adjacent Area* (Red zone) Cambodia Waters and Malaysia Waters

Marine environment of Undulated surf clam habitat in Thailand

Sea Surface Temperature

Anake et.,al. (2007) explains some factors what influence to sea surface temperature (SST) in the Gulf of Thailand e.g. air temperature, season, sea depth, transparent, and etc. Referred to the marine environment survey conducted by Department of Fisheries in year 2003, average SST in the Gulf of Thailand is $29.2 \pm 1.1^\circ\text{C}$.

Department of Fisheries and Pollution Control Department-Thailand (PCD-Thailand) surveys marine environment of significant undulated surf clam habitat and reports SST range is between $22.0\text{-}34.0^\circ\text{C}$

Table 4 Sea Surface Temperature Maximum and Minimum of Undulated surf clam habitats in Thailand

Undulated surf clam habitat	Range of sea surface temperature ($^\circ\text{C}$)	
	Minimum	Maximum
Ao Trat Bay, Trat Province	22.0	33.0
Klong-darn District, Samut prakarn Province	26.4	32.1
Mahachai Bay, Samut sakhon Province	24.0	34.0
Pranburi Estuary, Prachaub khiri khan Province	29.3	32.4
Ban-don Bay, Suratthani Province	26.0	31.2
Moo Koh Ang-thong Archipelago, Suratthani Province	30.2	31.0

Source: Summarize from Department of Fisheries (1992) and PCD-Thailand (2007)

Chalanda (1978) investigate temperature tolerate of undulated surf clam by experiment in the laboratory. Experiment results that clams start dying while sea reach temperate 39°C and all of clams died at temperature 42°C .

Salinity

Anake et.,al. (2007) explains some factors what influence to salinity of the Gulf of Thailand, e.g. monsoon, freshwater runoff and seasonal current. Referred to the marine environment survey conducted by Department of Fisheries in year 2003, salinity range in the Gulf of Thailand is $22.1\text{-}36.5$ part per thousand (ppt) and average salinity is 31.2 ± 1.3 ppt.

Department of Fisheries and PCD-Thailand surveys marine environment of significant undulated surf clam habitat and reports SST range is between $10.1\text{-}35.0$ ppt.

Yodchai et.,al. (1983) conducts the experiment to investigate salinity tolerant of undulated surf clam, size 4.0-5.0 cm in shell length (average 4.6 cm). The result shows that 50% survival is died within 24 hrs in salinity 14.3 ppt, temperature 25.5-26.5 °C and pH 7.0-7.7

Chalanda (1978) conducts the experiment to investigate salinity tolerant of undulated surf clam. The results shows that 50% survival is died within 1:30-2:30 hour in salinity below 23.0 ppt. Clam, average size 3.4 cm in shell length and 3.9 g in weight, shows that 50% survival in salinity 21 ppt. Clam , average size 4.5 cm in shell length and 10.2 g in weight, shows that 50% survival in salinity 20 ppt. The result reveals that large size clam is more tolerant than smaller size clam and conclusion that clam size has different salinity tolerant.

Munprasit and Sasaki (1991) conduct the experiment to investigate salinity tolerant of undulated surf clam. The results shows that clam size 4.0-5.0 cm in shell length and 3.9 g in weight, shows that 100% survival in salinity 25 ppt. after 96 hours. However 100% is died in salinity 0, 8, 16 ppt within 25, 27 and 37 hours respectively. Clam size 3.0-4.0 cm in shell length, shows that 100% survival in salinity 25 ppt., after 96 hours. However 100% is died in salinity 0, 8, 16 ppt within 24, 28 and 40 hours respectively. Clam size 1.0-2.0 cm in shell length, shows that 100% survival in salinity 25 ppt. and 33 ppt., after 96 hours. However 100% is died in salinity 0 after 25 hours and 8.0 after 36 hours. Survival rate is constant 89% in salinity 16 ppt after 29 hours.

Table 5 Range of Salinity (Part Per Thousand) of undulated surf clam habitat in Thailand

Undulated surf clam habitat	Range of salinity (ppt.)	
	Minimum	Maximum
Ao Trat Bay, Trat Province	13.0	35.0
Klong-darn District, Samut prakarn Province	17.0	33.1
Mahachai Bay, Samut sakhon Province	10.1	32.1
Pranburi Estuary, Prachaub khiri khan Province	27.5	30.5
Ban-don Bay, Suratthani Province	30.0	33.0
Moo Koh Ang-thong Archipelago, Suratthani Province	34.0	35.0

Source: Summarize from Department of Fisheries (1992) and PCD-Thailand (2007)

Acidity and Alkalinity (pH)

Variation of pH around coastal area influences by photosynthesis of microorganism (Phytoplankton). Reducing of Carbon dioxide (CO₂) cause increasing of pH, consistent with concentration of Dissolve Oxygen (Manuwadee, 1989)

Anake et.,al. (2007) explains trend of pH in the Gulf of Thailand that different among the month and area of survey. Referred to the marine environment survey conducted by Department of Fisheries in year 2003, pH range in the Gulf of Thailand is 7.2-8.9 and average pH value is 8.1 ± 0.2

Department of Fisheries and PCD-Thailand surveys marine environment of significant undulated surf clam habitat and reports pH range is between 7.3-8.5

Table 6 Range of pH of Undulated surf clam habitat in Thailand

Undulated surf clam habitat	Range of pH	
	Minimum	Maximum
Ao Trat Bay, Trat Province	7.6	8.5
Klong-darn District, Samut prakarn Province	7.34	8.5
Mahachai Bay, Samut sakhon Province	7.3	8.5
Pranburi Estuary, Prachaub khiri khan Province	7.0	8.5
Ban-don Bay, Suratthani Province	7.98	8.4
Moo Koh Ang-thong Archipelago, Suratthani Province	7.6	8.5

Source: Summarize from Department of Fisheries (1992) and PCD-Thailand (2007)

Dissolved Oxygen (DO)

Anake et.,al. (2007) explains some factors what influence to concentration of Dissolve Oxygen (DO) of the Gulf of Thailand, e.g. monsoon, freshwater runoff. The area what low concentration of DO is observed in raining season. Freshwater runoff carries and enhance the organic matters to estuary. DO is consumed to decompose these organic matters and change into inorganic matter. Referred to the marine environment survey conducted by Department of Fisheries in year 2003, DO range in the Gulf of Thailand is 1.94-9.59 mg/l and average concentration is 5.80 ± 1.07 mg/l

Table 7 Range of Dissolve Oxygen of undulated surf clam habitat in Thailand

Undulated surf clam habitat	Range of Dissolve Oxygen (mg/l)	
	Minimum	Maximum
Ao Trat Bay, Trat Province	4.0	9.0
Klong-darn District, Samut prakarn Province	3.5	6.9
Mahachai Bay, Samut sakhon Province	0.03	7.2
Pranburi Estuary, Prachaub khiri khan Province	5.5	7.4
Ban-don Bay, Suratthani Province	5.5	6.6
Moo Koh Ang-thong Archipelago, Suratthani Province	6.8	8.2

Source: Summarize from Department of Fisheries (1992) and PCD-Thailand (2007)

Department of Fisheries and PCD-Thailand surveys marine environment of significant undulated surf clam habitat and reports pH range is between 0.03-9.0 mg/l

Total Suspended Solids (TSS)

TSS quantity is affected by seasoning. During early raining season, freshwater runoff and carries organic matters and suspended solid from river to estuary but decrease after pass to the middle of raining season. In opposite phenomena concentration of nutrient is increased after mid raining season.

Department of Fisheries and PCD-Thailand surveys marine environment of significant undulated surf clam habitat and reports pH range is between 8.0-487.0 mg/l

Utilization of Undulated surf clam of Thailand

Utilization of undulated surf clam of Thailand is separated into 2 significant type depended on the consumptions i.e. 1) Domestic consumption and 2) Export industrial

Domestic consumption

Domestic consumption of undulated surf clam is limited on fresh and alive marketing without processing. Raungrai et al. (1985) reported 16% of undulated surf clam landing is material for domestic consumption. Regarding to the daily consumption, process for market chain is only cleaning and sorting size for setting price. However trend of consuming is adapted from fresh-alive clam to steam and frozen clam. Some supermarket and megastore supply the packages of steam and frozen clam to customers. Landing size of clam is classified into 4 major sizes, i.e.

- 1) Less than 180 clams per kg
- 2) Between 181-280 clams per kg
- 3) Between 281-320 clams per kg and
- 4) More than 320 clams per kg

Export industrial

Export of undulated surf clam is processing by frozen and cannery. Raungrai et al. (1985) reported 80% of undulated surf clam landing is material for export industrial. Clams as material for frozen and canning is processed by boiling. Shell is sorted out before transfer to industrial plants. Material of processing industry is only clam without shell. Ratio of fresh clam and clam without shell is 6.25-8.47 kg (fresh or alive clam)/ kg (boiled clam). Boiled clam as material of frozen industry is classified into 4 major sizes, i.e.

- 1) Smallest size: 700 clams per kg
- 2) Medium size: 500-700 clams per/kg
- 3) Large size: 300 – 500 clams per kg and
- 4) Largest size: 100-200 clams per kg

Undulated surf clam cannery product is composed with clam in salt liquid, smoked clam in oil, and crispy clam. Boiled clam as material of canning industry is smaller size than material for frozen industry. Boiled clam as material of canning industry is classified into 4 major sizes, i.e.

- 1) Smallest size: 1,500-2,000 clams per kg
- 2) Medium size: 1,300-1,500 clams per kg
- 3) Large size: 1,000-1,300 clams per kg and
- 4) Largest size: 700-1,000 clams per kg

Production of canning factory has trouble with uncertain quantity material. Export market is major consumer of canning product. Demand and market price is depended on foreign consumers that may reduce until unaccepted benefit for export enterprise. (Sanit et.,al., 1985)

Raungrai et al. (1985) reports that undulated surf clam marketing in Thailand share 80% for material of processing industries. Domestic consumption share 16 % and 4% is the loss of production caused by handling process. The ratio is change to 28.59% for material of processing industries, 57.52% for domestic consumption and 13.89% for the loss of production caused by handling (Bumrungsak, 1993)



(A)



(B)



(C)

Figure 15 Undulated surf clam processing (A) Frozen product (B) Canning product and (C) Fresh Clam

Fisheries Statistic of Undulated surf clam of Thailand

Isara (2007) review fisheries Statistic of undulated surf clam of Thailand. The review shows that the record of marine mollusk production prior year 1974 has not classified into species, utilization and processing. Since 1974, the records of marine mollusk are classified into species but without source of production. Since 1985, the records of marine mollusk are separated source of production into Gulf of Thailand and Andaman Sea. There is not mollusk classification by fishing gear however it is presumed that most of undulated surf clam production is harvested by dredge fishing. Refer to Department of Fisheries (1997) iron dredge is only commercial fishing gear used for harvesting undulated surf clam resources and possible to catch Cockle resources in Thailand.

Refer to marine fisheries statistic year 1974-2003 reported by Department of Fisheries, undulated surf clam production has fluctuated. The first production is recorded in 1974 is 13,806 metric ton (mt) and raise to 23,300 mt in year 1976. Production in year 1978 is decreased to 10,600 mt but raised to 62,220 mt in year 1981. Production in year 1983 is decreased to 31,823 mt but raised to maximum 130,000 mt in year 1987. Clam production is continuously decrease since year 1987 and reaches 30,860 mt in year 1995. Production is raised up to 52,889 mt in year 1996 but decreases to 35,852 in year 1997. During year 1998-2000, clam production is between 50,000-70,000 mt and gradually decreases to 29,000 mt in year 2003. Regarding to the fluctuated production, undulated surf clam from processing material is import from Cambodia, Thailand and India

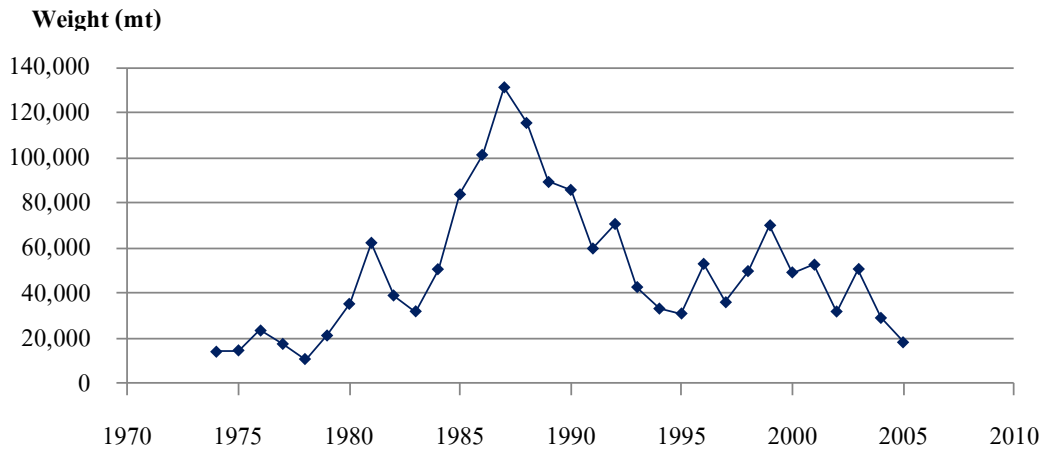


Figure 16 Undulated surf clam production during year 1974-2005

Source: Department of Fisheries-Thailand (1976-2008)

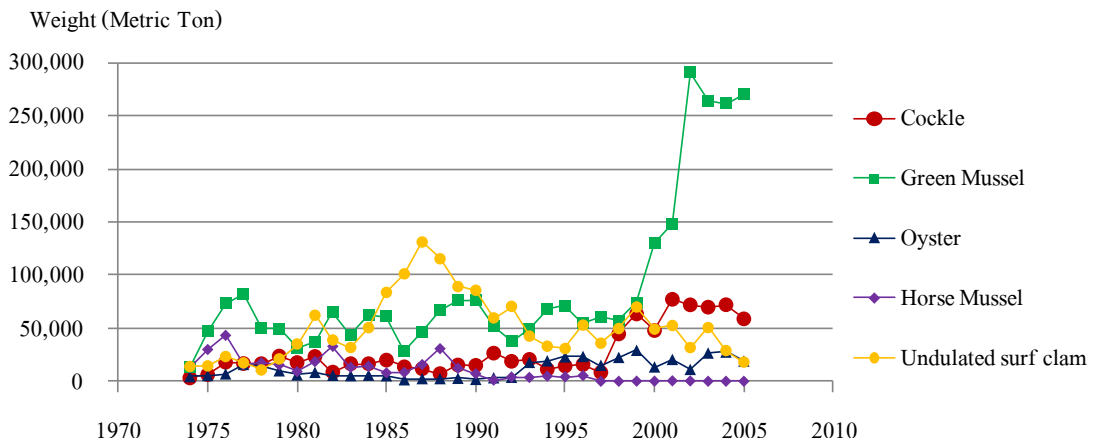


Figure 17 Marine mollusk production of Thailand during year 1974-2005

Source: Department of Fisheries-Thailand (1976-2008)

Fishing Technology

Dredge is the most important fishing gear to catch clam

Dredge Fishing gear in General

FAO (1990) explain the definition of dredges; are fishing gears which are dragged along the bottom to catch shellfish. They consist of a mouth frame to which a holding bag constructed of metal rings or meshes is attached. There are three main type of dredges; heavy dredges towed by boats (boat dredges), and lighter ones operated by hand in shallow waters (hand dredges).

1) Handy dredge

Hand dredge are small, light dredges consisting of a mouth frame attached to a holding bag constructed of metal rings or meshes. No specific equipment is required for fishing operation. No boat, or only small undecked vessels are employed.

2) Boat Dredge

Boat dredges are gears consisting of a mouth frame to which a holding bag constructed of metal rings or meshes is attached. Boat dredges are principally of two variants: dredges that scrape the surface of the bottom and dredges that penetrate the sea bottom to a depth of 30 cm or more to harvest macro-infauna. Some surface dredges include rakes or teeth to penetrate the top layer of substrate and capture animals recessed into the sea bed. Infaunal dredges can be further separated into those that penetrate the substrate by mechanical force (i.e. long teeth) and those that use water jets to fluidize the sediment (hydraulic dredges). Most dredges are heavy and require winches and sometimes cranes for handling. Some dredges are mechanized for transporting the catch by pumps or conveyor belts to the deck for sorting.

3) Mechanized dredges

Hydraulic jet dredges are used to dig and to wash out mussels that have buried themselves in the seabed. Some dredges are so improved that the prey is not only dug out, or stirred up and collected in a bag, but is also conveyed on board the vessel by the same gear. Therefore this gear, combining and hauling, can be considered a harvesting machine. This is especially true in cases where mechanical shellfish diggers are combined with suction pumps, escalators or conveyors.

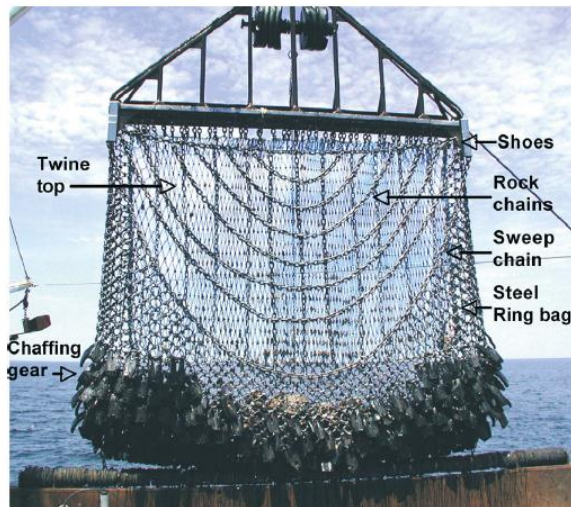


Figure 18 Scallop dredge width of 4.5 weight of about 1870 kg

Source: Kevin D. E. Stokesbury and Bradley P. Harris, 2006

Background of Dredge in Thailand

Prior year 1943, Thai fishers harvested marine mollusk e.g. cockle, undulated surf clam, enamel venus shell and etc, only around shallow water by dive and hand grope. Department of Fisheries (1943) reports operating of handy dredge (Namely in Thai “La-mor” or “Cha-nor”) mobilized by man power or current force or wind force with non-motorized boat in year 1943. Undulated surf clam commercial fishery by using iron dredge has not definitely recorded before year 1957. The first record found in year 1969 (Department of Fisheries 1969) and widely spread after year 1971 (Department of Fisheries 1971). Information collected through the interview of dredge fishers reveals that iron dredge is firstly observed from the eastern part of The Gulf of Thailand, Trat Province. However there is not any reference to support. (Figure 16)

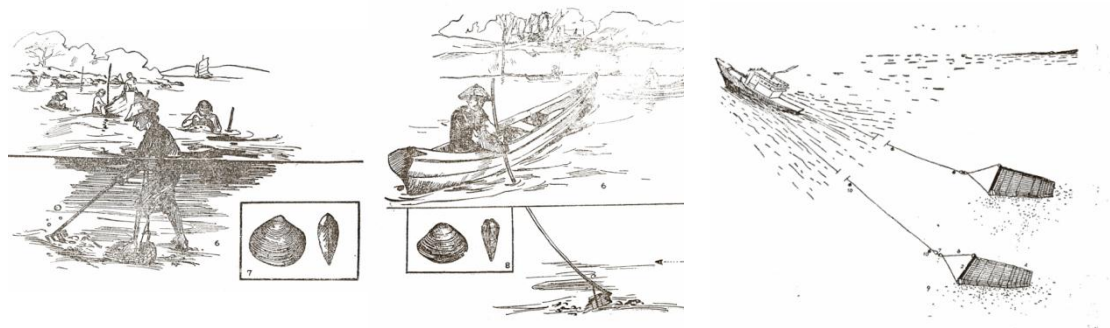


Figure 19 Development of dredge fishing gear from 1943 to 1969

Source: Department of Fisheries (1969)

Dredges fishing in Thailand

Department of Fisheries classify boat dredge into dredge category. Dredge is look like big sieve. Shape is rectangular shape. Operation is used by tow dredge onto seabed. Dredges scrape or dig on sea bed. Macro benthos, living on the sea bed, is trapped into dredge and other small objects are release through dredge slit.

Department of Fisheries (1997) classifies dredges into 3 major types in regarding to the target species 1) Short-necked surf clam or undulated surf clam 2) Cockle clam and 3) Other dredges

Department of Fisheries (1968) reports the iron dredge fishing gear is iron frame rectangular box shape. The front size is slightly higher that rear size. Iron frame is made by iron bar diameter 10.0 mm. Front side is 60 cm in width, 160 cm in length and 12-13 cm in height. Dredge slit is made by iron wire No.16. Dredge slits are 0.8-1.5 cm interval. Dredge slit is depended on the target size of clam. Target catch of dredge slit 1.2 cm is undulates surf clam size bigger than 200 Clams/kg. Fisher will use dredge slit interval 8 mm to catch undulates surf clam size smaller than 300 Clams/kg.

Dredge construction is composed with 3 main parts, i.e.

1) Opening or entrance or mouth of dredge

Opening or entrance side is made by iron plate 60 cm in length, 10 cm in width and thickness is 0.7 cm. Iron plate attached with frame of dredge in 30 degree angle. Then dredge opening become wider to 68 cm in width and 22 cm in height. Both side of the front attached with towing warp.

2) Front frame

Front frame is attached with opening (or entrance) part. It is constructed by iron bar, diameter 10 mm. Front side is 60 cm in width, 90 cm in length and 13 cm in height.

3) Rear frame

Rear frame is same material as front frame. Front side is 60 cm in width, 72 cm in length and 13 cm in height. At the rear part is 30 cm then made the rear frame look like a trapezoid box.

Two (2) pieces of dredge pendants are made by iron chain diameter 40 mm, 100 cm in length. Each chain is fixed with each side of entrance. The other end of chain is connected by big swivel. Towing warp is nylon rope diameter 20 mm, Z-twist, 4 strands and 60 m in length. There are few concrete weight fixed with towing warp to prevent dredge entrance move oblique to sea surface.

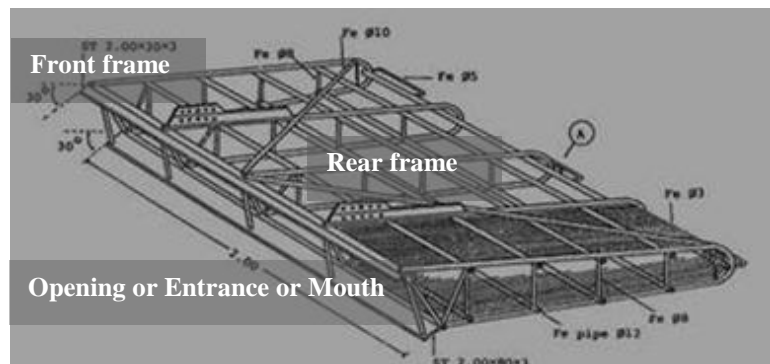


Figure 20 Iron dredge construction

Nowadays iron dredge is same principle and design as the previous time. Development of iron dredge is change dimension and shape. Dredge is developed the designed for increase swept area by expand width at the front side, longer than distance between front side to rear size. Dredge structure is not separated into 3 parts but constructs into the same piece of dredge. Dredge frames are made by iron pipe, diameter 8-10 mm, 3 mm thickness. An iron plate, length is equal the width of dredge entrance, width of plate is 8-10 mm and 3 mm thickness, is fixed with entrance of dredge, in oblique angle 30-40 degree. There are 2 pendant iron chain fixed with upper side of dredge near left and right corner.

There are 3 main dredge size operated in Thailand.

1) Small Size

The smallest size dredge is 120 cm in width (length of entrance), 70 cm in length (from entrance to rear side) and 12 cm in height. Fishermen use to catch clam spat, not only Undulated surf clam but also others e.g. spat of cockle. This dredge size also operated as harvested gear in to cockle farm.



Figure 21 Small size iron dredge and outboard engine fishing boat

Photo: Isara Chanrachkij

2) Medium Size dredge (180-240 cm)

The medium size dredge is 180-240 cm in width (length of entrance), 100-110 cm in length (from entrance to rear side) and 12-16 cm in height. Weight of dredge is approximately 80 kg. Dredge pendants is made by iron chain. Dredge warp is made by polypropylene (PP) rope, 4 strand Z twist and 24 mm diameter. Warp length is 2-3 time of Sea depth. Fishermen operate to catch undulated surf clam and Cockle. Dredge price, size 180-240 cm, is 8,000-12,000 baht.

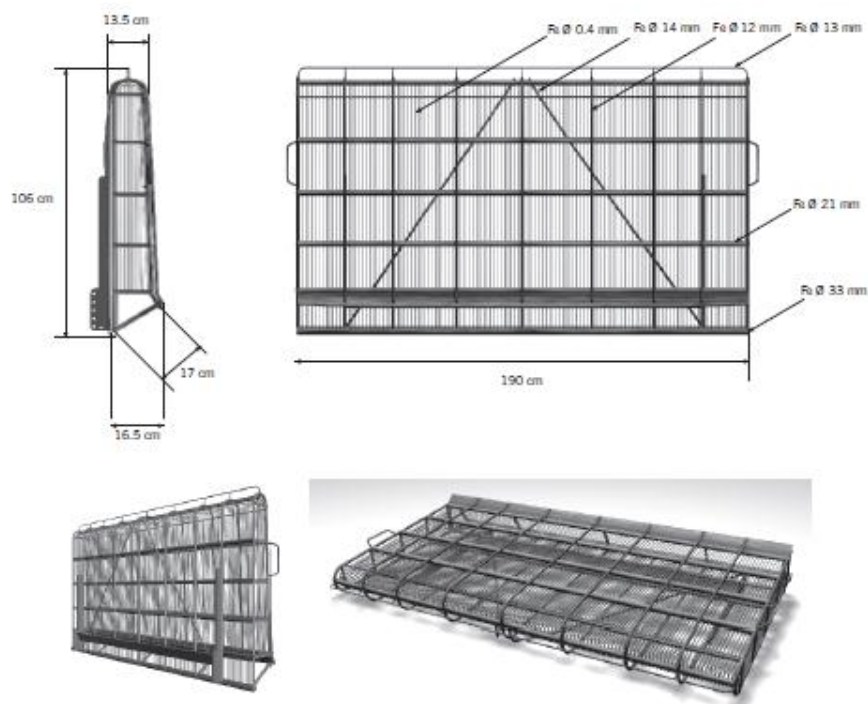


Figure 22 Construction of iron dredge, entrance size 190 cm.

Source: Modified from SEAFDEC (2546)

3) Large size

The largest dredge size is between 300-350 cm in width (length of entrance), 120-130 cm in length (from entrance to rear side) and 12-16 cm in height. Weight of dredge is approximately 120 kg. Dredge pendants is made by iron chain. Dredge warp is made by iron wire, 6 strands and 14 mm diameter. Warp length is 2-3 time of Sea depth. Fishermen operate to catch Undulated surf clam and Cockle. Dredge price, size 300-320 cm, is 12,000-15,000 baht.

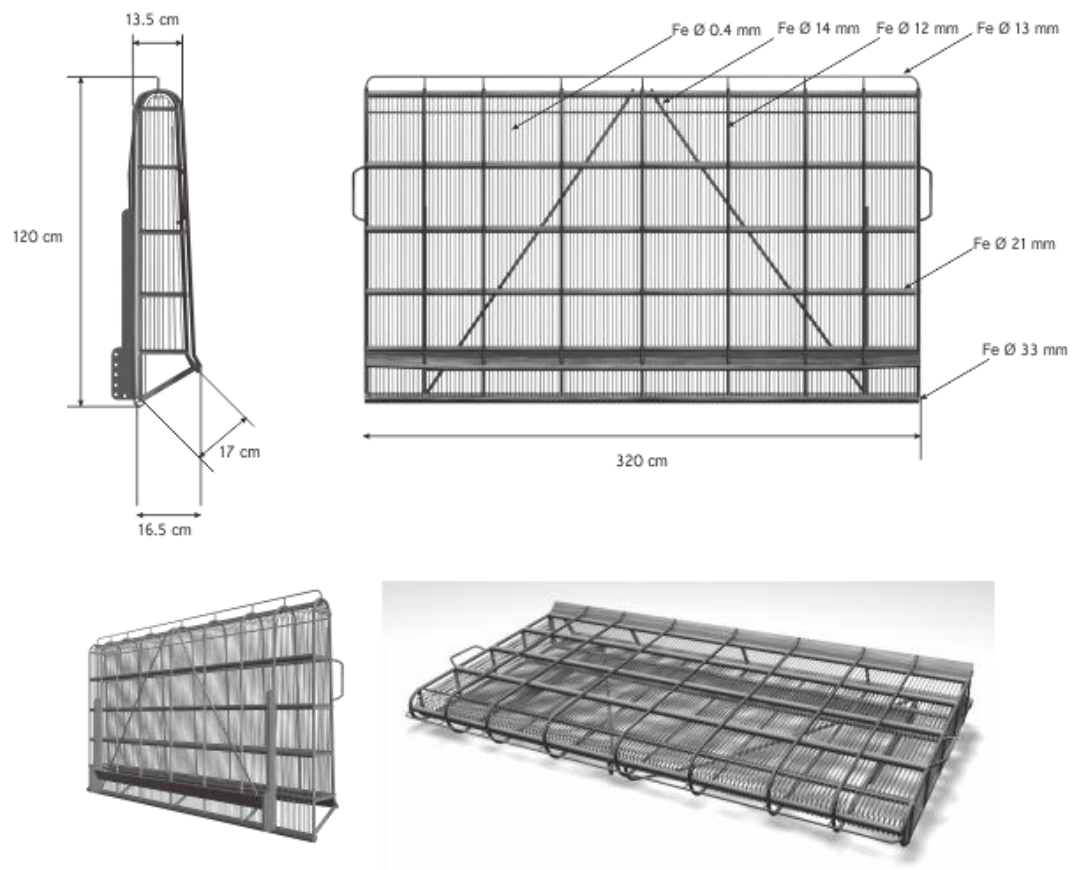


Figure 23 Construction of iron dredge, entrance size 320 cm.

Source: Modified from SEAFDEC (2546)



Figure 24 Iron dredge, entrance size 320 cm.

Photo by Isara Chanrachkij

Fishermen do not prefer to construct iron dredge bigger than 3.5 m. There are 2 main purposes;

1) Controlled of the Fisheries Announcement by Ministry of Agriculture and Cooperative (effective on 8 March 1990) Dredge entrance size is bigger than 350 cm is prohibited regarding to control fishing capacity. Allow fishing boat less than 18 m (LOA) installs with dredge and limit the numbers of dredge onboard are not more than 2 sets.

2) Fishermen try to use dredge entrance size bigger than 350 cm but they found that such size is easy to damage while hit with hard underwater objects. Dredge easy to bent and difficult to repair compare with entrance 350 cm. That made lifespan of bigger dredge is shorter than the smaller dredge. (Interview of Mr. Prasit Lumyong, dredge fisherman at Tumbon Bangtaboon Subdistrict, Ban-laem District, Petchburi Province)

Dredge modification by expanding size is the attempting of dredge fisher to increase fishing capacity. However modification is needed to expend suitable with size of fishing boats. Dredge fishing boat what the most convenient modification is beam trawler what stern deck is modified to construct the special platform for sorting catch and store iron dredges.

Fishing gear selectivity of dredge is focused on the interval or distance of dredge slit. Mickmin (1990) conduct the experiment of iron dredge selectivity in Laem-ngob District, Trat Province and Klong-darn District, Samut Prakarn Province. Experiment conducted by using 3 dredge's slit size, i.e. 8, 10 and 12 mm. Result shows that slit size 8 mm has trapped 50% in number (LC_{50}) of clam shell length 2.61 cm and 2.47

cm. Slit size 10 mm has shown LC_{50} of clam shell length 3.00 cm and 3.09 cm. And slit size 12 mm has shown LC_{50} of clam shell length 3.97 cm and 3.39 cm. Mala and Jintana (2005) conducts the dredge slit selectivity experiment in Petchburi and Samut songkram Province by using iron dredge slit 12 mm. Result shows LC_{50} of clam shell length is 3.70 cm

Mickmin (1990) concludes the appropriate iron dredge slit by biological information of length at the first mature. Biological research conducts by Department of Fisheries, length at the first mature of undulated surf clam collected from Suratthani Province is 29.0 mm in male and 31.0 mm in female, from Trat Province is 42.5 mm (without sex separation) and Upper Gulf of Thailand is 32.0 mm (without sex separation). Refer to result of experiment, dredge slit size 12 mm is the most appropriate to sustain utilization of undulated surf clam. Department of fisheries has announced the control of dredge slit must bigger than 12 mm.

It is the fact that some dredge fishers violate the regulation by using 8.0 mm dredge slit. Target catch is premature clam, size smaller than 300 clams per kg. These fishermen always operated in the area of around the Upper Gulf of Thailand in particular off Tachin Estuary, Samutsakhon Province and Bangprakong Estuary, Chacherngtoa Province. They claim that they harvest them before massive clams are died after freshwater runoff from river in October and November every year. Resources are also recovered in several months later. Furthermore these premature clams are accepted by processing factory to use as material for canning industry. If target clam is for local consumption, same fisherman change the iron dredge to 12 mm dredge slit for clam 200 Clams/kg.

Dredge Fishing boat

Department of Fisheries-Thailand (1969) report dredge fishing boat is during is wooden boat installed with 10-90 hp inboard engine, LOA is 10-12 m. Stern deck is expanded to be small platform for working and store dredges. There are 2 poles fixed at stern deck for tightening with towing warp, each side a dredge. During fishing operation, fisherman uses both dredges but alternative towing. Department of Fisheries (1997) report dredge fishing boat is during is wooden boat installed with 10-250 hp inboard engine, LOA is 6-18 m. Stern deck is expanded to be small platform, rectangular shape (1.5 x 2.0 m), for sorting clam and store dredges. There are 2 poles fixed at stern deck for tightening with towing warp, each side a dredge. Nowadays dredge fishing boats are classified into three size regarding to the dredge size

1) Smallest size dredge fishing boat.

Small size dredge fishing boat is an outboard engine boat design, modified to install with boom, portside and starboard size. An outboard engine is modified by small truck engine 85-100 hp install at stern (Long-tail fishing boat design).



Figure 25 Outboard (Long-tail) engine fishing boat with small size iron dredge

Photo Isara Chanrachkij

2) Medium size dredge fishing boat

Medium size dredge fishing boat operated with medium size iron dredge, 1.8-2.4 m in length of dredge opening. Fishing boats installed with inboard engine 200-300 hp and length overall (LOA) is 12-14 m. Fishing operation employed 10-12 crew members and operate with limited deck machinery. Capstan winch is mainly used for heave up anchor, not for fishing operation. Dredge fishing boat equipped with Echo Sounder, Global Positioning System (GPS) and radio communications.

In some fishing ground, local fishermen modified other type of local fishing boat e.g. squid cast net, bottom gillnet for dredging operation. They always modify their fishing boats while dredging season and other dredge fishing boats from other place start dredging around their local fishing ground. These modified fishing boats are 12-14 m in LOA.



Figure 26 (A) Medium scale fishing boat, length over all (LOA) 12-14 m, operate without deck machinery (B) Medium scale iron dredge, entrance length is 2.0-2.4 m

Photo Isara Chanrachkij

2) Largest size dredge fishing boat

Largest size dredge fishing boat operated with largest size iron dredge, 3.0-3.2 m in length of dredge opening. Fishing boat install inboard engine 300-500 hp. Fishing operation employed 10-12 crew members. and operate with capstan winch, hoist and winch. Towing warp hauled by capstan winch installed at the front of wheel house. Two derricks with blocks are installed above the stern deck to hang dredge during remove catches. During fishing operation, fisherman uses both dredges but alternate towing individual iron dredge. While one dredge is hauled to remove the catch on platform, the other is launch into the seabed for consecutively dredging. Fishermen also prepare a spare dredge (the third one) and used while any dredge is damage by fishing. Dredge fishing boat equipped with Echo Sounder, Global Positioning System (GPS) and radio communications. Dredges are manufacture by factories in Samut Prakarn Province, Samut Sakhon Province, Samut Songkram Province and Petchaburi Province

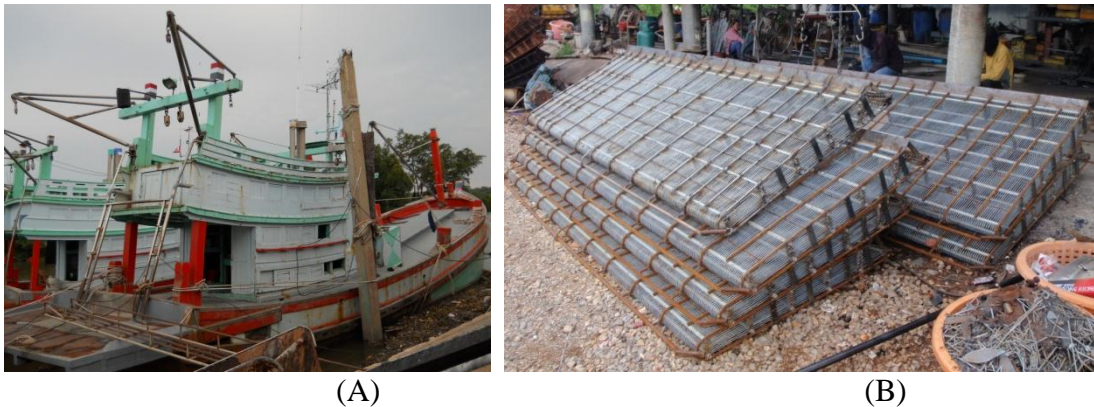


Figure 27 (A) Large scale fishing boat, length over all (LOA) 18 m., operate without deck machinery (B) The largest scale iron dredge, entrance length is 3.0-3.2 m.

Photo Isara Chanrachkij

Department of Fisheries gets trouble on monitoring numbers of dredge fishing boat regarding to the convenient of fishing boat modification. In particular numbers of dredge fishing boats are changed in regarding to fishing season, fishing ground and resource abundance. Study on the abundant, catch per unit effort cannot be accuracy conducted then efficiency resource management is not able to legislate. Resource survey by Department of Fisheries research vessels always less in result because officers' skill are less that fishers. Landing survey is need to catch information supplement but the limitation is undulated surf clam is not landed at public or municipal fishing port. They always land their catches at private port because product for canning and frozen factory needs to start processing (boiling and shell sorting) at landing site.

Department of Fisheries legislate the policy on control fishing capacity of Clam fishing by a Agriculture and Cooperative Ministry Announcement (effective on 18

February 1969) by demarcating conservative area from shore 3,000 m and the Agriculture and Cooperative Ministry Announcement (effective on 8 March 1990) determine dredge size, dredge slit, number of dredge and fishing boat. Details are focused on the control number of dredge installed onboard not more than 3 units/fishing boat. Dredge entrance is not wider than 350 cm and dredge slit is wider than 1.2 cm. Length overall of Fishing boat must not longer than 18 m. (Mala and Jintana, 2004)

Conclusion

1. Commercial undulated surf clam species in Thailand is *Paphia Undulata* (Born, 1778). Growth coefficient is between 0.9-1.74 according to fishing ground. Length of the first mature (L₀) is measured from 23.0 to 46.6 mm. Reproductive season of undulated surf clam in Thailand has found two periods of years, February-May and August-November. Only habitat around Ao Mahachai Bay, Samut Sakhon Province is only period of year, August-October caused by massive freshwater runoff from Tachin River during November kill undulated surf clam and parental stock is not sufficient for reproduce in the period of February-May.

2. Undulated surf clam dredge fisheries is found around the estuary of the Gulf of Thailand and Andaman Sea. Significant undulated surf clam fishing ground of Thailand is around Trat Province, Samut Prakarn Province, Samut Sakhon Province, Samut Songkram Province, Petchburi Province, Suratthani Province and Trang and Satun Province. There are few fishing grounds with less fishing activities because have serious conflict between local fishers and dredge fishers, i.e. Prachaub Khiri Khan Province and Nakhon Sri Thummarat Province. The other fishing grounds do not show with statistic record, e.g. Ranong Province, Phangna Province, Songkla Province and Pattani Province. These fishing grounds may be local consumption utilization.

3. The maximum statistic record on the undulated surf clam production is showed in Year 1987 with 130,000 metric ton and minimum is showed in year 1978 with 21,000 metric ton. Trend of undulated surf clam production is fluctuated regarding to temporary over fishing in many undulated surf clam dredge fishing ground in Thailand. Nowadays undulated surf clam production is from fishing ground in upper Gulf of Thailand, Trat Province Suratthanni Province and Satun Province. There are imported frozen clam used for material of processing industry of Thailand.

4. Thai fishers started harvested bivalve fisheries resources by dive and hand grope. The development started by inventing of handy dredge mobilized by man power or current force or wind force with non-motorized boat. Undulated surf clam commercial fishery by using iron dredge has the first record in year 1969 and widely spread after year 1971. Dredge fishing gear in Thailand are classified into 3 major types in regarding to the target species 1) Short-necked surf clam or undulated surf clam 2) Cockle clam and 3) Other dredges Nowadays iron dredge is same principle and design as t40 years ago. Dredge frames are made by iron pipe, diameter 8-10 mm, 3 mm thickness. An iron plate, length is equal the width of dredge entrance, width of plate is 8-10 mm and 3 mm thickness, is fixed with entrance of dredge, in oblique angle 30-40 degree. There are 2 pendant iron chain fixed with upper side of dredge near left and right corner.

5. There are 3 main dredge size operated in Thailand. Small size dredge is 120 cm in width (length of entrance). Dredge fishers always operate this dredge size to catch clam spat, and used into cockle farm. Medium Size dredge is 180-240 cm in width (length of entrance), 100-110 cm in length (from entrance to rear side) and 12-

16 cm in height. Dredge fishers always operate this dredge size to catch undulated surf clam and cockle with fishing vessel 14 m. Large size is between 300-350 cm in width (length of entrance), 120-130 cm in length (from entrance to rear side) and 12-16 cm in height. Dredge fisher operate this dredge size to catch undulated surf clam and cockle with fishing vessel 18 m. length overall. Interval of dredge slit is 2 sizes, i.e. 8 mm and 12 mm. Dredge slit with interval 8 mm is used for catching premature size 300 clam/kg. Dredge slit with interval 12 mm is used for catching premature size 200 clam/kg. The modification to narrower dredge slit from 12 mm to 8 mm is one of major cause to damage undulated surf clam before mature size. That causes undulated surf clam resources spend few year to restock population after massive dredge fishing.

Recommendation

1. Undulated surf clam fisheries development is started by the mobilization of processing for export since 1977. The present situation of market/product chain of undulated surf clam including with the trend of export production, is priority to investigate annually.

2. Although Department of Fisheries has legislated fisheries management measures to control fishing capacity strengthened on the fishing technology and fishing ground, fishing boat is able to modify in particular local fishing boat around fishing ground. Therefore number of dredge fishing boat of Thailand is not constant and management is less effectiveness.

3. Undulated surf clam resource survey should regularly conduct in order to understand the season, restocking period and fisheries biology of undulated surf clam. The survey should be undertaken at all fishing ground of Thailand both by fisheries research vessel and landing survey. It is noted that the of Department of Fisheries research vessels are less skill, dredging techniques and dredging capacity than professional dredge fishing boat. Survey by local fishing boat may obtain virtue resource situation.

4. Development of fishing gear design and construction should be carefully and strengthened monitor by local fisheries officer and fishing gear technology scientist.

5. Fisheries management applied for coastal fishing zone management base on the scientific evidence including with co management practices should be applied to reduce conflict of utilization coastal fisheries resources.

6. Regarding to undulated surf clam import for raw material of processing industries of Thailand, it is necessary to support neighbor countries e.g. Viet Nam, Cambodia and Myanmar to conduct undulated surf clam research resource survey. And develop the survey methodology similar to Thailand including with stock assessment methodology into same standard. That is in order to prolong the imported raw material of undulated surf clam for processing industries of Thailand under sustainable manner.

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