MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT
DEPARTMENT OF CAPTURE FISHERIES
AND RESOURCES PROTECTION

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REPORT

OVERVIEW OF TRAWL FISHERIES SELECTIVE FISHING DEVICES AND THEIR APPLICABILITIES IN TRAWL FISHERIES OF VIETNAM

HÀ NỘI - 2014

INTRODUCTION

In the future, capture fisheries will be a key sector to provide human food and it is up to the 21st century, aquaculture production will be equal to marine capture fisheries catches. However, under heavy fishing pressures in recent years, many marine stocks have been threaten and depleted. Implementation of management measures is very necessary to recover such depleted stocks as well as ecosystem well-being status.

In recent decades, there has been a proliferation of attempts by researchers, fishers and others worldwide to develop effective bycatch reduction devices (BRDs) for tropical shrimp and trawl fisheries. In some of these fisheries, the introduction of BRDs has been very successful and the bycatch of many species has been substantially reduced or almost eliminated. However, these successes are not universal, particularly in developing countries where economic, social and political conditions may contribute to hampering the appropriate and effective research and development (R&D) of BRDs. Some developing countries also have a poor record of exploiting marine resources in a sustainable manner. Fishing capacity is often in excess of that required to fish sustainably without overfishing, fishing practices often include the use of poorly selective fishing gear, some of which also substantially modifies the sea bed and fish habitats, and the effective management, control, and surveillance of fishing activity is often non-existent or limited.

Some of these countries also suffer from a lack of technical expertise, capacity, and infrastructure necessary to conduct appropriate and effective bycatch reduction research. These problems are all complex, and finding solutions are not an easy task. In the meantime, the development of BRDs remains relatively slow or non-existent, and the capture and mortality of bycatch in tropical shrimp and trawl fisheries remains an ongoing issue.

Recognizing a need to overcome these problems, FAO has been spearheading efforts to facilitate BRD research and development worldwide. These efforts include the execution of a five-year global project titled “Reduction of environmental impacts of shrimp trawling, through the introduction of bycatch reduction technologies and change of management”. This project commenced in 2002, and was funded by the Global Environment Facility, FAO and participating countries from Latin America, West Africa, Southeast Asia and the Persian Gulf region. This project has filled vital information gaps, and provided education and training for many researchers, fishers and others with an interest in bycatch reduction in tropical shrimp-trawl fisheries. It has also served as an excellent springboard for enabling each country to continue efforts to reduce bycatch, and some countries have now made good progress towards developing their own and regionally specific BRDs. However, despite this progress, a major limitation to more widespread R&D of BRDs in many countries has been a lack of guidelines on how to carry out BRD fieldwork.

Marine capture fisheries in Vietnam, like other countries in the region that is the current state of resources are increasingly depleted. According to recent stock assessments from 2011 - 2013 showed that present fisheries resource biomass in Vietnam is about 4.25 million tons, reduced down 16.3% compared with the period from 2000-2005, particularly demersal marine resources decreased by 58.5% (RIMF,

2014). Thus, it can be seen that in order to develop sustainable fisheries in Vietnam it is necessary to implement suitable measures to protect resources, including technical solutions such as the use of juvenile exclusive devices, trash fish and sea turtles. In 2001, a first attempt of Vietnam has conducted under a collaboration program between Research Institute for Marine Fisheries and Southeast Asian Fisheries Development Center (SEAFDEC) to investigate Juvenile and Trash Excluder Device (JTED) for shrimp trawlers in the waters of the Gulf of Tonkin. Since then there have also been a number of small-scale studies on juvenile exclusive devices, trash fish and turtle, however they were just at the initial trials and have not been applied in practice. In addition, there have been a number of trawl selectivity studies in Vietnam and these were used to establish mesh size regulations under National Circular No. 02/2006/TT-BTS (issued on 20th March 2006) and other supplementary legal document No. 62/2008/TT-BNN (issued on 20th May 2008). However, adoption of the measures presented in these Circulars has been limited. A fundamental reason for the poor level of adoption has been the unwillingness of fishing ~~sector~~ communitiesto accept short-term catch or benefit losses (which is likely a ~~likely result~~ consequencethat the improved selectivity gears will bring).

This work will review previous trawl selectivity trials and experiences conducted with fishing communities. This will include a comprehensive cost-benefit analysis of improved selectivity measures, weighed against short-term catch reductions. Only if these analyses look positive then a next step is to implement to provide further trials of trawl selectivity. The objective of this consultancy is therefore to assess the results and outcome of earlier selectivity trials, identify potential gear modifications and draw up the work plan for further actions and designs. This must take into account the likely acceptance of the BRDs and increased mesh sizes, to local ~~fishermen~~ communitiesand the realistic live~~ke~~lihood of these technologies being adopted in the longer term and transferred to other locations in Vietnam.

1. Overview of bycatch reduction devices for trawl fisheries in the world

BRDs have received appropriate considerations by many countries and regional fisheries management organizations (RFMOs) ~~to study~~ to reduce bycatch such as juveniles, trash fishes or endangered species in order to protect marine resources.

1.1. Juvenile and trash fish exclusive devices

1.1.1. Square mesh codend

~~For~~ Using thediamond mesh codend in fishing operations fishes will be putted into the end of codend and ~~cause~~ this part of the codend~~this section~~will ~~to~~ be stretched out, while mesh connection between the net body and the codend is smaller causing juvenile and small fishes cannot escape. Therefore, though using diamond mesh codend with large mesh size as regulated, escape of small fish shall remain ineffectively because mesh sizes then are smaller than as usual due to net loading increased(such as self-mesh size reduction) (***Figure 1*** ~~***Figure 1***~~).

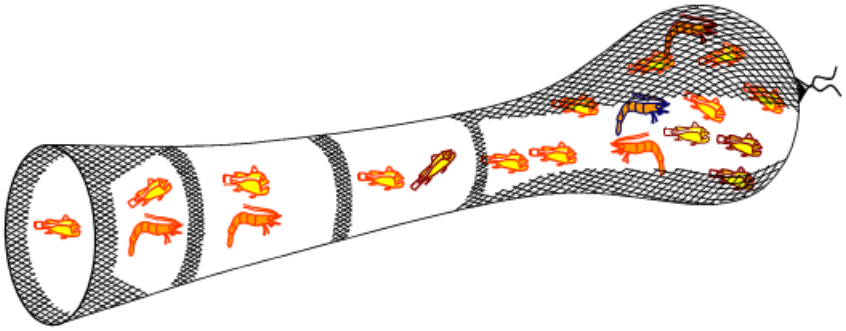


Figure 1: Outside structure of diamond mesh codend

To overcome self-mesh size reduction due to net loading area of the mesh, we use squared mesh codend. While the force impacted horizontally down (mainly friction and prevention) square mesh will not change the size and thus fish escape area remains the same, meaning that escape ability of the fish out of hole does not change (***Figure 2~~Figure 2~~***).

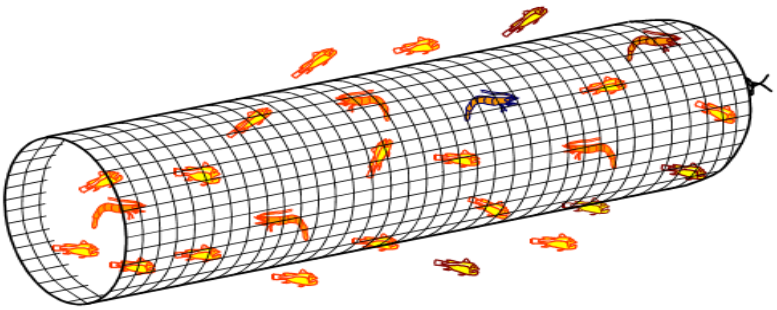


Figure 2: Outside structure of squared mesh codend

The square mesh codend was studied by Robertson et al in Scotland bottom trawling from 1982 to 1986. Study results showed that the proportion of cod individuals with length at 50% maturity (L_{50}) which is retained in square mesh codend higher than the percentage retained in diamond mesh codend of the same size, suggesting that many fishes whose sizes are smaller than minimum limits have been escaped through square meshcodend (Robertson, 1986).

China has also tested square mesh codend of 30.3 mm for coastal bottom trawlers from 1997 to 2000. Studied results showed that the proportion of fish escaped from the net averaged were from 29.76% by number of individuals and 8.46% by weight. Analysis of the ability to escape the net of four economic fish species indicated that the proportion by mass escaping of *Nemipterusvirgatus*was 14.6%, *Sauridatumbil* 51.9%, *Upeneusbensasi*56.6% and *Trachinocephalusmyops* is 65.8%. Escaped rate were calculated according to the number of individuals with size smaller than fishing allowable size for*Nemipterusvirgatus* was 43.2%, *Sauridatumbil*60.2%, *Upeneusbensasi* 82.1% (ZHANG Xufeng et al., 2006).

Research on the economic loss when using square mesh codend for trawlers, Mohamed et al. (2009) have used square mesh codend with size of 40mm. Studied results indicated that escaping rate of juvenile and small fishes averaged 8.1 kg/haul, accounted for 20% of total catches/haul, however the value of the escaped fish

accounted for only 1.3% of the total value of the haul. The results of this study demonstrated that the loss rate of economic when using square mesh codend with size of 40 mm for trawlers was negligible and noeffectiveness on the economic performance of the fishing fleet (Mohamed et al., 2009).

To answer the question if using the square or diamond mesh codend with larger sizes to enhance escape ability of juveniles and small fishes, Lucchetti et al (2008) have carried out experiments and compared the ability of fish to escape between the the square or diamond mesh codend with larger sizes using 2 types of mesh sizes of 44 mm and 54 mm. This study results showed that the fish length at 50% maturity (L50) of *Mullusbarbatus* in the codend as follows: L50 for diamond mesh codend = 44mm was8.21 cm and square mesh codend = 44 was 13.30 cm, while these figures with diamond and square mesh codend at 54mm was 11.36cm and 16.91cm, respectively. The minimum size of fish which is allowed to exploit with *Mullusbarbatus* in the Mediterranean Sea is 11cm, so it is clear that diamond mesh codend has ability to escape less than square meshes, even though mesh sizes increased rhombus more 23% with diamond then square mesh codend(Lucchetti et al., 2008).

1.1.2. JTED using square mesh windows

In addition to studies using square mesh codend, the scientists also studied experiments on JTED using square mesh panels, also known as the window for square fisheyes for trawlers. Like square mesh codend, size of square mesh panels will not change in the fishing operation and thus juveniles and small fish can easily escape.

For square mesh panels, selection of mesh size is very important and necessary to determine the suitable mesh size for the most easily escape of juvenile and fish larvae and to reduce maximum amount of lost shrimp. Sizes, dimensions and mounting position of square mesh panels must be especially interested. Putting in place between adjacent area of the codend and net body is the most reasonable position to be able to reduce amount of lost shrimp. Square mesh panels should not be placed near the end of codendbecause if it is placed near the end of codend, the shrimp amount will be more lost, especially while net retrieving (Robertson, 1993).

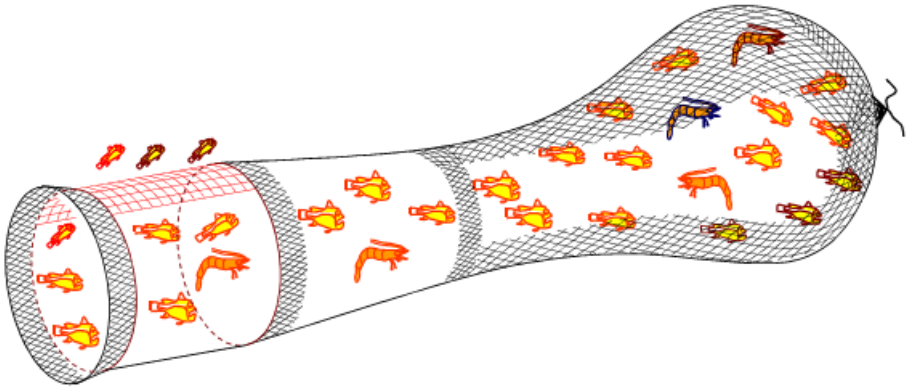


Figure 3: Outside structure of squared mesh panels

One of the advantages of square mesh panels are that juvenile and small fish can easily escape to reduce the sorting time of the products. In addition, construction, transport, repairs and replacement of this device is also easy. However, there are also

disadvantages that shrimp and other fishes can be lost if square mesh panels placed too close to the end of the codend, especially when net retrieving and when sea wave sea is at high level. In addition, codend shapes can be deformed without to be installed correctly.

In 2001, MetinCengiz et al has conducted a research on the escape ability of juvenile and fish larvae using square mesh panels for 3 species of *Diplodusannularis, Mullusbarbatus* and *Pagelluserythrinus* of bottom trawlers in the Aegean Sea, Turkey. The study results showed that the escape ability of thementioned species using square mesh panels with mesh size of 40mm was better than of those of fish using the diamond mesh codend with same mesh size (MetinCengiz, et al., 2005).

1.1.3. Juvenile and Trash Excluder Device

An attempt to study technical solutions to protect marine resources, since 1998 SEAFDEC in collaboration with Southeast Asia countries to design and test Juvenile and Trash Excluder Device (JTED) for bottom trawlers. Some experimental results of JTED are following:

In 1998, SEAFDEC has organized two types of JTED (rectangular and semi curve devices) for bottom trawlers in coastal waters of PrachubKirikan and Chumporn, Thailand. The open month (fish escape part) of the rectangular device is designed with sizes of 8cm, 12cm, 16cm and 24cm while open month of the semi curve devices is 4cm, 6cm, 8cm and 12cm. The tested devices are shown in Figure 4 and 5.

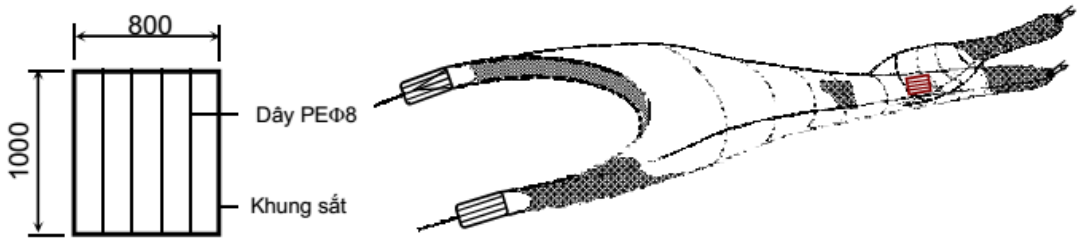


Figure 4: JTEDtype of rectangular

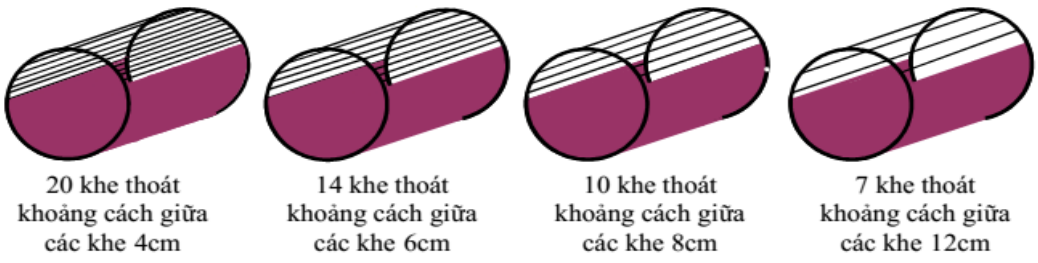


Figure 5: JTED type of semi-curve

Experimental results of JTED rectangle type showed that the escape proportion calculated by mass of economic fish species from 32-59% and escape rate of trash fish groups were from 5-20% and octopus group of from 78-100%. For type semi-curve, the escaped percentage by mass through the device of economic fish species was from

29-36% while escaped rate of trash fish groups of from 5-13% and octopus groups of from 19-44%.

Analysis of the escape ability by sizes of economic fish species showed that rectangular JTED was about 5% of juveniles (with size smaller than 13cm) and approximately 3% of adult fish (with size larger than 13cm) for economic fishes escaping through the devices. For semi-curve device this figure was approximately 37% for juvenile and 19% of adult fish to be escaped through the device (BunditChokesanguan et al., 2000).

In 2000, SEAFDEC organized BRD and JTED experiments at Brunei using rectangular steel frame with a fixed distance between 2 iron bars (escape hole of juvenile fish) is 30cm and a type mesh doubledcodend with mesh size of 50/35mm (inside codend has mesh size of 50mm and the outside of 35mm mesh size). The study results showed that with the rectangular steel frame device, rate of *Nemipterus sp.*at 13cm in length retailed at the inside codend was higher than 83% and 17% at the outside codend. For the type of mesh doubled codend50/35 mm, the retailed fishrate at the inside codend was 39% and of 61% at outside codend.

Thus, it is clear that fish's escape ability strongly depends on hole type of the device. In other word,if using suitablesize JTED or diamond codend devices, then fish can easily escape. However, this result was only for reference because numbers of hauls tested of the 2 device types were limited with only 5 catches for each type was carried out (BunditChokesanguan et al., 2001). To find out which device types are suitable for bycatch and juvenile fish of other species can effectively escape, SEAFDEC has conducted a second trial using JTED for trawlers in Brunei. In this experiment, 3 devices were testedincluding: (1) steel bar device with 3 types of hole sizes of 1cm, 2cm and 3cm; (2) rectangular steel frame device and (3) semi curves device. Study results showed that escape rate of fish by weight through the steel bar device with 1cm gap was 30.38%, 2cm gap of77.67% and 3cm gap of 86.29%. The escape rate through the rectangular steel frame device was 40.03% and the semi curves device of 12.77%. However, some large size individuals also could escape through the steel bars with gaps of 2cm and 3cm and even though with rectangular steel frame and semi curves devices. For *Leigonathus spp*., lengthat 50% of escape capable fish (L50)with the steel bars with gap of 1cm was 10.30 cm and 13.29 and 14.22 cm for bar size of 2 and 3cm, respectively. With the rectangular steel frame, the L50 was 4.28 cm and with semi curve device this parameter was 9.16 cm. For *Gerres spp*., fish length at escape(L50) of the bar device was 11.77, 13.40 and12.90cm with the bar gaps of 1, 2 and 3cm, respectively. The L50 of the rectangular steel frame and semi curvedevices was 11.91 and 10.01 cm, respectively (BunditChokesanguan et al., 2004).

In 2001, SEAFDEC continued to test JTED for trawlers in Malaysia using steel bars with gaps of 12mm and20mm (*Figure 6*~~*Figure 6*~~).For equipment of JTED with distance between two iron bars of 20mm released about 73% of total fishing catch, the rate of escape of bycatch group reached 87% of the total catch of trash fish and escape rates of small pelagic fish and shrimp groups were 44 and 63% of total catch, respectively. For equipment of JTED with distance between two iron bars of 12mm, only 35% of fishing catch was escaped and the escape rate of bycatch group was 70% of the total catch of trash fish, escape rate of small pelagic fish and shrimp group was

under 10% of total catch of each group. For *Rastretrelligerbrachysoma*with sizes of medium and larger than 12 cm are not likely to escape through JTED with distance between two iron bars of 12mm, but only 40% of this fish could escape through device with distance between two iron bars is 20mm. For *Nemipterus sp*. with size higher than 11cm was retailed in the codend in daily fishing (BunditChokesanguan et al., 2001).

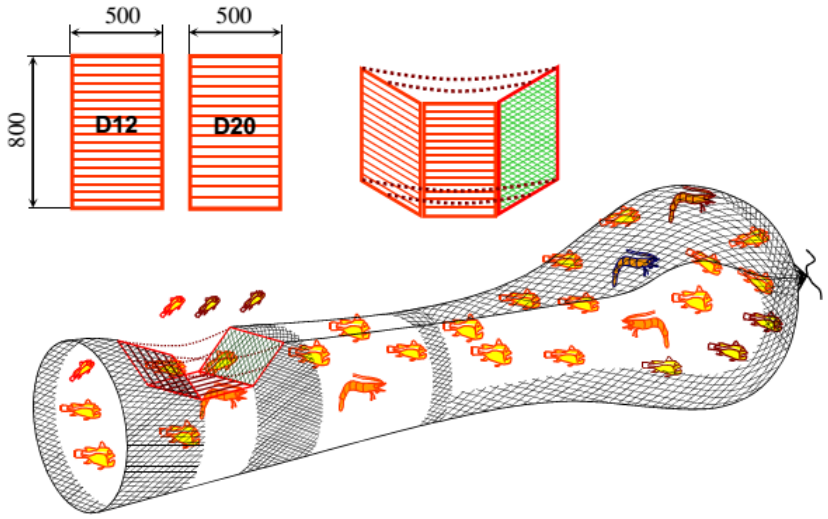


Figure 6: JTED with design by steel bars tested in Malaysia

In 2002, SEAFDEC has conducted an experiment on JTED for trawlers in Indonesia, including the type of equipment such as steel bars, rectangular frame and semi curve with gap distance to escape by fish all of 40mm (***Figure 7*** ~~***Figure 7***~~).

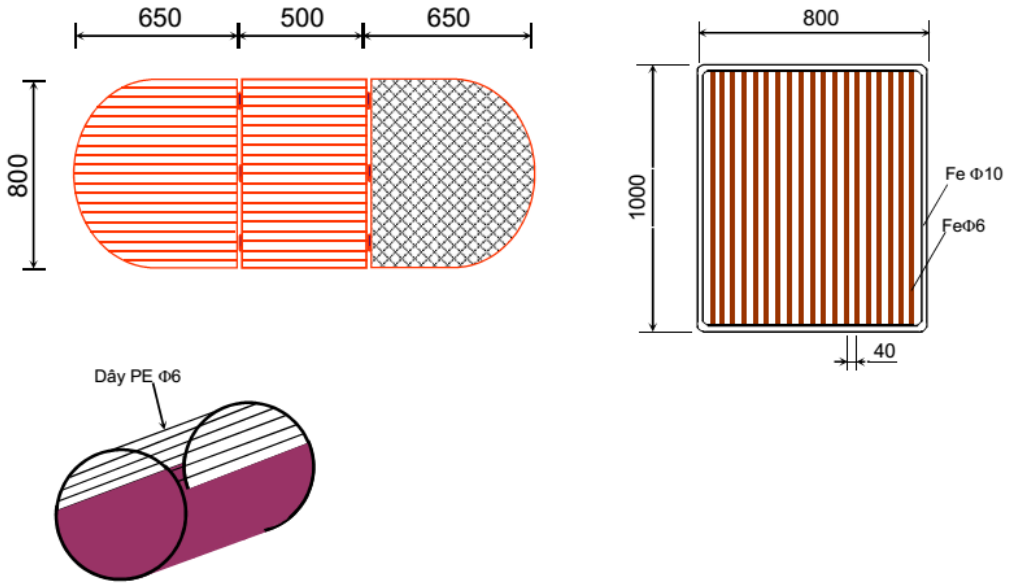


Figure 7: JTED's designs tested in Indonesia

Test results showed that the escape rate through the iron bars form of JTED reached 79% of total catch and approximately 25% for rectangular frame device and semi curves form. The escape rate of small pelagic fish groups through the devices were from 49 to 97%. Of those it was especially high for steel iron form (97%) and only 53% for semi curves form and rectangular frame device of 49%. The escape rate of

bycatchthrough the iron bar form device was 68% bars and semi curve and rectangular frame formwas 4 and 17%, respectively. However, research findings also indicated that the JTEDs and BRDs with distance of 40mm did not meet in terms of economic efficiency for shrimp trawlers in these experiments, especially in the form of iron bars with escape rate of shrimp through the device of very high while shrimp is the main target species. The semi curve form was more suitable than other types in the tests.

1.2. Turtle Excluder Devices

Sea turtle are considered threatened and endangered due to overexploitation and unsustainable and unreasonable turtle use has seriously been reduced on this resource and can become extinction. In order to protect sea turtles, some countries such as Australia, the U.S., Mexico and regional fisheries management organizations such as SEAFDEC have tested Turtle Excluder Devices (TED) for shrimp trawlers. Depending on the made material TED is classified into hard and soft TED. The hard TED is made by hard materials such as metal or hard plastic while the soft TED is made by nylon net. Each device type has different advantages and disadvantages but generally soft TED is less effective to release sea turtle than hard TED devices and thus it is not encouraged to apply.

Since the early 1990s of 20thcentury, Australia has investigated and tested TED equipment for shrimp trawlers with a variety of devices used including oval and rectangular device...

+ Oval TED is designed with oval-shaped and fitted with the codend with a fixed angle of 45^0 (***Figure 8~~Figure 8~~***). Turtles and large size individuals are directed to the escape area by a mesh panel while the shrimp, fish and other small individuals can pass through the opening area between the bars of the device and go into the codend.

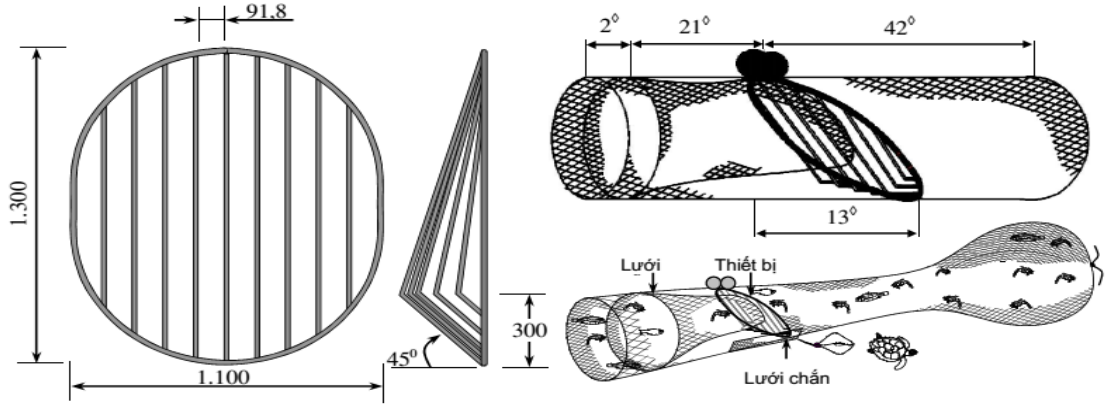


Figure 8: Configuration of oval-shape TED and how connect to the codend

+ Rectangular frame TED is designed by a rectangular aluminium frame and is mounted with the codend and fixed with an angle of 35^0. The distance between the bars of the device is 60mm. Turtles and other individuals which have large size were directed to the escape area while shrimp and small fish pass through the slot between the bars of the device and go to the codend. A mesh lid is mounted on the outside of

the escape door to prevent shrimp escaping through the escape door of sea turtles (***Figure 9~~Figure 9~~***).

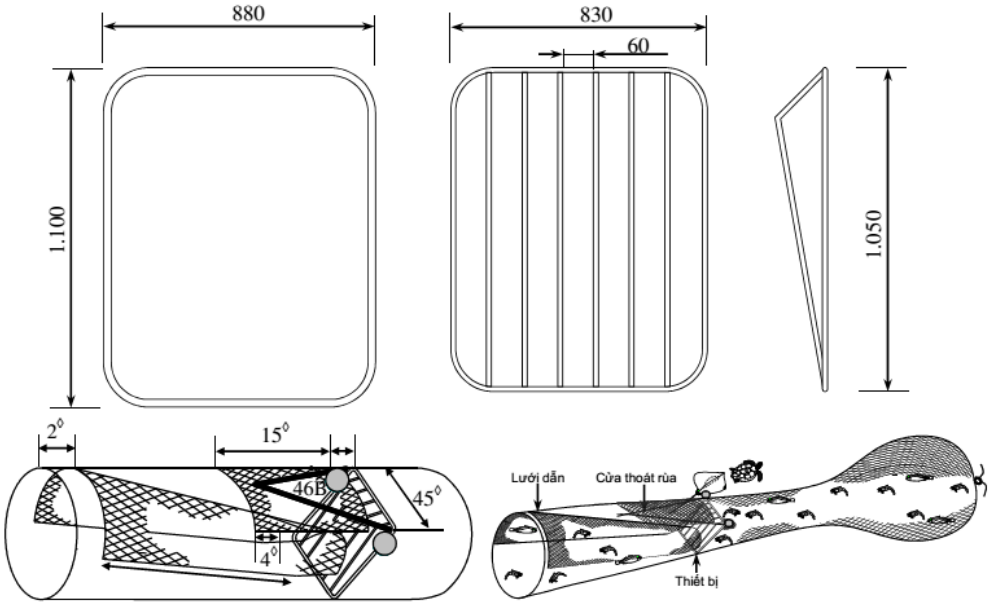


Figure 9: Configuration of rectangular frame TED and how connect to the codend

SEAFDEC has also associated with a number of countries in the region to study the types of TED for shrimp trawlers. Some tested TED include: TTFD device (Thai turtle free device), the Bent pipe device, oval-shape device (Super Shooter), rectangular frame devices and devices of Mexico and Georgia Jumper's device.

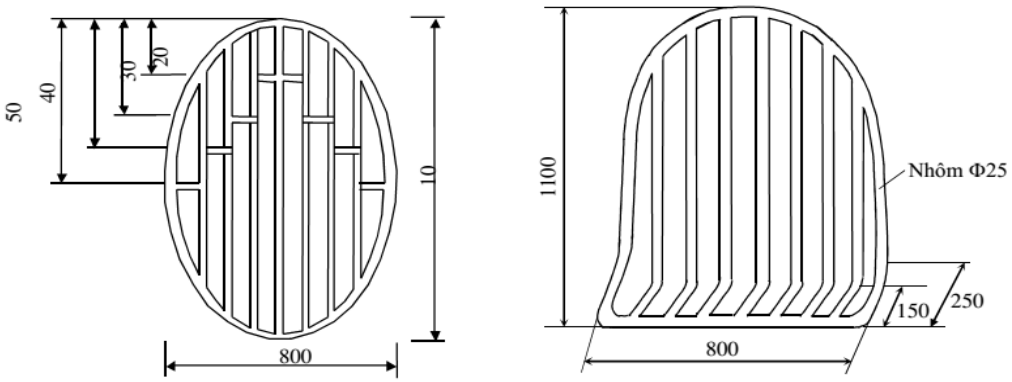


Figure 10:Turtle excluder device of Thailand (TTFD) and ofBent Pipe

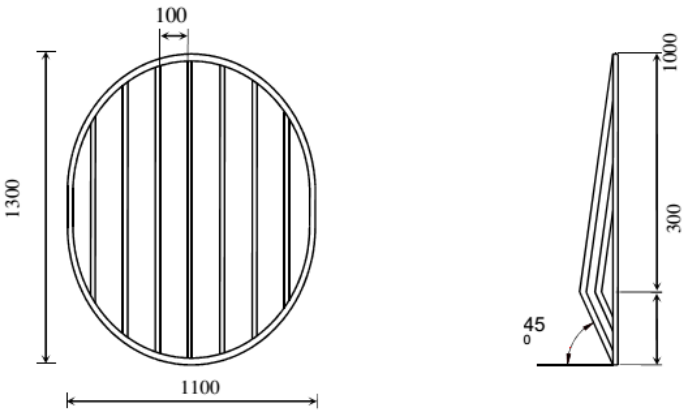


Figure 11: Turtle excluder device of Super Shooter

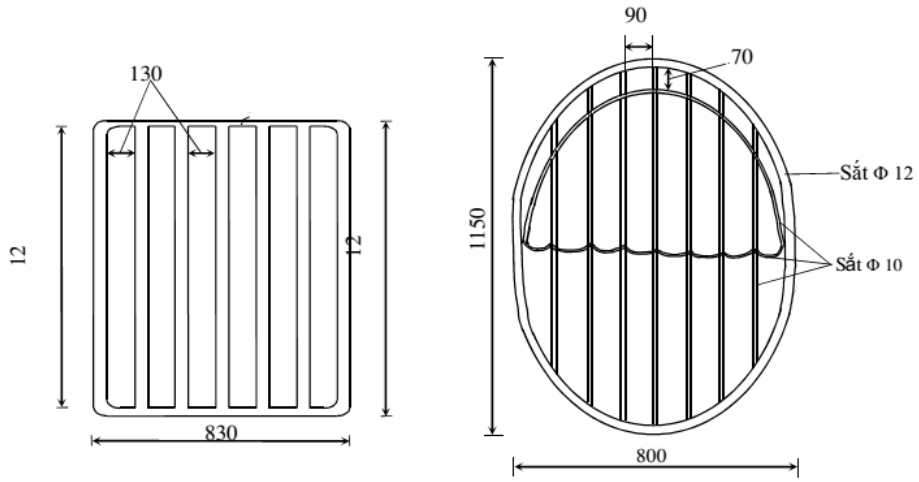


Figure 12: Turtle excluder device of Mexico andGeorgia Jumper

The experimental results on TED types of SEAFDEC in Thailand indicated that Super Shooter device, TTED and Georgia Jumper providing good results when releasing many sea turtles and the loss ratio of shrimp and fish were low. The loss ratio of shrimp and fish with Super Shooter device were from 1.91 to 8.36%, for TTFD from 1.04 to 1.80% and for the Georgia Jumper devices from 0.85 to 11.00%. In 1996, Thailand held a workshop on using TEDs for shrimp trawlers. Throughout the workshop, fishermen had a positive outlook for the use of TEDs and many fishermen have voluntarily use TEDs to release sea turtle to protect this species.

In 1997, SEAFDEC tested TEDs for shrimp trawlers in Malaysia. TTFD device with 2 different sizes were used. The experiment results showed that the TTFD released sea turtles without much influence on catch of shrimp and fish in the haul. The loss rate of fish and shrimp with twothese device types were 2.3% and 5.25% respectively, for daytime fishing activities and this figure for night activities were 0.01% and 4.67%, respectively.

2. Bycatch reduction device experiments for trawlers in Vietnam

2.1. Juvenile and Trash Excluder Device inVietnam

Trawl fishery is one of the main capture fisheries in Vietnam. To protect marine resources, in 2001 Research Institute for Marine Resources (RIMF) in collaboration with SEAFDEC has conducted an experiment on Juvenile and Trash Excluder Device (JTED) with iron bars for bottom trawl of Vietnam. The device is composed of three steel frames (2 frames with fixed iron bars to create opening areas for juvenile fish can escape and 1 grid frame). Size of each steel frame is 500x800mm. Iron frame A and B (***Figure 13*** ~~***Figure 13***~~) is mounted to parallel iron bars with distance between the two bars of 20mm (JTED20), 30mm (JTED30) and 40mm (JTED40). Iron frame C is covered bythe net. The steel frames areconnected together by hinges forming JTED. The JTED device was tested on a shrimp trawlerwith capacity of 75 HP in the Tonkin Gulf (Cat Ba Island, HaiPhong).

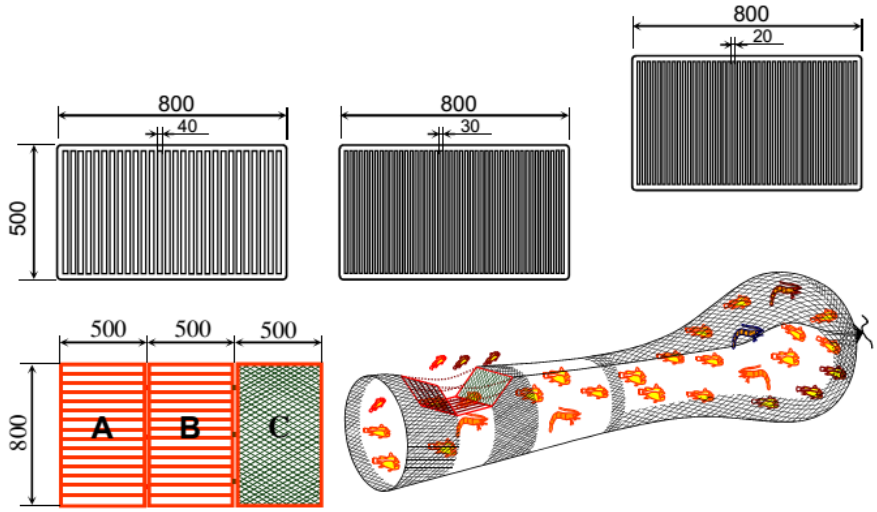


Figure 13: Juvenile and Trash Fish Excluder Device (JTED) tested in Vietnam

Test results showed that the rate of fish escaping through the device reached from 10 to 40% of total catches. Of those, pelagic species had the highest escape rate from 22-40%, the escape rate of demersal fish of from 10-17% and this rate of trash fish group escaped through the device of from 12-28%. On analysis of the escape ability by species corresponding to each device type indicated that there were differences on the specific rate by species between different device types. Of those it was from 10-25% withJTED40 device and 25 and 50% with JTED30 and JTED20 devices, respectively. For squid, the escape rate through the JTED device reached from 25-50%. The analysis results also showed that there were no significant difference on the escape ability of sardines and squid bydifferent devices (JTED30 and JTED20) (BunditChokesanguan et al., 2001).

In 2004, Nguyen HaiPhong has tested JTED with distance between the two iron bars of 20mm for shrimp trawlers with capacity of 45HP inKienGiang province. The experiment results indicated that the escape rate of juveniles and trash fish through the device was 72.3% by volume and that retailed fishes in the codend were larger than of those escaped. The loss rate for shrimp was 7.9% and forcommercial fish groups (economic species) of 16.1%. However, this study could only determine the volume of juvenile and trash fish escaping as well as determine the loss rate for the target species without identifying the escape rate by the number of individuals for each species.

From 2003 to 2004, RIMF has conducted a national project namely: "Investigation on design and application of some JTEDs in capture fisheries at Vung Tau province". There were two types of JTED applied under this project using a vessel with capacity of 215 HP. The JTED with iron bars with four types of the iron bars of12mm (D12), 20mm (D20), 25mm (D25) and 30mm (D30). The design of above JTED types indicated in the ***Figure 14*** ~~***Figure 14***~~.

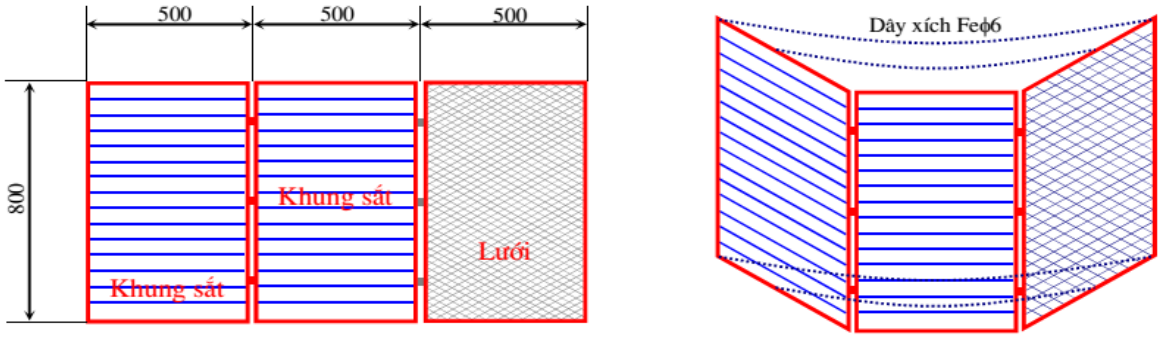


Figure 14: Design of JTED using iron bars

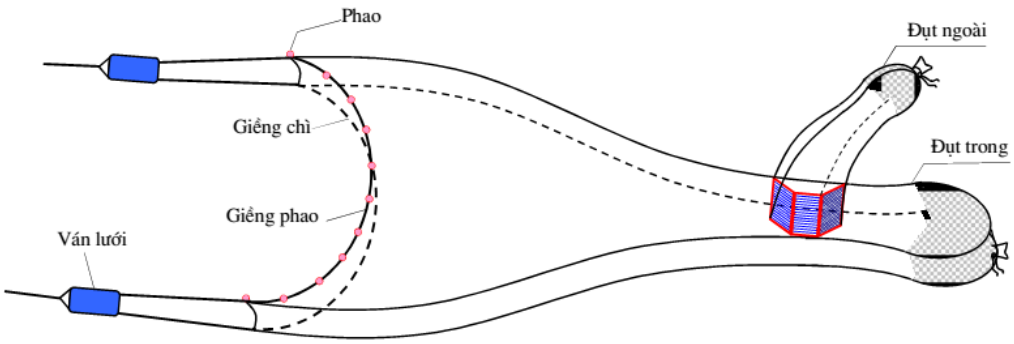


Figure 15: Method to install the iron bars in the codend

The JTED with square mesh size using four mesh sizes was 20mm (TLV20), 25mm (TLV25), 30mm (TLV30) and 35mm (TLV35).

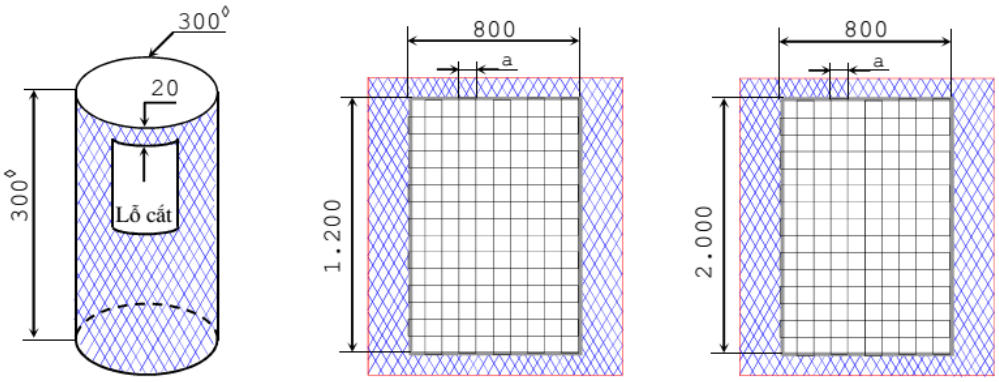


Figure 16: Design of JTED with square mesh size

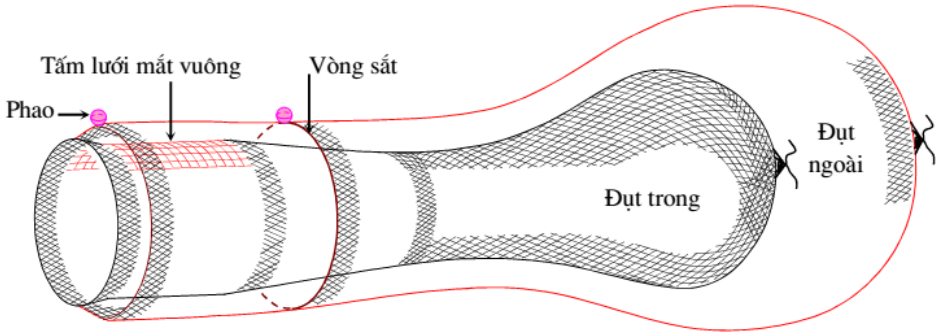


Figure 17: Method to install with square mesh size in the codend

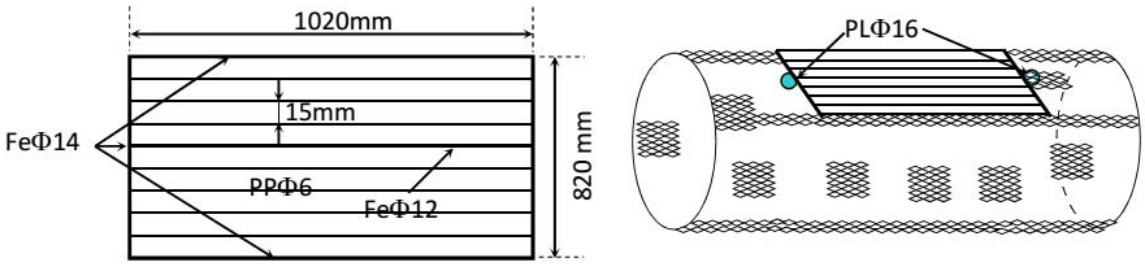
The study results showed that the escape ability of fish through the square mesh panels was from 53.59 to 66.69% of the total catch in average. This figure of mollusc group varied from 12.02 - 34.35%, crab group of from 5.47 to 21.79% and the shrimp of from 13.17 to 37.42%. However, if this rate was calculated according to the number of individuals in the group, escape ability of fish was from 69.52 to 83.85%, molluscs from 33.99 to 50.38%, crabs from 8.62 to 25.82% and shrimp group from 15.91 to 73.52%. Analysis on the escape ability of juvenile fish of some target species (snapper, sardines, squid and cuttlefish) using square mesh panels indicated that applicationof TLV20 was the most suitable to harmonize between protecting marine resources and enhancing productivity. The escape ability of the target species with size from 1 - 5 cm escaped through the devices of from 50.21 to 83.33 % of the total number of individuals.

For the iron bar devices, the escape ability of fish was from 63.91 to 86.28% by weight, octopus group from 24.72 to 63.92%, crab groups from 7.24 to 21.42% and shrimp from 30.74 to 47.64%. The escape capacity of fish through the device was from 79.51 to 95.78% of total number of individual in haul. The escape ability of octopus group varied from 53.72 to 87.63%, crabs of 9.20 - 21.97% and shrimp of 26.44 to 57.19%. Based on the escape rates of some target species, this project identified that the iron bar with diameter of 20mm (D20)met requirements in terms of resource protection and economic efficiency. Using this device, the escape rate was from 76.20 to 97.30% of the number of individual ofcroaker, sardines, snapper, squid and cuttlefish in size from 1 - 5 cm (juvenile fish).

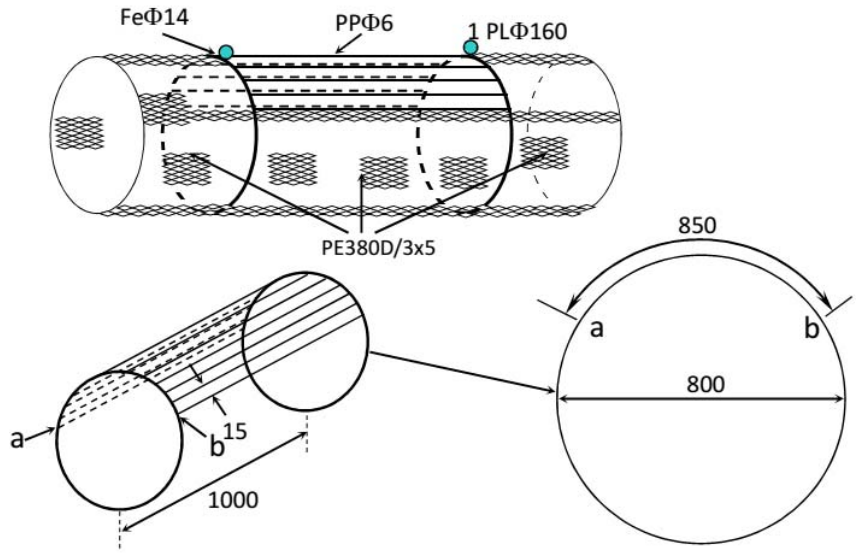
Comparison of the escape ability by using the iron bars and square mesh panels indicated that with same size of gap width, the iron bar device was more effective than square mesh panels from 1.00 - 1.61 times by weight and from 1.02 to 1.26 times by number of individuals escaping through the devices. However, if we consider combination of different factors such as applicable convenience, economic efficiency and stable ability of the devices, the square mesh panels was the better type than the iron bars. In addition, the project's results also recommended that the use of square mesh panels (TLV20) for bottom trawlers in Vietnam can effectively release juveniles and trash fish.

In 2005, Research Institute for Marine Fisheries in collaboration with Southeast Asia Fisheries Development Center (SEAFDEC) conducted a trial on JTED for bottom trawlers in the Gulf of Tonkin. This trial were carried out on a shrimp trawler with

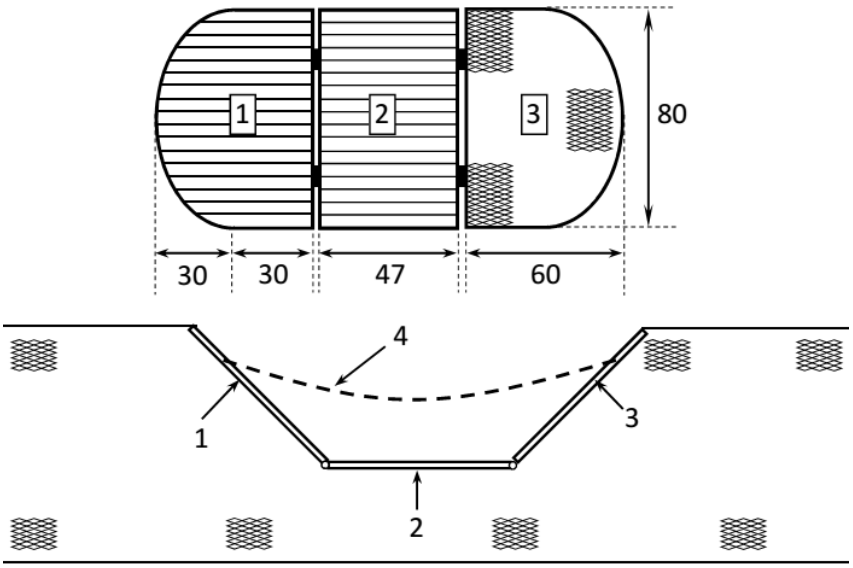
capacity of 55 HP using gird iron frames (SG-JTED) with three gaps of 10mm, 20mm and 30mm, and semi-circular curve device (SC-JTED) and JTED Window (W-JTED).



Cấu tạo thiết bị thoát cá W-JTED



Cấu tạo thiết bị SC-JTED



Cấu tạo thiết bị SG-JTEDs

Experiment results showed that the escape rate by weight of SG-JTED was proportional to bar distances. Of those, the device type had the most escape rates of SG-JTED30 (82.37%), followed by SG-JTED20 (72.35%) and SG-JTED10 (40.12%). The SC-JTED and W-JTED device was 17.63 16.76%, respectively. Overall, SG-JTED10, SC-JTED and W-JTED had relatively satisfied requirements in term of both resource protection and economic efficiency. The SG-JTED20 and SG-JTED30 only met requirements in terms of resource protection without meeting requirements on economic efficiency with some target species (large fish could also escape).

With the objective to reduce bycatch of juveniles on the local trawling, in 2013 Sub-Department of Capture Fisheries and Resources Protection of HaiPhongalso conducted a study on JTED using square mesh size with three types of mesh size of 25mm (DV25), 30mm (DV30), 35mm (DV35) and square mesh panels device also with 3 types of mesh size of 25mm (LV25), 30mm (L30), 35mm (Lv35). Study results showed that the proportion of juveniles and trash fish of bottom trawlers in Haiphong accounted for 60-87% of the total catches. The average escape rate for square mesh panels was 55.2% and for square mesh size was 62.2%. On the basis of these findings, the square mesh panels with type DV30 and square mesh size with type L30 were proposed to apply for bottom trawlers of HaiPhong because they meet the requirements to protect marine resources and economic efficiency.

2.2. Experiment on turtle excluder device of Vietnam

According to a report of Chu The Cuong (Institute for Marine Environment and Natural Resources) on "Sea Turtle Conservation in Vietnam" indicated that currently sea turtles of Vietnam is seriouslybeing reduced, Of those*Lepidochelysolivacea* has been reduced up to 75%, Hawksbill and Leatherbacks declined to 95 and 99%, respectively. Survival rate of sea turtles to adult individuals was about 1:1,000 individuals. There are many causes influence on decline of sea turtles in Vietnam today. Of those, bottom trawling is one of the direct causes of this decline since sea turtle can be bycatch of trawl fisheries.

To help protect the sea turtle resource, Research Institute for Marine Fisheries has studied the types of sea turtles excluder device (TED) for shrimp trawlers in Ha Tien, KienGiang in 2003 asa first experiment in Vietnam. The devices being tested include oval device, rectangular device and circle device. The study results showed that the oval device with 57^0 oval angle and net pathway length of 1.45 m had escape rate of 100% for turtles and 3.14 to 3.72% forprawns. In this experiment, loss rate of commercial fish group was from 18.0 to 18.76% and this rate of squid of from 8.26 to 11.50%. For the rectangular device with a 54^0 angle and net pathway length of 2.02 m grid has the escape rate of turtles of 100% and the loss rate of shrimp of from 7.82 to 8.92% andthis rate of squid of from 26.37 to 29.27% and ofcommercial fish group offrom 22.83 to 35.28%. For circle device with a 51^0angle and net pathway length of 1.19 m, the turtle escape rate was 100% and the rate of loss of shrimp from 2.65 to 3.69%,ofcommercial fish groupof 11.25% and of squid of from 3.96 to 4.67%.

On the basis of these findings, it was recommended that the circle device should be applied for shrimp trawlers in Vietnam to rescue sea turtles. This device met both requirements of the turtle’s escape ability and loss prevention of shrimp.

3. Applicability of bycatch reduction devices for trawlers in Vietnam

Trawl fishery is one of the major fisheries in Vietnam. According to the statistics of Department of Capture Fisheries and Resources Protection (2011) the number of trawl accounted for 17.6% of total fishing vessels in the country. Number of trawler with capacity higher than 50 HP was 38.5%. Also trawl fishery is currently considered destructive highest resource fisheries among capture fisheries in Vietnam. In total catch of trawl fisheries, bycatch composition accounted for 33.9 to 54.9% of the total catch with 41.8 to 54.9% for single trawlers and 33.9 to 54.8% for pair trawlers.

Table 1.Bycatch proportion in total catch of trawlers (Nguyen Van Lung, 2009)

Capacity (HP)	Single trawler	Pair of trawler
< 20	54.9	52.1
20 - < 50	48.3	40.1
50 - < 90	47.2	34.6
90 - < 150	43.8	33.9
150 - < 250	41.8	43.3
250 - < 400	42.1	54.8
≥ 400	53.3	34.3

Trash fishes are bycatch or unwanted catches of trawlers that have low economic value. However, in bycatch composition there are juvenile fish of commercial and economic species. The question is how to reduce the proportion of trash fish in trawling. In fisheries management regime based approaches of resource open access, fishers have intended to race to fish and they try to catch as much as possible.

According to the research results of use and exploitation status on trash fish of some major fisheries in Vietnam in 2009 showed that trash fish catches of trawlers averaged about 463,349 tonnes/year, of which single trawlers was about 209,392 tonnes/year and pair trawlers of 253,957 tonnes/year. The proportion of juveniles in the composition of trash fish was 46.2% for single trawlers and 54.0% for pair trawlers. So juvenile catch proportion caught in the bottom trawlers in Vietnam averaged about 233,877 tonnes/year. To releasejuvenile fish for bottom trawlers based on mesh size regulations regulated on Circular No. 62/2008/TT-BNN dated 20/5/2008 of a number of major species like *Nemipterusspp*, lizardfish (*Sauridaspp*) and*Priacanthusmacracanthus*research identified appropriate mesh size in the codend (single and pair trawlers) of 30mm. The findings of the study also showed that there were about 41% of trawlers in Vietnam violating minimum mesh size regulations in the codend and this figure of the pair trawlers was 50% (Nguyen Van Lung, 2009).

However, in a study assessing the impact of some factors influence on selectivity of bottom trawls in the South-eastern waters using logical information, Le Xuan Tai (2005) has concluded that the mesh size of the codend has significant relationship on the escape ability of fish, but fishermen are still using the codend with mesh size of between 20 - 30mm. These mesh sizes were too small and not good for small fish selectivity. With such mesh size, all species will not be able to escape once they were at the codend.

According to a study by Pham QuocHuy (2008) on species composition of trawlers in the East – Southwest region showed that the proportion of juvenile fish ranged from 23.0 to 66.8% with an average of 40.8%. Proportion of juvenile fish in the shrimp trawlers was from 3.9 to 74.7% with an average of 32.5% and for pair trawlers was from 33.0 to 68.6% and with an average of 49.1%.

In a rapid assessment of shrimp trawlers in Ha Tien, KienGiang (2010) showed that the species composition of trash fish in shrimp trawlers at Ha Tienwas diverse in number offamilies and species. The dominant species in trash fish included Tonguefish(Cynoglossidae, 17.2%), anchovy (Engraulidae, 22.5%), croaker(Sciaenidae, 7.9%), herring (Clupeidae, 7.8%), eel (Ophichthidae, 3.8%), (Gobiidae, 5.7%). Study's results also showed that catches of trash fish in shrimp trawlers in Ha Tien accounted for 37% of the total catch reached at the second highest proportion only followed shrimp group (40%), however the value of trash fish groups accounted for only 8% of the total revenue of trip.

Thus, in terms of value, trash fish are not the target species caught by shrimp trawlers in Ha Tien, however, due to higher fishing costs and present fishing operations of open access, it is inevitable on trash fish (95% of respondents surveyed). Study results on the ability to use JTED to release trash fish and juvenile indicated that there were only about 5% interviewed shrimp trawl fishermen agreed to install JTED, the other group only agreed to install the device only if they have Government's supports on loss production. Almost interviewed fishers (100%) did not know theJTED and they were worry that the device installation can make losses of catches of shrimp (Nguyen Ba Thong, 2010).

A study of HaiPhong Nguyen et al (2007) about applicability of the JTED for shrimp trawlers in KienGiang showed that the revenues of trash fish on shrimp trawlers in KienGiangreached from 3-34% of the total revenue and this proportion wasgradually decreased with an increase of vessel capacity. The revenue from trash fish of fleet with capacity <11kw was 34% of total revenue of trip while this rate of fleet with capacity of 34 - 44kw was only 3% of total revenue.The study also showed that fishermen of fishing fleet less than 11kw did not agree to use the JTED to release juveniles and trash fish because their revenue were significantly based on total value of trash fish. There were approximately 47% of fishermen of fishing fleet with capacity from 11 - 22kw agreedto use the JTED while the agreed rate of fishers for vessel group with a capacity of 23 - 33kw was83% and vessel with a capacity 34 - 44kw was 100%. This meant that consensus degree in the use of JTED in trawlers totally depended on the revenues of trash fishes in total revenues of trip and thus, if the revenue from trash fish is small, the fishermen are willing to use the JTED.

Preliminary survey results on trawl fisheries in KienGiang (2014) indicated that the main species of pair trawlers in KienGiangis squid (*Loligospp*) and thus trash fish are only bycatch species which have low economic value. Total catch of trash fish group was from 40-50% of total catch, while the value of this group accounted for only 6-10% of the total revenue of the trip. Survey results also indicated that currently fishers use the codend with small relative mesh size and thus bycatch are difficult to escape. For resource availability, 100% respondents of the survey thought that marine resources have beendeclined. Of those, 80% respondents thought that marine resources

declining about 40 - 50% comparing to over last five years. Fishing capacity increasing is a reason to blame. Fishing cost is gradually increasing while catch price unchanged and thus fishers try to catch as much as possible including trash fishes to compensate the lost benefits. Almost the interviewed fishers responded that marine resource protection is very necessary but there were about 60% of those disagreed with increasing mesh size in the codend because they explained that this method will not be feasible and practice.Regarding to bycatch and trash fish devices, 100% of fishing vessel's owners in KienGiang agreed to use JTED. However, the owners also gave opinions that for pair trawlers fishing in offshore waters and in trash fish rate of economic groups is relative high and thus it is necessary to use the device type as JTED or not? A pre-requirement at the moment is to have a study to determine species composition of the trash fish group in trawlers, and then it will provide a clue that which fishing fleets have to use JTED suitability and effectively.

4. Discussions

In the situation that marine resources in the waters of the world are increasingly depleted, to help protect marine resources, many research on bycatch reduction devices to reduce trash fish for bottom trawlers have been carried out. Many different devices have been tested as square meshcodend, square mesh panels or steel frame JTEDs. Each device type has different advantages and disadvantages depending on fishing grounds and target species toselect and use which devices are suitable and can achieve its objectives. Some countries haveregulations for the bottom trawl vessels using JTEDs and BRDs to protect aquatic resources and endangered and threatened stocks.

In Vietnam, JTED was firstly tested in 2001 and up to now there are some studies on this issue at different regions with many tested devices. In general JTED experiments in Vietnam were mostly trials at small scale and focus to evaluate escape ability through the devices by weight and number of individuals with just some of these can provide results on different of escape rate by species. Some devices have been proposed to use in fishing operations of trawlers such as square mesh panels with mesh size of 20mmand 30mm,square meshcodendwith mesh size of 30mm and iron frame device with bar's distances of 20mm.However, these experiments have not consider to evaluate economic efficiency when these devices used and this is an interest of the most fishing communities whether or not they are willing to use or not.

In general, JTED can be applied overwhelming on trawl fisheries of Vietnam because agreed rate to use JTED by fishers was 47 – 100%. Except fisher using small boat fishing shrimp in the coastal areas have refused to use this device because trash fish contributed a large amount of their total catch and economic income. Number of people who agreed to use JTED is proportion to vessel capacity with higher capacity then higher compliance ability. However, one issue that fishers all considered is the device must be applied for all fishing fleets.

Juvenile accounted for from 46 – 54% of total catch of trash fish f trawlers in Vietnam and juvenile fish in total catch estimated was 233,877 ton/year (NguyễnVăn Lung, 2009). In order to protect this group, a legal document No. 02/2006/TT-BTS was established by former Fisheries Ministry on 20/3/2006. According to this legal

document, mesh size at the codend of shrimp trawlers are from 20 – 30mm and 28 – 40mm for fish trawlers. However, in reality fishers usually use mesh size at the codend from 20 – 30mmand this sizes are too small to release juvenile fishes (LêXuânTài, 2005). Therefore, to release juvenile fishes, a technical measure is to apply a suitable JTED because this device can be the most effective to release bycatch and juvenile fishes in the case of Vietnam.

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