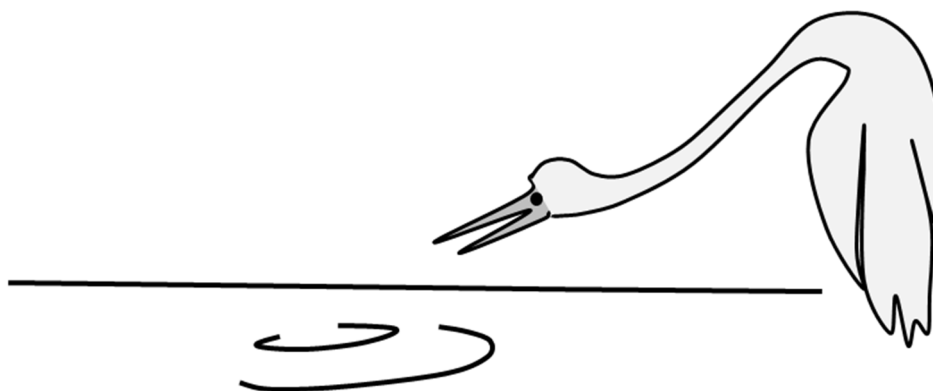


Specified Skills
Educational Textbook for the Fishing Industry Skills Proficiency Test
(Fishing)
(Net Fishing)



Japan Fisheries Association
(First Edition: December 2019)

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Roundhaul Fishing

1. Overview of Roundhaul Fishing

Roundhaul fishing is a fishing method which entails using one or two trawlers to encircle a school of fish that has been found using a belt-shaped net then capturing the fish inside after closing the net hem so they cannot escape. Roundhaul operations are classified into two broad categories based on the operation time: daytime operations in which either fish are caught directly in simple schools or schools of fish are searched for and discovered attached to drifting objects such as driftwood, payaos, and artificial rafts; and nighttime operations in which lights are used to attract and catch schools of fish. Operation systems are also broadly categorized into two groups: the single-ship roundhaul system, in which an equipped ship (usually a trawler) is used, and the ship-group roundhaul system, which is used for both single-ship roundhaul fishing and dual-ship roundhaul fishing.

2. Targeted Fish

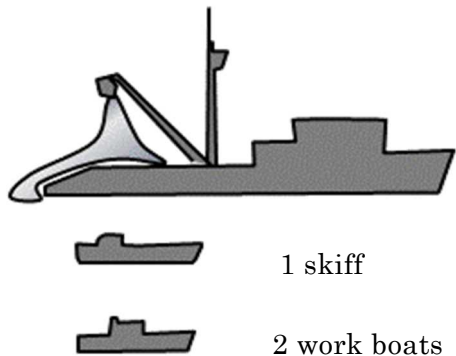
Roundhaul fishing targets large-catch pelagic fish in the waters around Japan. The main species targeted are Japanese anchovy, Japanese sardine, jack mackerel, mackerel, blue mackerel, bonito, albacore tuna, yellowfin tuna, bluefin tuna, and yellowtail.

3. Operation Systems and Trawlers

(1) Operation System

Roundhaul operation systems are divided into two main groups: the single-ship roundhaul system, in which an equipped ship is used, and the ship-group roundhaul system, in which a group of ships centered around a trawler is used. The former is mainly seen in overseas roundhaul fishing and the latter is mainly seen in small- to

medium-scale and medium- to large-scale roundhaul fishing operations. The standard structures used for these roundhaul systems are as shown in Figs. 1 and 2.



1 trawler



1 trawler



1 to 2 search vessels



1 to 2 lightvessels



2 to 3 carriers

Figure 1: Single-ship roundhaul system structure (the skiff and work boats are loaded on the trawler)

Fig. 2: Ship-group roundhaul system structure

(2) Trawler

A trawler takes the central role in both single-ship and dual-ship roundhaul operations, and all the essential fishing devices for operations are loaded on the trawlers. The standard fishing devices for trawlers are shown in Fig. 3.

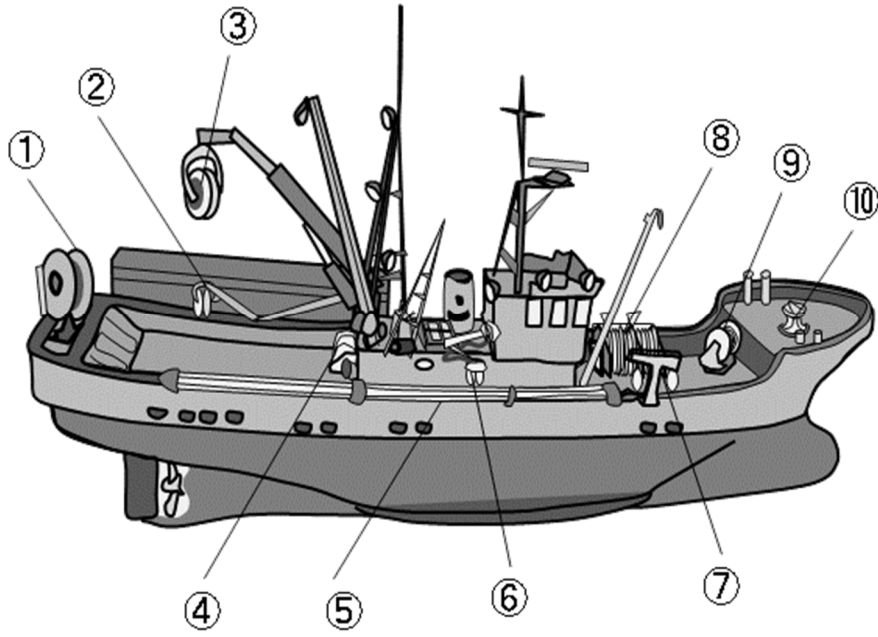


Fig. 3: Standard fishing devices for trawlers

- | | |
|-------------------------|--|
| (1) Net hauler | (6) Ball roller |
| (2) Float handler | (7) Ring-line davit |
| (3) Power block | (8) Purse winch |
| (4) Large winding winch | (9) Purse reel |
| (5) Side roller | (10) Capstan (also used for various winches) |

4. Fishing Devices

(1) Net Hauler

A net hauler is a movable fishing apparatus mounted on the stern of a trawler. It hoists net gathered into a bar shape from the float side to the sinker side by inserting it into a v-shaped groove which it rotates (Fig. 4).

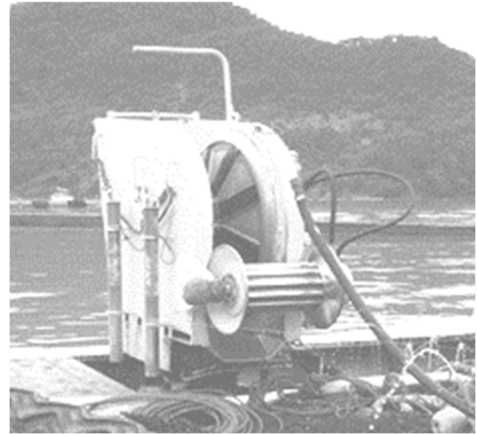


Figure 4: Net hauler

(2) Side Roller

A side roller is a piece of equipment mounted on the right side of the trawler.

It rotates via hydraulic drive, pushing the net into the top area and pulling it onto the ship using friction (Fig. 5).

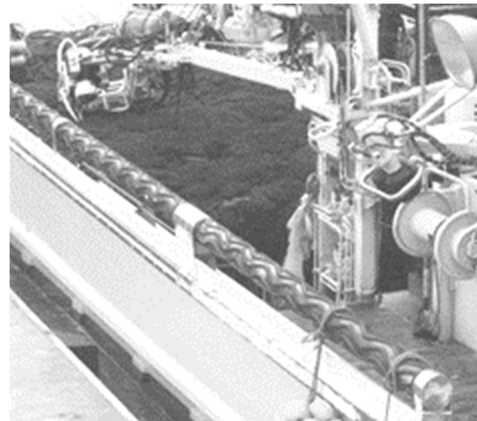


Figure 5: Side roller

(3) Power Blocks

Power blocks are rotating drum devices which have rotating portions with wedge-shape structures and are attached to a crane or a derrick. They lift the bundled, bar-shaped roundhaul nets that have been hauled onto the ship by the net haulers to a high location, move them to a predetermined location for net storage, and perform netting stacking operations (Fig. 6). There are also other similar fishing devices used in netting stacking such as the net conveyor (handler) shown in Fig. 7 and float handlers.



Figure 6: Power block

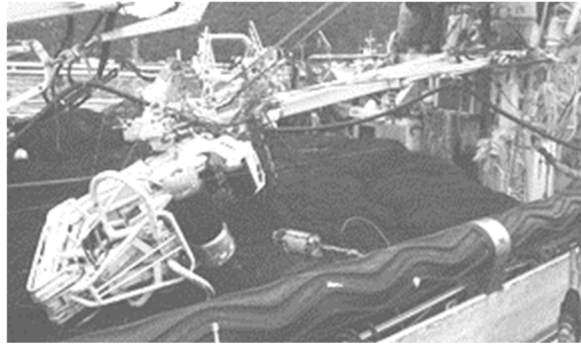


Figure 7: Net conveyer (handler)

(4) Purse Winch

A purse winch is a direct-winding winch (Fig. 8) mounted on the left of the bow-side deck that winds a purse wire which closes the net hem after the roundhaul net has been cast. There are single-series and dual-series winches, and the single-series type have their standing rollers and purse reels mounted separately.

(5) Ball Roller

A ball roller is a device that rotates two spherical pieces of rubber to enclose and lift a net to haul or handle nets on the fish-catching side of operations. Typically, two to three of these units are used, and they are attached to a movable arm (Fig. 9).



Figure 8: Purse winch



Figure 9: Ball roller

(6) Fish Pump

A fish pump is a device used to transfer fish caught in nets during operations to carriers, as well as to unload caught fish from carriers at the market (Fig. 10).

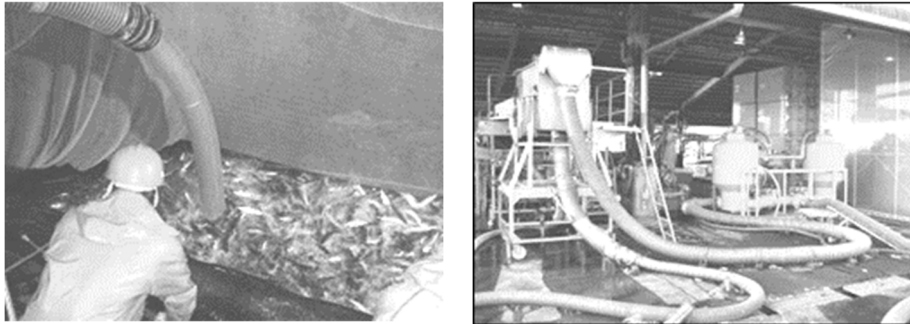
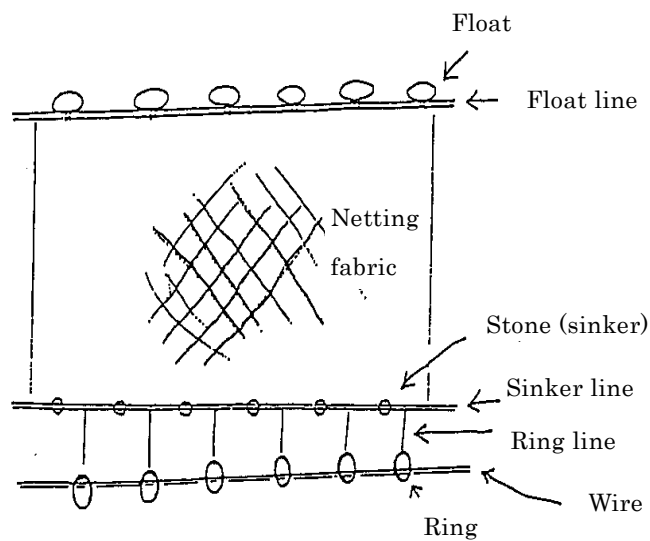


Figure 10: Fish pump (Left: During fishing operations, Right: During unloading)

5. Fishing Tools



(1) Float Line

A line with floats attached located on the upper side of a net which is used to float it.

(2) Sinker Line

A line with sinkers attached on the lower side of a net which is used to sink it.

(3) Wire

A wire used to close the bottom of a net which is passed through the ring.

(4) Ring Line

A short rope with a ring which is tied to a sinker line.

6. Devices Installed on the Bridge

(1) Fishfinder

A device that searches for schools of fish under a ship.

(2) Net Sonde

A device that measures data such as the depth and sinking speed of a roundhaul net and the temperature of the seawater.

(3) Sonar

A device that searches for schools of fish swimming in the sea.

(4) GPS

A device that accurately records the ship's position.

7. Operation Methods

For roundhaul fishing operations conducted at night using fish-luring lights, operations are conducted in the following order after arriving at the fishing grounds:

(1) finding the fish, (2) luring the fish, (3) casting the nets, (4) closing and hauling the nets, and (5) drawing in the fish. Ship groups conducting one-day operations depart from the harbor in the evening and head for the fishing grounds, then return to the harbor the next morning and unload the fish at the market.

(1) Finding the fish

The ship group heads out for the fishing grounds together and searches for schools of fish using tools such as sonar and fishfinders after arriving.

(2) Luring the fish

After the ship group finds a school of fish, a lightvessel lights its fish-luring lights in order to vertically position the location of these fish. In areas where underwater lights are used, these underwater lights are also lit and put into the sea.

(3) Casting the nets

The trawler commences net casting while confirming the speed and direction of the current, as well as the position of the school of fish. At the instruction of the chief fisherman, one retrieval boat or lightvessel (or carrier) approaches from the stern of the trawler and takes in the fish-catching end of the roundhaul net, commencing net casting. The trawler then casts the roundhaul net from the stern portion and sails around the lightvessel which continues luring the fish, traveling in a circular motion. In this way, the netting is cast out in such a way as to surround the school of fish. At the time of net casting, it is important to take care to make sure no crew members get their feet entangled in netting or ropes.

(4) Closing and hauling the nets

After the roundhaul net has been cast, one end of the fish-catching side of the net is taken in by the retrieval boat. The captain of the trawler verifies the sinking state of the roundhaul net while watching the measurement values of the depth measurer, closes and hoists the ring line, and commences net hauling work by closing the net hem. When performing net hauling, multiple fishing crew members on the side of the deck facing the stern side of the trawler load the net, which is hoisted via the power block, onto the deck while folding it. At this time, as the members are handling a wet, heavy net, they are careful to avoid getting their feet entangled, which could cause them to be into the fishing equipment in operation.

(5) Drawing in the fish

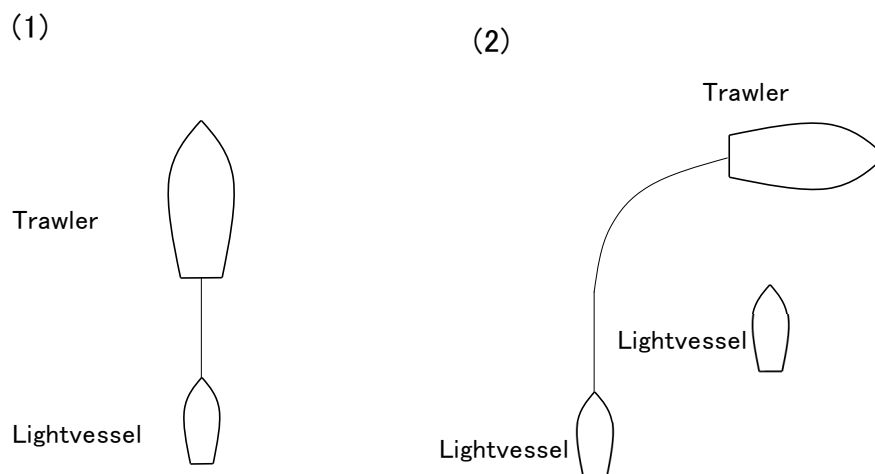
When the net-hauling work of the roundhaul net has progressed and only the portion with the caught fish remains in the water, the carrier receives one end of the portion with the caught fish. When taking the caught fish onto the carrier, the fish are drawn in either by scooping with a triangular net or a landing net or by using a fish pump (Fig. 11).



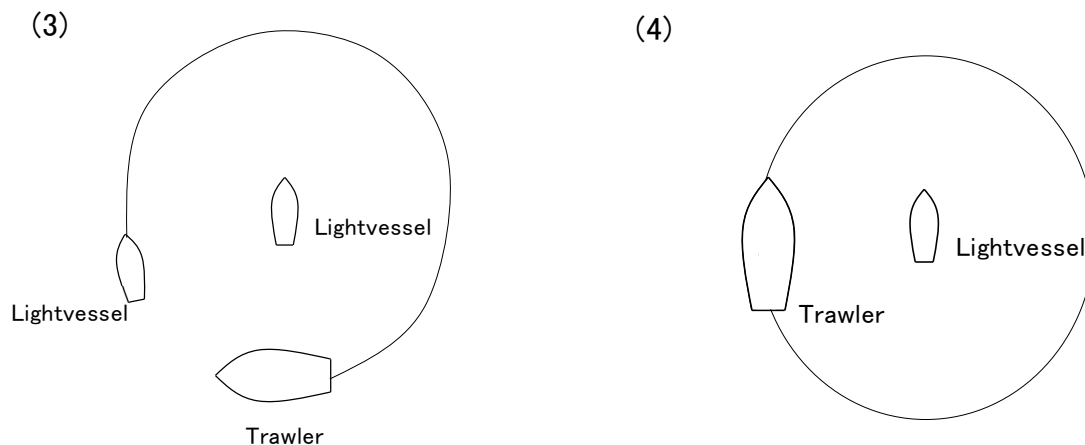
Fig. 11: Drawing in the fish

8. Operation Procedures

- (1) The lightvessel (or the carrier) approaches from the stern direction of the trawler, and takes one end of the side with the caught fish.
- (2) The trawler accelerates and travels around the lightvessel, casting the net.

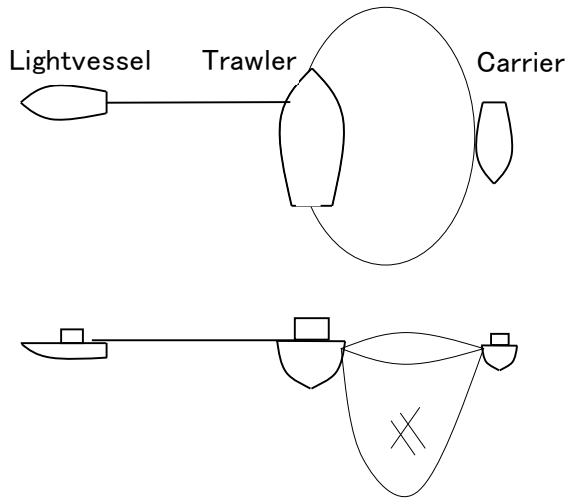


(3) to (4): The trawler travels around the lightvessel while casting the net, and the lightvessel (or the carrier), which performs the role of the receiving boat, takes one end of the portion with the caught fish.



(5) In net hauling work, the purse wire attached to the sniker side is wound first. Next, the sinking situation of the net is confirmed using the depth measurer attached to the net, and when the net hem reaches the lower layer portion of the targeted school of fish, winding of the purse wire commences using the purse winch installed on the bow side of the deck of the trawler. In order to prevent the trawler from moving and causing of the net to warp during net hauling, the lightvessel, which is connected to the trawler with a rope, performs "back rowing" and pulls the trawler. When the net hauling moves forward and the net becomes smaller, the carrier approaches the opposite side of the trawler and takes in a part of the net, thereby arranging the shape of the net to make it easier to draw in the caught fish.

(5)



Gill Net Fishing

1. Types of

Gill Nets and Their Uses

The fish-catching functions of gill nets include "gill catching," in which the net threads tighten around the bodies of the fish caught in the mesh, and "tangle catching," in which the spines and fins of the bodies of the fish get caught in the net threads.

Gill nets can be categorized from two perspectives. The first is dividing them by the three layers of the ocean in which they are set: the surface layer, middle layer, and bottom layer; and the second by the two setting methods used: fixed and unfixed (floating). By combining these two groups of categories, there are a total of six types of gill nets possible, but most gill nets fall into one of the following three types: surface layer floating type, surface layer fixed type, and bottom layer fixed type (Fig. 12).

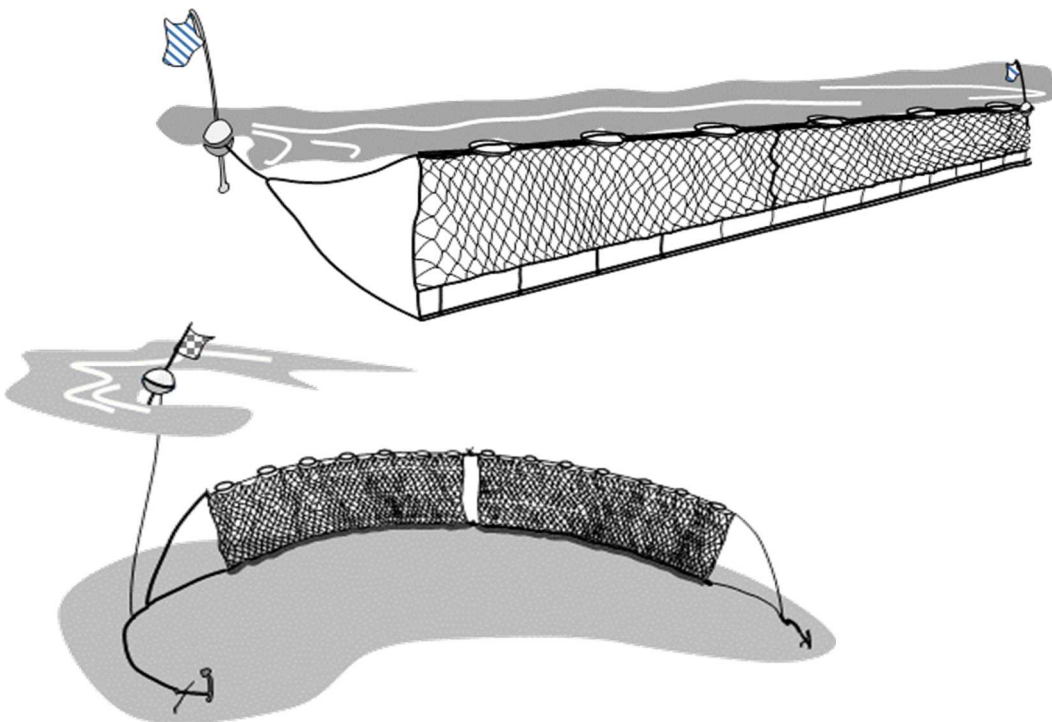


Figure 12: Surface layer floating type (top figure) and bottom layer fixed type (bottom figure) gill nets

Generally, a gill net simply referred to as a "gill net" is most often a bottom layer fixed-type gill net (single-layer net). This type of gill net is used in coastal fishing and offshore fishing, and is the most common type in all gill net fishing. There are large variations in terms of design and operation methods for this type of net.

The major targeted species for various gill nets are as shown below (Table 1).

Table 1: Main targeted species for various gill nets

Type of gill net	Main targeted species
Bottom layer gill nets	Herring, forktail bullhead, silver white croaker / nibeamitsukurii, types of sea bream, types of jack mackerel, halibut, types of shark, types of crab
Fixed-type surface layer gill nets	Herring, sardine, flying fish, mackerel, types of salmon/trout, types of shark
Flowing nets	Types of marlin, bonito, Spanish mackerel, types of salmon/trout, mackerel, types of shark, herring, saury, yellowtail
Three-layer nets	Yellowtail, gizzard shad, seabass, types of sea bream, types of halibut/flounder, rockfish, flathead, cuttlefish, squid, prawn

2. Netting Fabrics

The general qualities required for netting fabric and materials for gill nets are as follows.

- (1) Difficult to see underwater
- (2) Soft net threads
- (3) Net threads with breaking strength sufficient to resist the swimming force of fish
- (4) Net threads with suitable stretchiness for holding fish within the mesh
- (5) Mesh knots strong enough to tightly hold in fish

(1) Mesh Size

Mesh size is the most important factor in deciding the quality of a gill net and is determined depending upon the type(s) of fish targeted and the size accounted for by a large proportion of these fish within a school. For a general gill net (single-layer net), when a fish passes through a mesh, the net threads cut into the body of the fish, resulting in gill catching (Fig. 13).

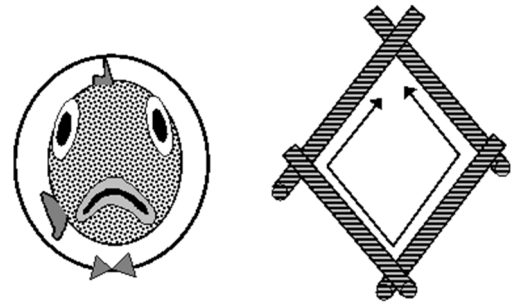


Fig. 13: Circumference of fish, and inner circumference of mesh

For gill nets which aim to catch fish using the tangling method, somewhat smaller mesh sizes are often used.

(2) Hanging Ratio

The hanging ratio is the most fundamental design element of a gill net. "Hanging ratio" is a ratio that is determined by the length of the netting fabric and the length of the rope that binds it, and the shapes of the diamonds that are formed in the mesh are determined by this ratio. It is a ratio of the length of the netting fabric when it is stretched to the length of a portion that is constricted and shrinks when it is bound by the rope afterward. A relatively small hanging ratio is generally used for

a gill net when aiming for gill catching. Conversely, a large hanging ratio is often used when aiming for tangle catching.

For a gill net, fundamentally, the float line and the sinker line have different lengths from each other, and the sinker line is 3 to 10% longer than the float line. Thus, the hanging ratio differs slightly from the float line side to the sinker line side. This is because at the time of net casting, the netting fabric on the sinker line side contracts more easily than that on the float line side; thus, the sinker line side is stretched in advance. However, in the case of threads on a bottom-layer gill net, the net shape on the sea floor after setting is taken into account; thus, depending on the targeted fish, the sinker line may conversely be made shorter when laying the net flat.

(3) Vertical Mesh and Net Length

The size of netting fabric is expressed by the number of vertical mesh units and the net length. The number of vertical mesh units is the number of mesh units included in the breadth (height / length / depth) direction of the netting fabric. The length of the netting fabric (in the horizontal direction when the gill net has been formed) is expressed in meters. For ready-made products, the number of vertical mesh units depends on the breadth of the net-making machine, and the common sizes are 100 and 200 mesh units. The netting fabric length is the length of one finished net, commonly around 50 m.

(4) Color and Visibility

Many types of fish have eyesight sufficient for recognizing the presence of netting fabric in the water, as well as the ability to distinguish colors. Currently, the element determining whether a fish can recognize the presence of a net in the water is thought to be the degree to which the material contrasts with the background. The materials which are currently commonly used for gill nets, light gray multi-filament thread and light blue synthetic fiber netting, achieve both transparency and low background contrast.

3. Floats and Sinkers

A variety of materials lighter than water, such as wood, bamboo, and cork, have been used for gill net floats. Currently, synthetic resin products are typical. The most important qualities for a float are residual buoyancy and pressure resistance. There are both filled and hollow floats, and two main types of shapes, threading floats, which have a hole through which a rope is passed, and flat floats, which are held between two ropes and used. The benefit of threading floats is that there is no possibility of them coming loose, whereas flat floats have the advantage of being easy to remove and attach for replacement when broken or to adjust buoyancy (Fig. 14).

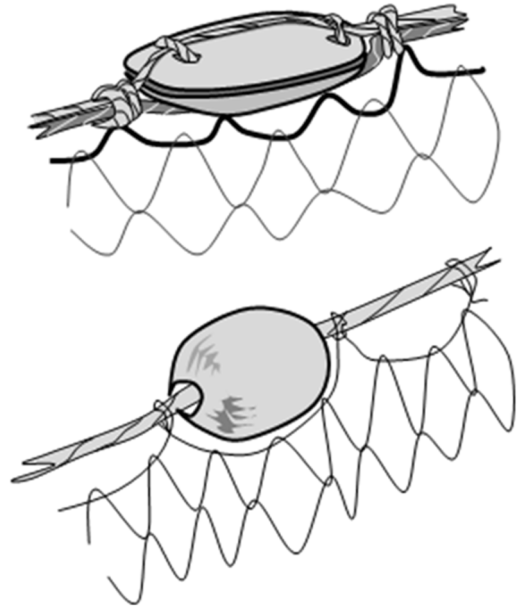


Figure 14: Flat float (top figure) and threading float (bottom figure)

For sinkers, any material that is sufficiently heavier than water, such as stone, ceramic, iron, and lead can be used, but lead sinkers are the most common for use with gill nets. Typically, the sinkers are barrel-shaped and have a hole through which a rope is passed. In recent years, lead ropes, which have lead woven into the rope fibers, are also used.

4. Ropes

Ropes are used mainly in the float lines and the sinker lines of gill nets, but there are also nets that lack sinker lines and nets that use accompanying rope float lines. Ropes are mainly selected based on specific gravity, operability (the roughness of the

surface), breaking strength, and cost. Due to factors such as their specific gravity, ropes made from polyethylene and polypropylene materials which are less dense than seawater are often used for float lines, and ropes made from polyvinyl alcohol (CREMONA, KURALON, etc.) and polypropylene are often used for sinker lines.

5. Tying Techniques

(1) Netting Fabric and Edge Net (Sewing)

Basically, the latest method is to sew a few more meshes while gradually increasing the thickness of the net thread, and it is standard to make the net thread of the outermost portion about twice the thickness of the netting material.

Both ends of one gill net either have edge threads passing through the mesh in the vertical direction of the net, or are left with cut mesh. To reinforce this portion of the net, fastening thread is used to lash the knots (Fig. 15).

Furthermore, when a part of the netting fabric tears, it is typical for the fishing crew to conduct repair work themselves.

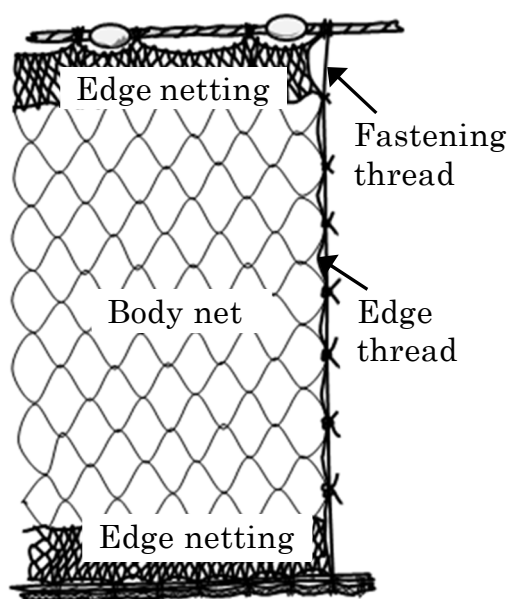


Figure 15: Edge sewing (net) and edge fastening

(2) Sewing

There is a great deal of variation in sewing used for the netting fabric, floats, sinkers, and ropes (Fig. 16). For the sewing of the float, a reverse lay rope with S-laying or Z-laying is used, and either one rope is passed through the hole in the float or two ropes are used to hold the float in place for sewing operations. When the diameter of one rope is slightly reduced, this is called an accompanying line. The yarn used to sew the netting fabric to the rope is called threading yarn. To avoid concentrating force into a single portion of the netting fabric, it is better if not all of the mesh is secured to a rope, and instead a design in which free movement is possible for the threading yarn is used.

There are two methods of sewing a rope to netting fabric. One method is hanging a rope in the air, making marks on the rope at intervals calculated during design, and sewing a similarly determined number of meshes at each mark. In the other method, the rope is not hung, and no marks are made. Instead, the distance from one lashing part to another is measured using the number of meshes while holding the rope, and points of return are sewn in conjunction with the hanging ratio (for instance, a distance of 10 meshes is stretched from one lashing portion, and if the hanging ratio is 40%, the point four meshes back is decided to be the next lashing portion). Each method has a disadvantage: while the former method is labor-intensive, the latter method does not allow the hanging ratio to be selected in a completely free manner (it can only be selected in units of half-meshes). In every part, a spun yarn made of a polyamide is often used when sewing components. This is because this surface of this material has sufficient roughness needed for lashing, and a low cost.

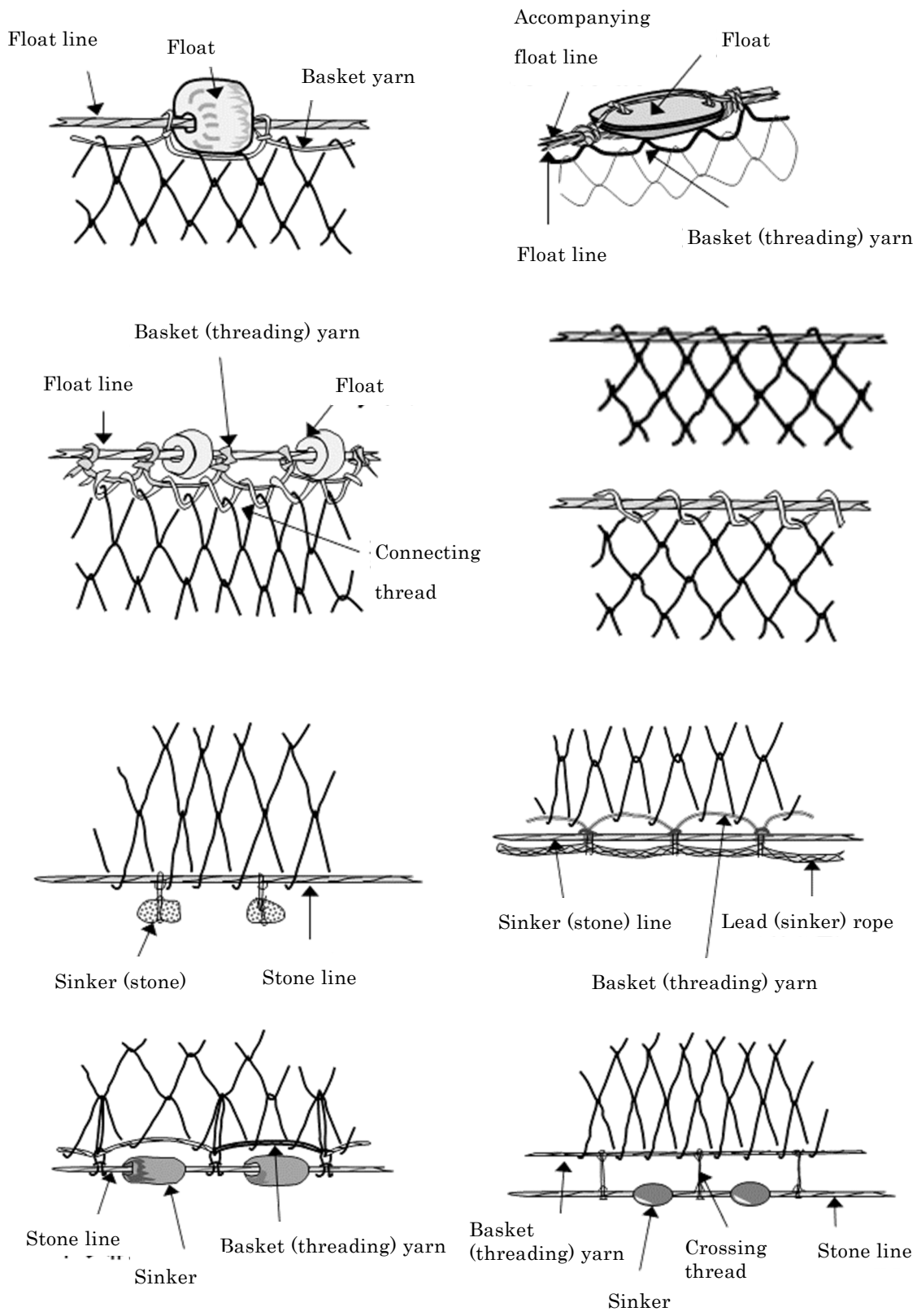


Figure 16: Various sewing methods of float part and sinker part

Trawl Fishing

1. Names of Major Net Parts

Generally, the net is made up of a sleeve net for collecting sea creatures at a mouth near the front of the net, a body net, and a codend for collecting fish. The foremost portion of the sleeve net has the largest mesh, and the mesh gradually gets smaller from there, with the mesh size of the codend being the smallest. A head rope is

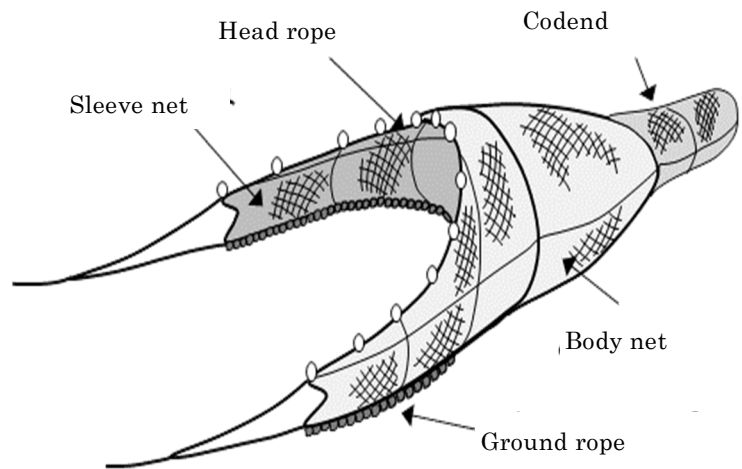


Figure 17: Names of major parts of trawl nets

attached from the upper end of the sleeve net to the upper part of the front end of the body net, and a ground rope is attached from the bottom end of the sleeve net to the lower part of the front end of the body net (Fig. 17).

2. Otter Roll Fishing Method

This is a fishing method in which the net is opened to the left or right using an otter board (Fig. 18).

This enables operations with a single vessel, and because fishing operations can be conducted even in a moderate storm, this method is used all over the world.

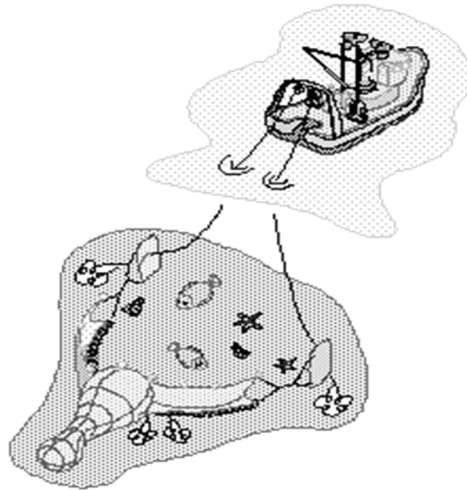


Figure 18: Otter roll fishing method

(1) Otter Boards and Rigging

An otter board is a board made from iron, wood, or FRP. Since these boards maintain a certain angle (angle of incidence) with respect to the direction of the towrope, similar to the wing of an airplane, a pressure differential between the front and back of the board translates into net-opening force, enabling them to open the nets.

Otter boards also have the function of creating "sand smoke," which swirls up due to contact with the seafloor, which the surrounding fish see as a threat, causing them to be lured toward the net opening.

(2) Net Casting and Hauling Method

At the start of operations, the net is cast starting with the codend. At this point in time, there are connections between the net, the net pennant, the hand rope, the play wire, and the warp, in that order (Fig. 19), but the otter board is not

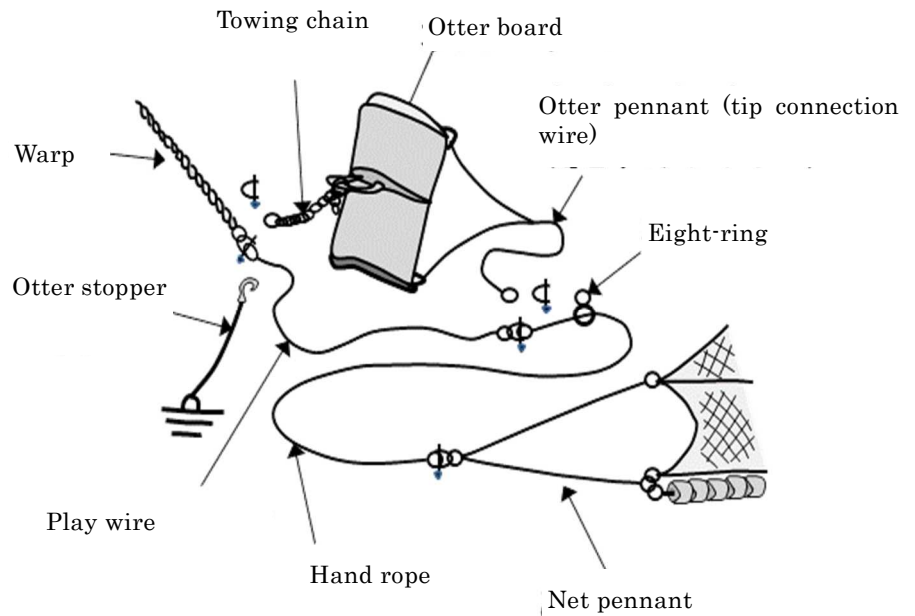


Fig. 19: Otter roller rigging

connected. The otter board is hanging down from a top roller in the stern gallows and a towing chain is connected to the warp, creating a state in which the warp, the otter board, and the net are connected.

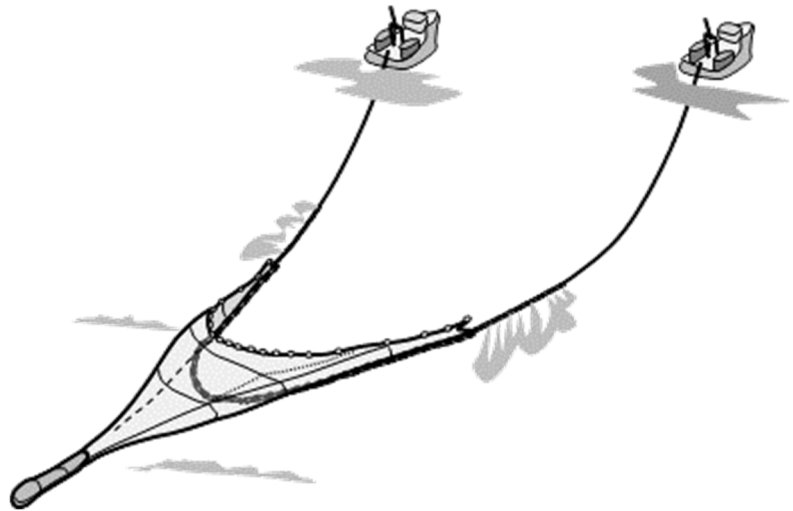
At the time of net hauling, when the warp shortens, the winding speed slows down, and the otter board is wound until it is lifted to the gallows. Afterward, the same procedures as net casting are conducted in the opposite order.

3. Bull Trawling Method

This is a fishing method in which a net is opened and drawn by having two vessels draw the net while maintaining a certain interval of distance between them (Fig. 20). Since it is a simple net drawing method, it is used around the world, but it requires more ships and considerably more effort than otter trawling and Danish seining.

(1) Towrope and Rigging

Two vessels draw the net while expanding its mouth, and fish are frightened and gathered together with a long, thick compound rope.



(2) Net Casting and Hauling

Method

Figure 20: Bull trawling method

In the bull trawling method, two fishing vessels, a lead ship and a secondary ship, form a team. After the lead ship casts the net, the secondary ship approaches the lead ship, transfers the end of its own towrope to the lead ship, and connects to a towline on one side of the lead ship's net, commencing net drawing. For net hauling, the secondary ship approaches the lead ship and passes the end of the towrope to the lead ship. The lead ship hoists the towrope using the winches on both sides to perform the net hauling. Meanwhile, the secondary ship commences casting work for its own net.

4. Danish Seining Method

A buoy is attached to the end of a towrope and cast into the water, and starting from this point, the ship travels in a path so as to draw a diamond shape in the water, thus casting the first towrope, the net, and the second towrope, in that order. Next, the buoy is taken onto the ship and the net is hoisted using the two ropes (Fig. 21).

Compared to other trawling methods, Danish seining has comparatively slow towing speed, and the fishing tools are light.

With conventional net drawing (a compound rope), the diameters at the ship side and the net side are different, so after net hauling, work is involved in which the towrope has to be reversed to prepare for the next net casting. In recent years, however, towropes which either are even or have symmetry are being used more often, enabling either side to be connected to the net side. Further, tools such as reels and net winches which reel in towropes have become common.

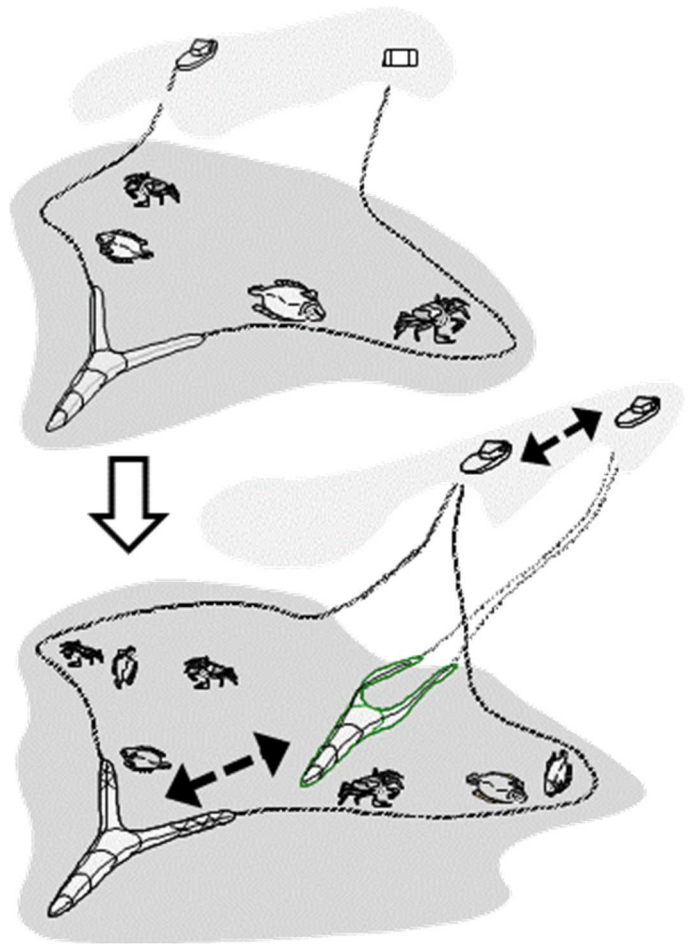


Figure 21: Danish seining method

5. Danger Prevention

Since the inside of trawling ships are narrow and sway, and there are wires and winches in operation, crew members must be sufficiently mindful of such locations as the following during operations.

- Sides of the ship with winches in operation
- Areas of ropes or wires that are under strong tension
- Slipways near sterns and areas near gangways
- Lower parts of derricks when nets are suspended
- Areas near the sides of ships during rolling (both sides)
- Decks that are slippery due to fish blood or oil

Fixed-Net Fishing

1. Characteristics of Fixed-Net Fishing

Fixed nets are some of the most commonly used fishing tools in coastal fishing in Japan. Fixed-net fishing is used to catch a wide variety of fish, and the fish caught using this method still alive when caught. In addition to direct consumption by humans, these caught fish can also be applied to diverse uses such as live bait for other fishing operations. Since even when large numbers of fish have been caught in nets, a portion of this catch can be kept as live fish, adjusting shipment volume is simple, and these adjustments can be used to prevent deflation due to market oversaturation.

2. Fundamental Elements of Fixed-Net Fishing

Traps are the most developed widely-used type of fixed nets in Japan, and they fundamentally consist of the following four elements.

Dredge: A single, simple net that stretches to the coast from an enclosing net. It has an action which providing stimulation that changes the migration route of a school of fish, luring them toward the entrance of the enclosing net. The mesh size of a leader net is extremely large, ranging from 30 to 90 cm, and most fish are physically able to pass through.

Enclosing net: The largest net enclosure, which first takes a school of fish into a net and is made up of numerous panels. It is also called a "movement space." It stops the migration of schools of fish and retains and holds the fish in the span until they head toward the funnel. Thus, all of the panels of the enclosing net are placed with schools of fish ascending and being led to the funnel and eventually the box net in mind.

Funnel: The side near the enclosing net is called the outer funnel, and the part that

passes into the box net side is called the inner funnel. The outer funnel is unified with the enclosing net panels and forms a movement space, and the inner funnel reinforces the snaring function of the box net and has prevents fish from escaping the box net. In addition to having the function of guiding fish toward the box net, the inner funnel has a function of joining the enclosing net with the box net.

Box net: This net has the fundamental functions of drawing in schools of fish from the funnel and storing and holding them until net hauling is performed.

3. Names and Structures of Each Part of Trap-Type Fixed Nets

(1) Names of Each Net Part

The fixed nets covered here are the standard trap-type fixed nets used in Japan. The names of each major part of the fixed net (trap) shown in Fig. 22 are as follows.

A: Leader net: Generally, this net is set up on the costal side with respect to the body net. A net set up facing an offshore side with respect to the body net is called an offshore leader net, and a leader net on the coastal side is called a shore leader net.

B: Front net opening: the opening of a net that fish enter and exit through. Generally it is on one side of the leader net, and is opened on the side opposite to the box net. The net opening on the other side of the leader net that is opened on the side of the box net is called the rear net opening.

D: Movement space: A location that is enclosed by side nets from the outer funnel to the movement space crossing. Generally, this location does not have a bottom net. It is a space in which schools of fish that have entered are retained.

E: (Movement space) crossing: Originally, this was a straight line with a right angle on the offshore and land sides, but as it is upstream from the tide, it is sometimes formed in the shape of a "<" to reduce tidal resistance.

F: End of the movement space: The location in which the offshore side of the net opening is reached.

H: Outer funnel (net): A net with the purpose of guiding schools of fish in the movement space to the box net. The slope from the seabed and the manner of funneling into the box net are both important.

J: Inner funnel (net): Continuing from the outer funnel, this is a net attached to the inner side of the box net. It serves the purpose of preventing schools of fish that have entered the box net from escaping.

L: Tether (net): A net that determines the width of the joining portion between the outer funnel and the box net. This term may also indicate the width.

M: Box net: A net that retains a school of fish. Generally, it is the net used for net hauling and fish catching, but as stated below, there are also structures in which multiple box nets are connected.

N: Fish catching (keeping area, box net crossing): Originally, this referred to a net portion woven with fine mesh and having thick thread, used to catch fish on the box net crossing side. However, the term is also used to indicate the box net crossing.

O: Safe net: A net fish are temporarily chased into for the purpose of keeping them alive when too many fish have entered the trap.

P, P': Arrowhead (wave front) large floats: These refer to large floats on the movement space side which support side tethers for offshore and land. Generally, these floats are on the upstream side of the tide.

Q, Q': Large floats: These refer to large floats on the box net side which support side tethers for offshore and land.

R: Body tethers: These are ropes that connect the end of the leader net, the ends of the side tethers for land, and the ends of the side tethers for offshore and land.

Refers to the maximum width of the rope.

W: Net opening sea depth: A basic value that determines the scale of each part of a fixed net.

P to Q (P' to Q'): Side tethers for offshore and land: Ropes that form the basis for hanging each part of a net.

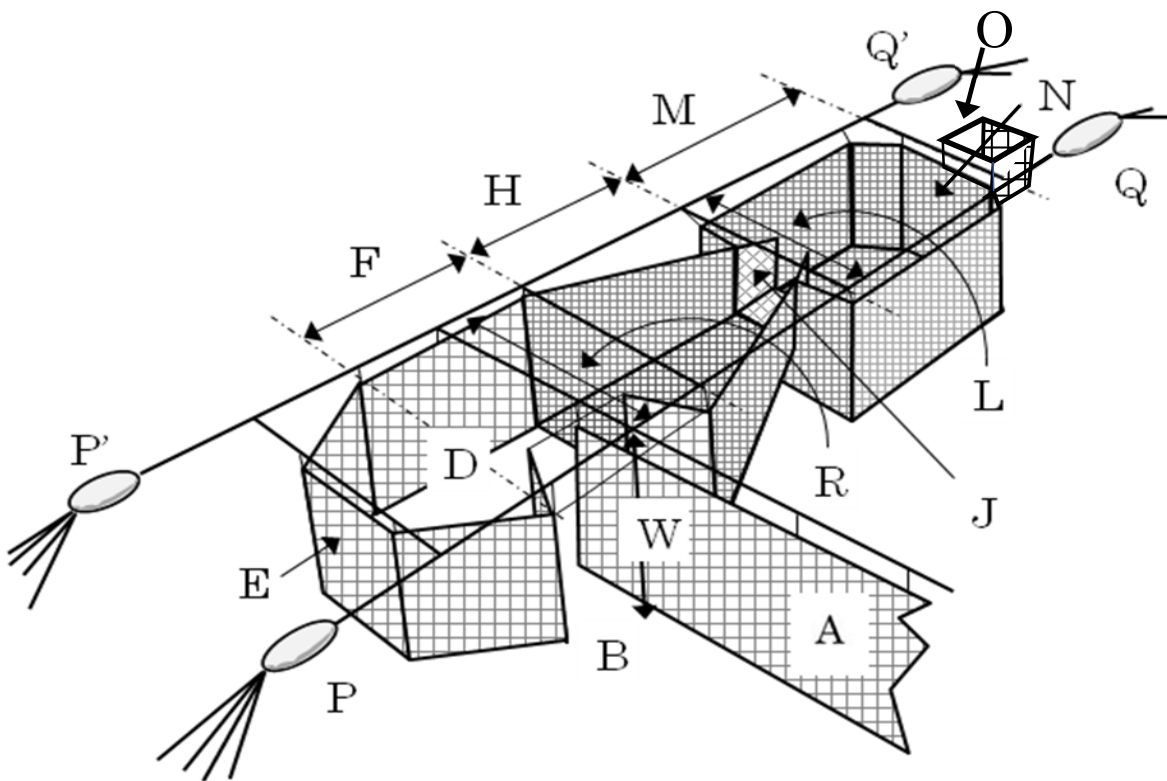


Figure 22: Structure of fixed net and name for each part

4. Names of Net Structures

Fixed nets have a structure in which each part of the net necessary for a side tether (rope) (including the movement space, funnel, and box net) is suspended. The basics for tethering include two side tethers (main sides) that run parallel to each other and

are on the offshore side and the land side and crossing tethers that are hung perpendicular to these (Fig. 23).

For a single fixed net, when continuously connecting a funnel with a box net as shown in Fig. 24 and there are two box nets, this is referred to as a fixed net with a dual box structure. Coming from the movement space, these areas are called the first level funnel, the first level box, the second level funnel, and the second level box.

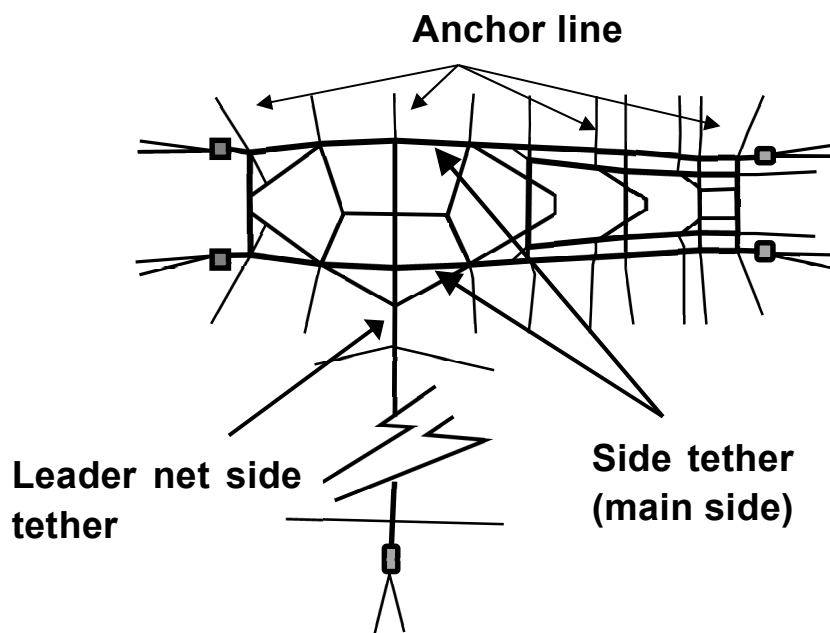


Figure 23: Side tethers of a fixed net

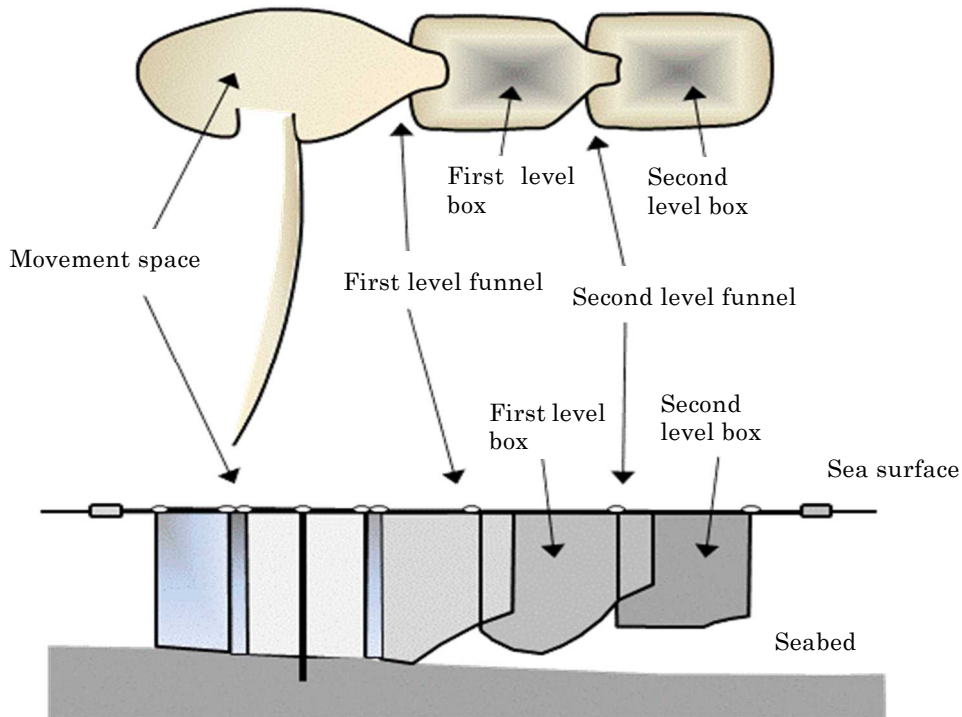


Figure 24: Fixed net with dual box structure (horizontal projection and cross-sectional view)

5. Net Hauling Work (Net Holding)

For net hauling, 1 to 3 vessels ranging in size from 5 to 20 tons are used. The commanding ship, which plays the central role, is called the *o-naka* vessel in Japanese and is particularly large. At the time of net hauling, there are two accompanying ships, one on the offshore side and one on the land side, surrounding this commanding ship. The ships close to the offshore and land sides of the commanding ship are referred to as side vessels. In addition to these, carriers for the fish to be caught or sculling boats (small boats with outboard motors) may also be used. The standard net hauling states are as indicated in Figs. 25 and 26.

(1) Upon arrival at the fixed-net fishing ground, the ships are driven within the net toward the border between the outer funnel and the inner funnel of the fixed net, commonly referred to as the "tightener" (peak, three openings) along the central

- tethers from the offshore side and the land side, for the purpose of net hauling.
- (2) With the commanding ship in the center, the side ships line up alongside it on the offshore and land sides and connect to one another using ropes between the bows and sterns to prepare for operations.
 - (3) At the same time, the commanding ship releases two spearing ropes, one from its bow on the movement space side and one from its stern, and connects to the central tethers. (When using a single spearing rope, it is released from the central portion of the commanding ship.)
 - (4) Hoist the hand ropes for net hauling attached to the bottom sides of the tightener part and both elbow parts (corner parts of the box net on the offshore and land sides of the inner funnel), and lower the central tethers to hold the net bottom near the seafloor. During this step, the inner funnel is closed, and the box net becomes an enclosed net with no entrance or exit.
 - (5) Loosen the tether ahead of the inner funnel. (There is also a method which tightens and hoists a net in front of the inner funnel.)
 - (6) Continuing from the net hoisting of the tightener and both elbow parts, lift the fish catching (standing area) side to the sea surface. In this case, there are two approaches used depending upon the net hauling method. These are a net hauling method in which netting fabric is sequentially lifted up to the sea surface by a hauler referred to as a ball roller (catch hauler), then attached to one side of the hauling vessel while the ships move; and a rope lifting method in which a line rope (net-hauling rope) attached to the bottom of a box net is hoisted using a standing roller (capstan) attached to the net hauling vessel, thereby sequentially lifting net fabric to the sea surface while the ships move.
 - (7) The spearing ropes are stretched and the ships move toward the area of the inner

funnel. Using the ball roller or the standing roller, the netting fabric and the rope are sequentially hoisted to the sea surface and the net is tightened toward the direction of the standing area (fish catching area).

- (8) When tightening toward the fish catching area from half of the box net, the net is tightened so as to aggregate it while ensuring a swimming space for the fish.
- (9) When the fish catching area is close, the two side vessels and the commanding vessel move closer together to encircle the net part (standing area) of the fish catching area in a backward "c" shape.
- (10) Next, the two side vessels separate to the outside of the net, and of these, one side vessel nears the fish catching side from outside of the net, encircles the net together with the commanding vessel inside the net, and stops tightening the net.
- (11) The fish inside the net, which was squeezed in a bag shape, are caught using the landing net. This work is called fish drawing. The fish can be housed by either the commanding vessel or the two side vessels.
- (12) When hauling a fixed net using only the commanding vessel, during the fish drawing step, the commanding vessel's derrick is used, one end of the float side of the fish catching net is lifted to prevent the catch from escaping while securing a bag-shaped space, and fish drawing operations are carried out (Fig. 27).
- (13) After the fish drawing is completed, the spear ropes are removed, and the net hoisted to the tightener is released. The inner funnel and other components are returned to their original state as well. The tethers and other elements of the net are also readjusted.

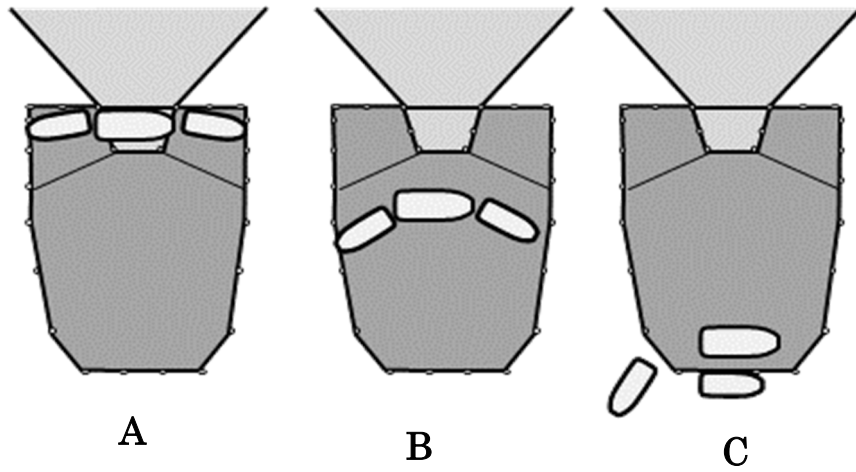


Figure 25: Net hauling work as seen from above in the order of A, B, and C

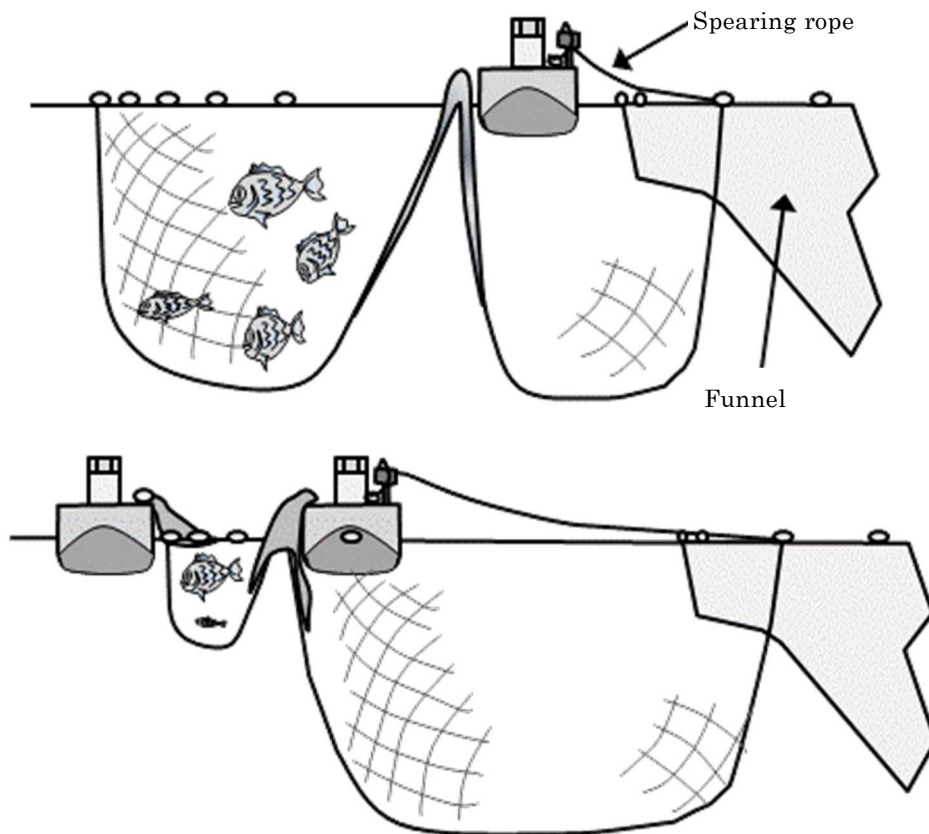


Figure 26: A cross-sectional view of net hauling work
The top figure is B from Fig. 25, and the bottom figure indicates the state of C.

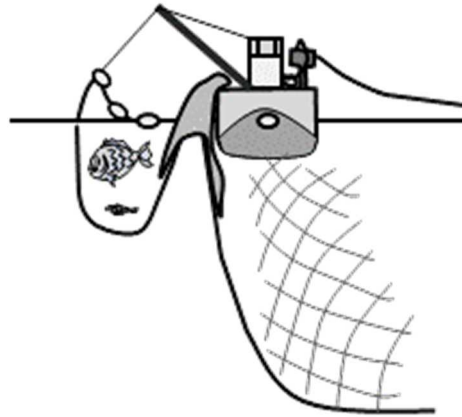


Figure 27.: A single net hauling vessel (commanding ship) drawing fish

6. Processing Catch

- Fish caught by fixed net fishing are either kept in a tank as live fish or are transferred to a fish hold mixed with ice water and seawater and kept in a fresh state while they are transported to the harbor.
- As live fish and fish with high levels of freshness can be sold for high prices, especially during the summer, it is important to use large amounts of ice to maintain freshness.

7. Danger Prevention

When performing operations on a fixed-net fishing vessel, crew members must be sufficiently cautious of the following during operations.

1. During net casting, be careful not to be caught in a rotating capstan or catch hauler.

2. When hoisting fishing equipment, etc. using cranes, be careful not to approach the side of the machine.
3. When pulling a net or rope, be careful that your fingers do not get entangled.
4. At times of strong waves or wind, there may be significant horizontal swaying (rolling) or vertical swaying (pitching) of the ship, so be careful.
5. The sides of the ship (bulwarks) are low, so be careful not to fall overboard.
6. When casting an anchor or sandbag into the sea, be careful not to get caught in the rope.

Basket Fishing

1. Basket Fishing

Branch lines are attached to a long main line, and basket nets with barbs that prevent sea creatures such as crabs and shrimp from escaping once they have entered are tied to the tips of the branch lines and sunk to the seabed. This is a type of fishing in which bait is put inside the baskets and sea creatures are lured in and caught.

2. Classification of Basket Fishing Tools

Various types of baskets are used around the world. When categorized according to their shapes, the baskets are grouped as shown in Fig. 28.

(1) Frustum basket: When put on the seabed, this type of basket is highly stable. It is also convenient when stacking baskets on a ship. Frustum baskets are used not only in Japan, but also other countries such as America and Canada. Some of the main baskets used in Japan are crab baskets (Fig. 28-a), shrimp baskets (Fig. 28-b), and Japanese Babylon / spiral shellfish baskets (Fig. 28-c). Generally speaking, crab baskets have one entrance (a chute) on the top of the basket, while shrimp baskets have two entrances on the sides of the basket.

(2) Cuboid basket: The netting fabric of the corners of this basket tend to fray during operations. Examples of this type are the conger baskets used in Saga Prefecture and the spiny lobster baskets used in Miyazaki Prefecture (Fig. 28-d), but overall this type is uncommon in Japan. However, in America, cuboid baskets are used in basket fishing for red king crab and snow crab (Fig. 28-e).

(3) Semi-cylindrical basket: It is convenient to create the frames for these baskets using wood and bamboo. These semi-cylindrical baskets are also known as *uke*, and are used around the world to catch spiny lobsters (Fig. 28-f). In Japan, they are used for basket fishing for blowfish in locations such as Nagasaki Prefecture and Kumamoto Prefecture, as well as for catching cuttlefish in Wakayama Prefecture (Fig. 28-g).

(4) Folding baskets: This structure enables the basket to be folded, allowing even small ships to use large numbers of baskets. Folding baskets are used in various locations such as Shizuoka Prefecture and Kagoshima Prefecture to catch blue crab (Fig. 28-h).

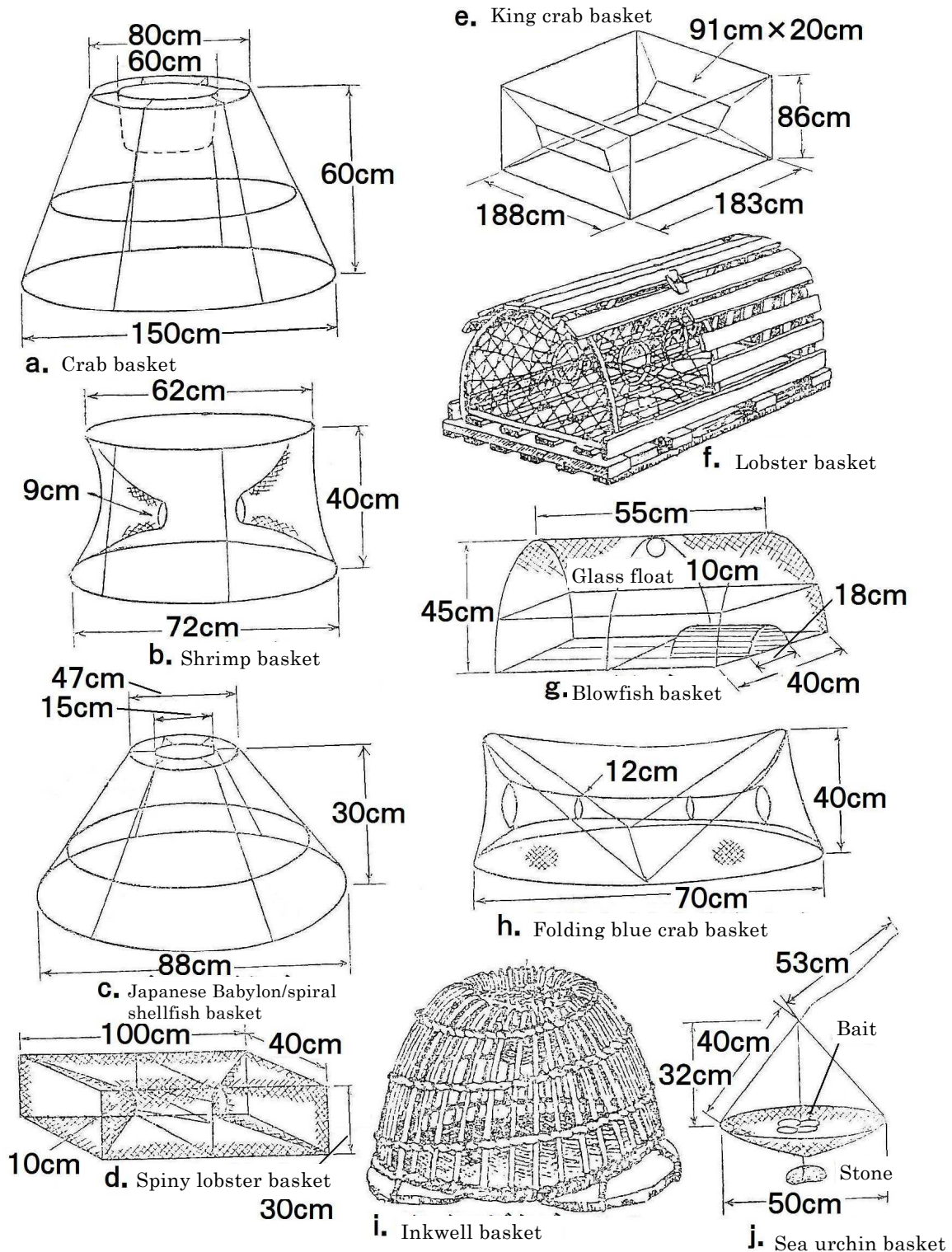


Figure 28: Various basket shapes

3. Basket Fishing Catch

The catch from basket fishing is mainly types of crab and shrimp. In addition, other seafood such as Japanese babylons / spiral shellfish, blowfish, conger eels, and squid are also caught with basket fishing, and all of these are premium seafood. Within the catch, main targets include red snow crab and northern shrimp.

4. Types of Fish Caught by Different Basket Types

- (1) Crab basket fishing: Various kinds of crab are caught, such as red snow crab, snow crab, horsehair crab, blue crab, blue king crab, and northern king crab.
- (2) Shrimp basket fishing: In areas such as the Sea of Japan northern shrimp (deep-water shrimp, Alaskan pink shrimp), *Pandalus hypsinotus* (Botan shrimp), and Morotoge shrimp (Hokkai shrimp) are caught.
- (3) Spiral shellfish basket fishing: Spiral shellfish (Japanese babylons) are caught.
- (4): Other: Seafood such as octopuse, squid, eel, and blowfish are caught.

5. Crab Basket Fishing

Crab basket fishing is mainly conducted in the Sea of Japan, and the main catch species are red snow crab and queen crab.

6. Operation Methods

There are 8 to 10 crew members for 70 to 100 ton fishing vessels. For vessels smaller than this, there are 6 to 7 crew members. After loading the baskets, the arrangement of fishing equipment installations is as shown in Fig. 29.

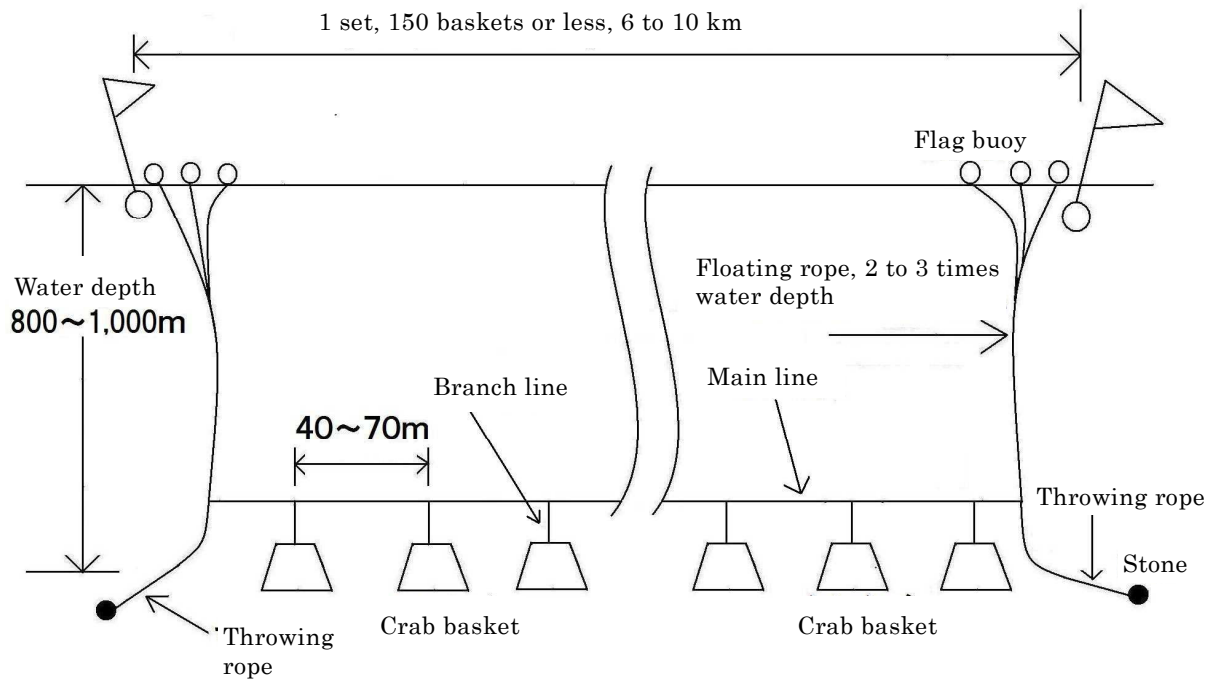


Figure 29: Arrangement of fishing equipment installations

(1) Basket casting (putting the baskets into the water)

- i. First, a location where many crabs are expected to be caught is searched for based on factors such as fishing conditions to that point, the water temperature, the water depth, and the substratum, and a basket casting spot is determined.
- ii. A floating rope (the length varies depending on the depth of the water, and is about 2 to 3 times that of the water depth) with flag buoys (marks) on it is cast from the left side of the stern.
- iii. A main line, throwing rope, and sinker stone are tied to the tip of the floating rope and cast out.

- iv. Next, the basket nets on the end of the ropes (branch lines) tying together the main line and the basket nets are cast into the water.
- v. For bait, fish such as mackerel, mahi, and frigate tuna.
- vi. At the time of basket hoisting, the baskets are loaded onto the stern without binding the bottoms of the basket nets with ropes. The ropes are bound when casting the baskets. This is to make it easier to load the baskets onto the stern.
- vii. There are up to three sets of fishing equipment ($3 \times 150 = 450$ baskets). First, one set is cast, then the ship moves a certain distance away and the second set is cast, then the ship moves a certain distance away again and the third set is cast.
- viii. During basket casting, sufficient caution must be taken to ensure crew members' feet do not become entangled (caught) in ropes.

(2) Basket hoisting (hoisting the baskets)

- i. The main elements of basket hoisting operations are shown in Fig. 30. The main line is wound by a drum on the left-side center via a roller on the left-side bow. At this time, operations are conducted with the wind either behind the side on which the basket is hoisted (left side), or behind the bow.

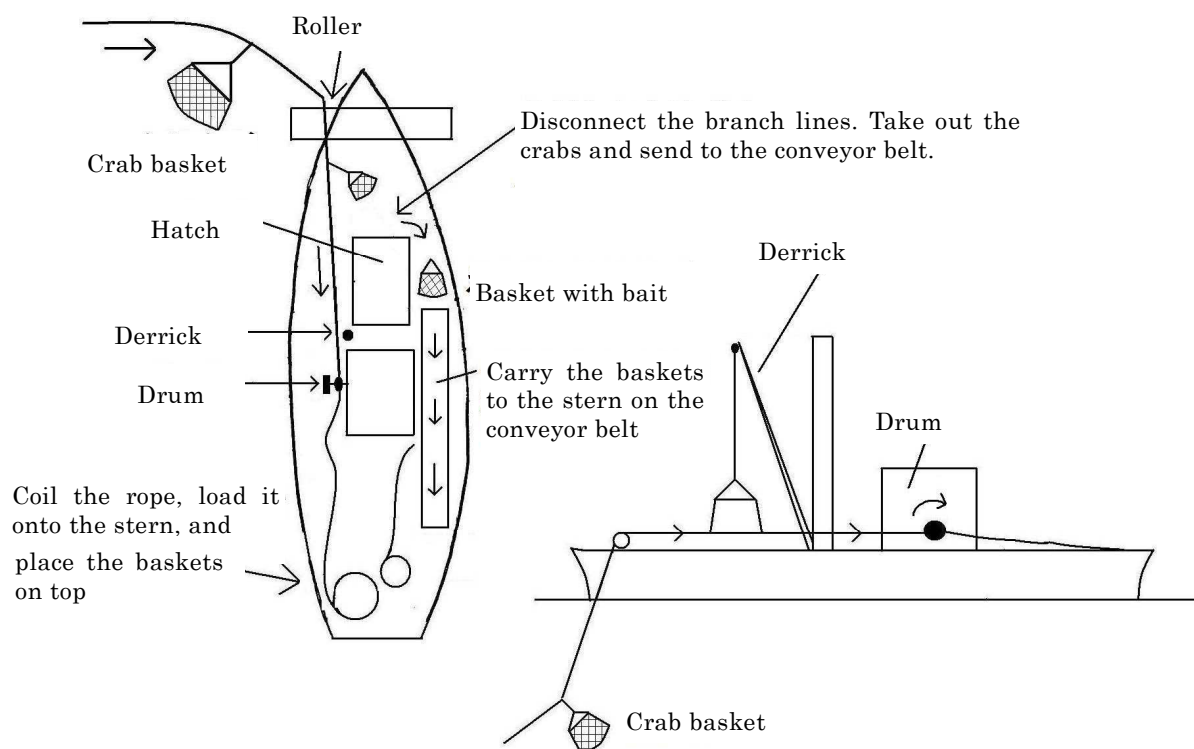


Figure 30: Main elements of basket hoisting operations for red snow crab basket fishing

- ii. When the baskets reach the sea surface, they are hooked using a bar with a hook attached to the end, and lifted using a derrick.
- iii. If there is caught seafood in the baskets, the ropes on the bottoms of the baskets are undone to remove the catch. If crabs have been caught, they are separated into large, medium, and small sizes, inserted into a draining basket filled with ice, and put into the fish hatch.
- iv. If red snow crabs have been caught, catching female crabs and male crabs under 9 cm is prohibited, so any catch smaller than this is released.
- v. Bait is put into emptied baskets without tying the ropes at the bottoms of the nets, the baskets are carried to the stern by a conveyor on the left side, and the baskets are prepared for the next casting.

- vi. The hoisted main line is sent from the bow to the stern on the left side of the ship, and the main line is coiled in an orderly fashion to prepare for the next basket casting. Next, the branch lines with the baskets attached to them are tied to the main line, and the baskets are loaded onto the stern.
- vii. Bycatch in red snow crab basket fishing includes porous-head eelpouts, Japanese babylons / spiral shellfish, and other species.
- viii. After one set of baskets has been hoisted, the next set of baskets is immediately cast from the stern if fishing conditions are good.
- ix. If the fishing conditions were bad for the first set of baskets, a search is carried out to determine a new basket casting location (fishing ground). The baskets are cast when good grounds are found, and the second set of baskets that had been cast ahead of time is hoisted afterward.
- x. These operations are repeated, the third set of baskets is hoisted, and then when the third set has been cast, the ship returns to the harbor to unload the caught seafood for the market.
- xi. If one set of baskets is hoisted and the fishing conditions are good, the next set of baskets is cast right away. In this case, basket hoisting and basket casting takes 4 to 5 hours. Assuming it takes about 8 hours round-trip to go to and from the fishing ground, the number of hours taken for one voyage is this travel time plus the time for operations multiplied by three sets (4 to 5 hours for each), or 12 to 15 hours. This means the total time is 20 to 23 hours when fishing conditions are good. If the fishing conditions are poor, a case of selecting a different fishing ground and conducting operations there involves incurring more time to travel to that fishing ground.

7. Precautions for Red Snow Crab Basket Fishing

- (1) The periods when red snow crab basket fishing is allowed are determined by each area.
- (2) There are periods when red snow crab basket fishing is prohibited.
- (3) The prices of red snow crabs are decided based on size, and caught crabs are categorized into large, medium, and small based on the sizes of their shell widths (the breadths of their shells) on the ship. The categories are as follows. Large: 12 cm and above, medium: between 10 and 12 cm, and small: over 9 cm.
- (4) For resource conservation, catching male crabs with shell widths of 9 cm or less and female crabs of all sizes is prohibited. If any such crabs are caught, they must be immediately released. Catching snow crabs via red snow crab basket fishing is prohibited as well, but since they inhabit different water depths, there is no bycatch or mixing.
- (5) Engaging in red snow crab basket fishing with the intent of catching other types of crabs (such as snow crabs) is prohibited.
- (6) Red snow crab basket fishing operations are prohibited in waters shallower than 800 m.
- (7) The size of meshes must be 15 cm or larger.
- (8) The maximum number of baskets allowed in one set is 150.
- (9) After returning to harbor, the caught crabs must be immediately sent to a processing location and boiled or otherwise processed. Out of the catch, those crabs which are still alive are sold as live crabs or put into a fish tank at a fishermen's cooperative and shipped at an appropriate time.
- (10) The number of crabs caught is thought to be even more strongly influenced by whether operations can be permitted due to weather, such as whether weather

conditions are good or inclement, than other factors such as the influence of seasons and fishing ground conditions.

8. Shrimp Basket Fishing

In shrimp basket fishing, species such as northern shrimp (Alaskan pink shrimp), *Pandalus hypsinotus* (Botan shrimp), and Morotoge shrimp (Hokkai shrimp), are caught, and out of these, northern shrimp have the largest catch volume. This species is also known by the name "deep-water shrimp," and these shrimp are familiar to people all around Japan. Northern shrimp are the largest shrimp resource in the Sea of Japan, and are mainly caught by offshore trawling, small-scale trawling, and basket net fishing. Basket net fishing is conducted along the coast of the Sea of Japan from Hokkaido down to the area off the coast of Tottori Prefecture. In addition, bycatch such as porous-head eelpouts and Japanese babylons / spiral shellfish are also mixed in.

9. Shrimp Basket Fishing Tools

Generally, a side-opened basket with an opening on the side of the basket as shown in Fig. 31 is used. Most baskets have a frustum shape. The number of baskets used is determined by each prefecture based on various conditions such as the circumstances of other fishing operations

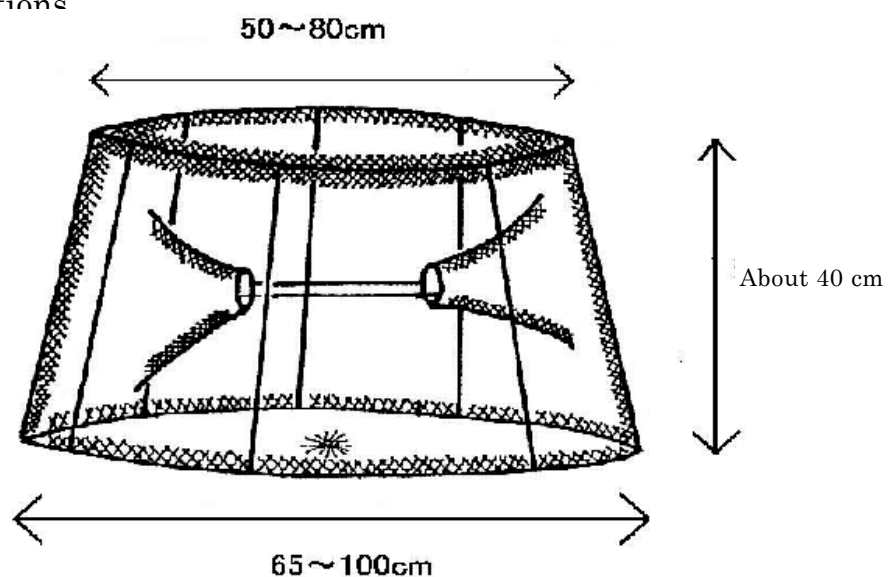


Fig. 31: Shape of a shrimp basket

The interval between baskets should be decided when attaching the baskets to the main line based on the breadth (length) of the range inhabited by the shrimp, in other words, the range of the distribution of shrimp that can be caught with one basket. However, in actuality, work-related issues (whether to tie the branch lines with the baskets attached to the main line before basket casting or to cast the baskets while tying the branch lines to the main line), and the differing time for hoisting the baskets depending on the length between baskets on the main line and the speed of basket hoisting should also be considered when determining the length of these intervals. For bait, seahorses, arabesque greenlings, snow crabs, and herring are used.

10. Operation Methods

(1) Basket casting

- i. The basket casting spot is determined by investigating factors such as fishing conditions to that point, the water temperature, the water depth, the substratum, and the seabed topography.
- ii. After the spot is determined, the flag buoys (markers), floats, and floating rope (2 to 3 times the length of the water depth) are inserted into the water from the stern.
- iii. A main line, a throwing rope of 25 to 45 m, and a sinker stone are tied to the very end of the floating rope and cast.
- iv. Next, the ship drives forward at full speed, and the basket nets on the ends of the ropes (branch lines about 3 m long) which tie together the main line and the basket nets are cast into the water. The interval between baskets ranges from 5 to 8 m.
- v. The baskets are prepared for casting by inserting bait during basket hoisting and tying ropes to their bottoms.
- vi. Fig. 32 shows conditions when shrimp baskets have been cast into the sea.

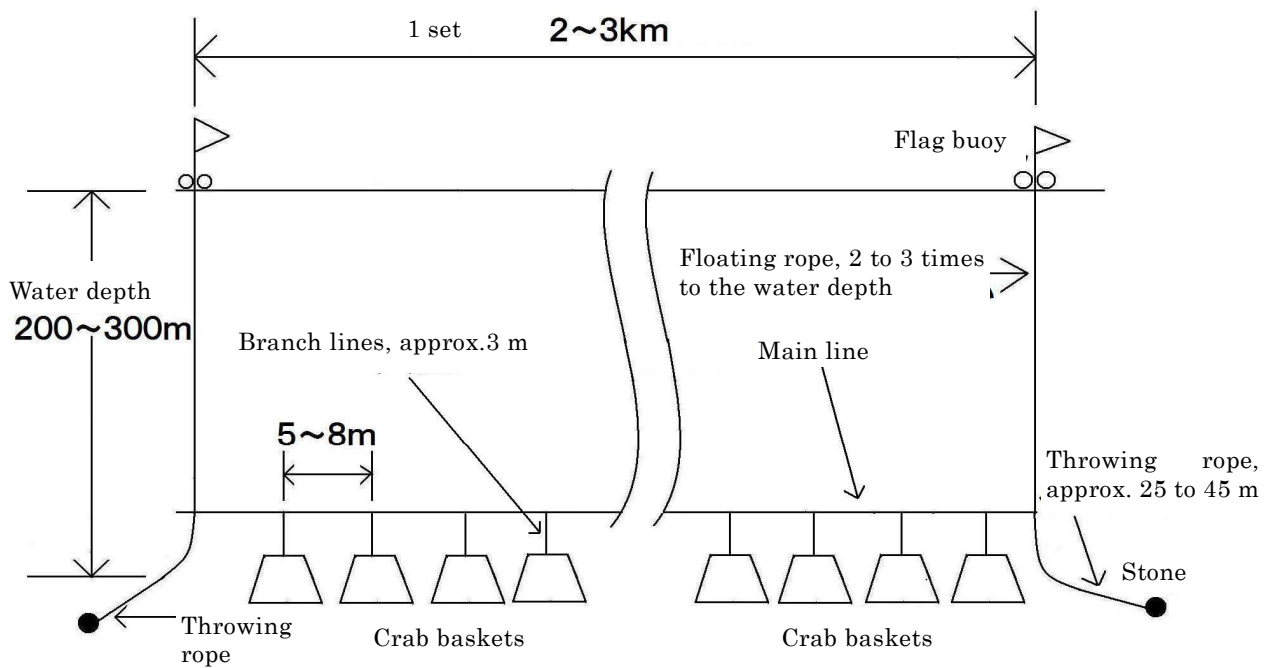


Figure 32: Conditions when shrimp baskets have been cast into the sea

(2) Basket hoisting

- i. As shown in Fig. 33, a clipping drum at the front of the right side is used to hoist the flag buoys, followed by the floating rope.
- ii. Next, the sinker stone and the main line are hoisted, and when the branch lines and the baskets attached to them come up, the baskets are detached from the main lines, including the branch lines.
- iii. The ropes on the bottoms of the basket nets are undone, the catch is removed, shrimp and other seafood are separated, and the shrimp are put into a live seafood tank. Emptied baskets are placed on conveyor belts on the right side of the ship and sent to the stern.
- iv. The hoisted main line is sent from the bow to the stern on the left side of the ship using the drum, and the main line is coiled in an orderly fashion to prepare for the next round of basket casting. Moreover, the branch lines with the baskets attached are tied to the main line, and loaded onto the stern portion.

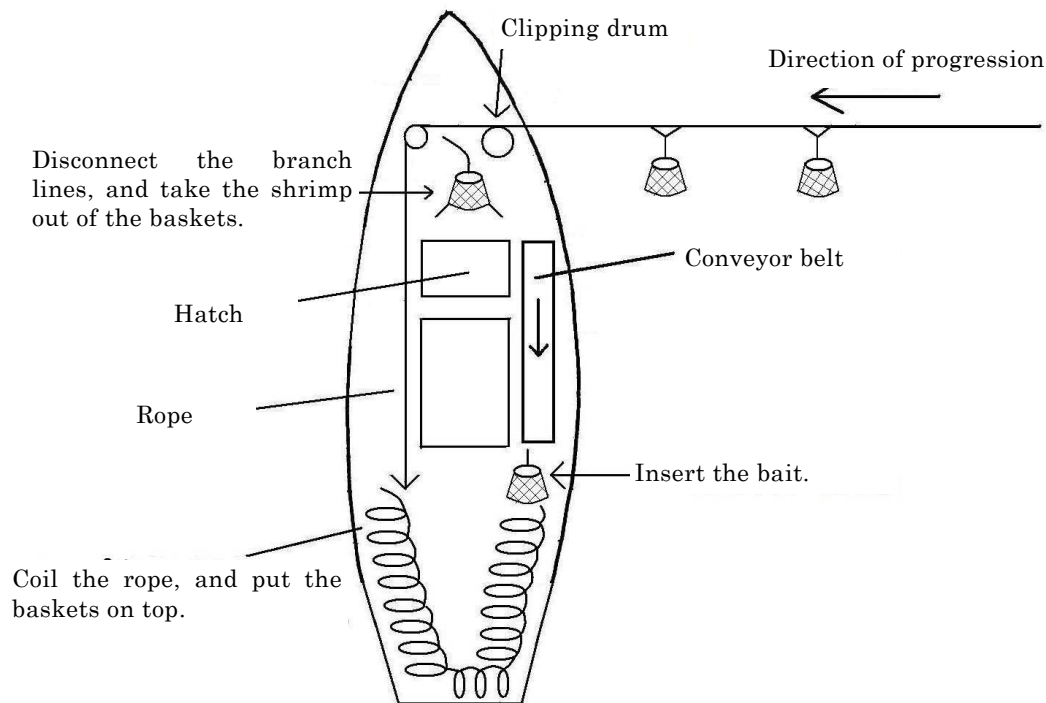


Figure 33: Shrimp basket fishing hoisting method

11. Precautions for Shrimp Basket Fishing

- Shrimp basket fishing is only allowed during limited time periods.
- After fishing, the shrimp taken from the baskets are immediately placed in live fish tanks. Live fish tanks should be filled with sea water chilled to a temperature of about 0°C, with oxygen supplied from the bottom.
- When the ship returns to the harbor, shrimp are sorted based on whether they are alive, their size, and whether they are pregnant.
- In Japan, whether shrimp are pregnant can affect the prices in some areas. Pregnant shrimp earn higher prices in the Kanazawa area, while large shrimp that are not pregnant are preferred in the Kansai area. This is due to differences in the taste of the eggs and the texture of the meat when shrimp do not have eggs.