

Specified Skills
Educational Textbook for the Fishing Industry Skills Proficiency Test (Aquaculture)
(General, Safety)

Japan Fisheries Association
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1. Introduction

Seafood is an extremely important food source for people. To ensure we can continue consuming seafood in perpetuity, we must take care of our oceans and be mindful not to take too much. However, the global population has increased and the amount of seafood eaten has grown, leading to a reduction in fishery resources. Further, in conjunction with the abundance resulting from economic growth, more and more people want to eat delicious seafood, but natural seafood production is limited.

On the other hand, aquaculture technologies have improved. As a result, in addition to "catching fisheries" which have been conducted up to now, "aquaculture" has also come to thrive. Accordingly, new methods and aquaculture of fish, shellfish, and seaweed species that could not be cultivated before are on the rise.

The main aquaculture methods in Japan are as follows.

(1) Feedless Aquaculture

This is a method in which aquaculture is conducted without people directly providing feed, making use of salts, food, and other nutrients in the natural water.

• Hanging Aquaculture (Figs. 1, 2)

This is a method of aquaculture in which the organism is cultivated in the water by attaching it to a rope and hanging it, inserting it into a net, or securing it in a similar fashion. This method of aquaculture is used for mainly species such as Pacific oysters, scallops, and laver, wakame, and kelp seaweeds.

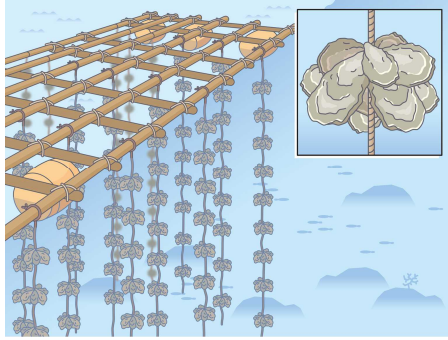


Figure 1: Pacific oyster aquaculture

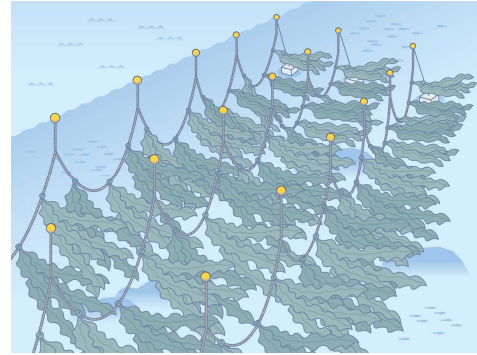


Figure 2: Kelp aquaculture

(2) Feed-Supplied Aquaculture

This is a method for aquaculture in which sea creatures such as fish or shrimp are kept in ponds or tanks and given feed to cultivate them.

• Land Aquaculture (Figs. 3, 4)

This is a method for aquaculture in which fish are cultivated in manmade ponds on land. This method of aquaculture is used mainly for species such as tiger shrimp, flounder, eel, and trout (such as rainbow trout).

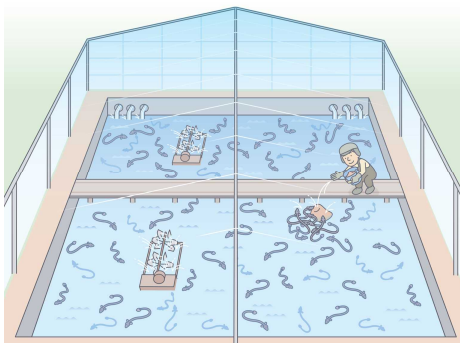


Figure 3: Eel aquaculture

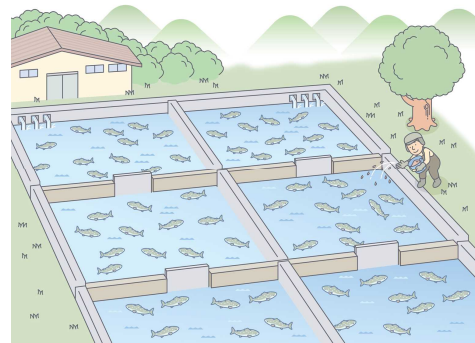


Figure 4: Trout aquaculture

• Netted Tank Aquaculture (Divided Aquaculture) (Fig. 5)

This is a method in which fish are cultivated in areas enclosed by nets on the surface of the water. This method of aquaculture is mainly used for species such as yellowtail, red sea bream, blowfish, striped horse mackerel, tuna, and carp.

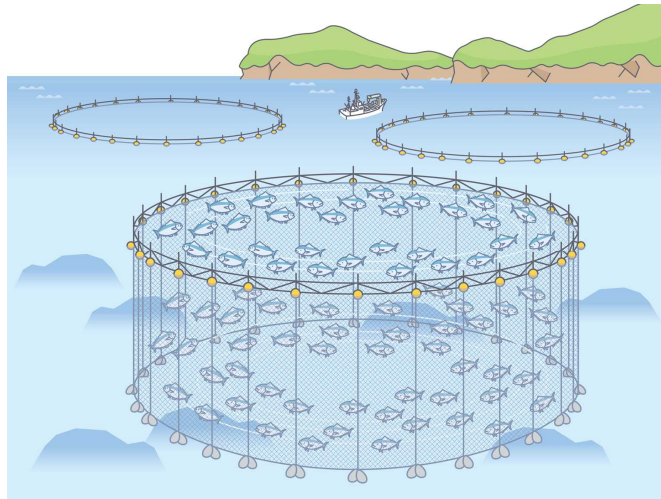
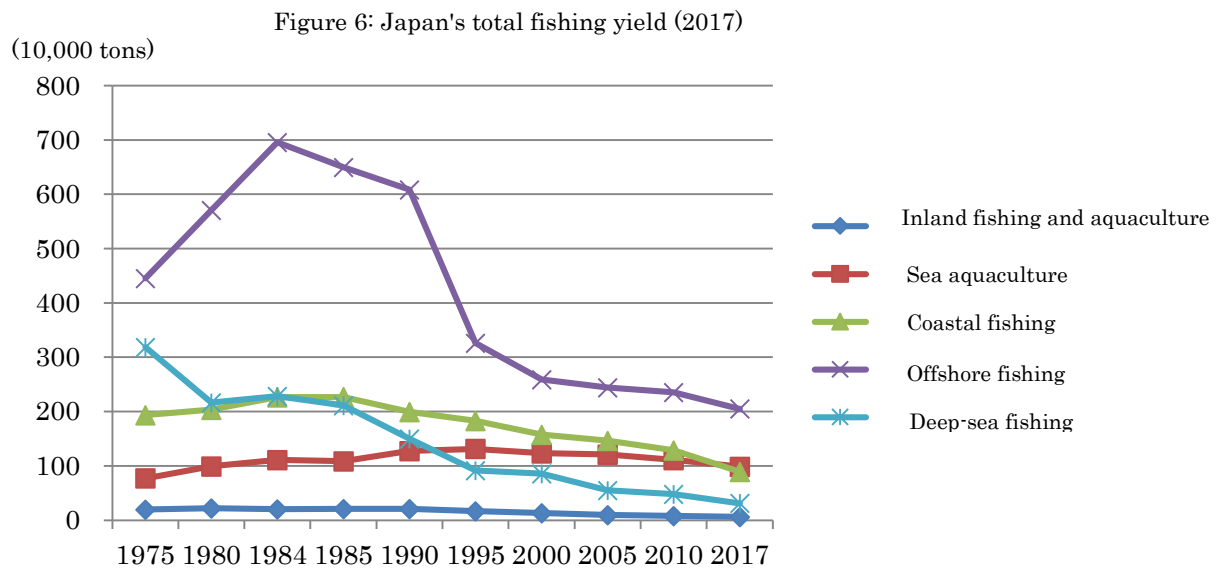


Figure 5: Tuna aquaculture

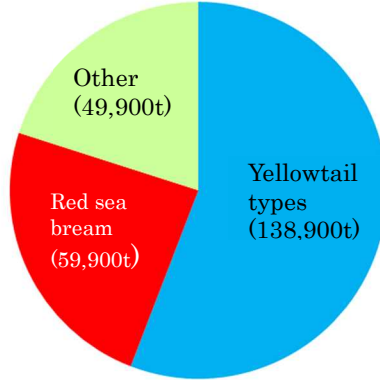
As shown in Fig. 6, the total fishing yield was highest in 1984, at about 12.8 million tons, and falling to about one third of this peak figure, 4.3 million tons, in 2017. In addition, the aquaculture yield (2017) accounted for about 1/4 of the total fishing yield, showing that it is an important form of fisheries production.



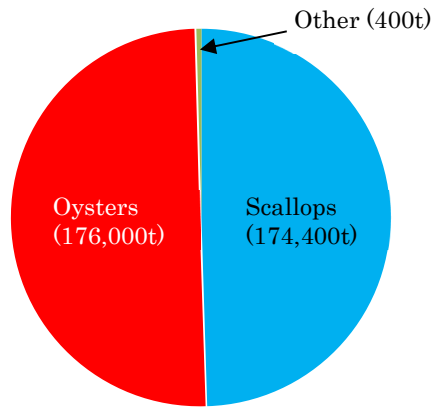
Source: Based on the FY2018 White Paper on Fisheries

As shown in Fig. 7 below, the haul amounts of the main types of fish are an important component of fishing production.

Haul amounts of main types of fish in fishing aquaculture (2017)



Haul amounts of main types of shellfish in shellfish aquaculture (2017)



Haul amounts of main types of seaweed in seaweed aquaculture (2017)

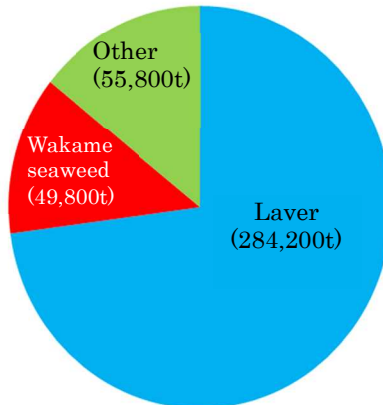


Figure 7
Source: "Production Statistics for Fishing and Aquaculture in 2018," Ministry of Agriculture, Forestry and Fisheries

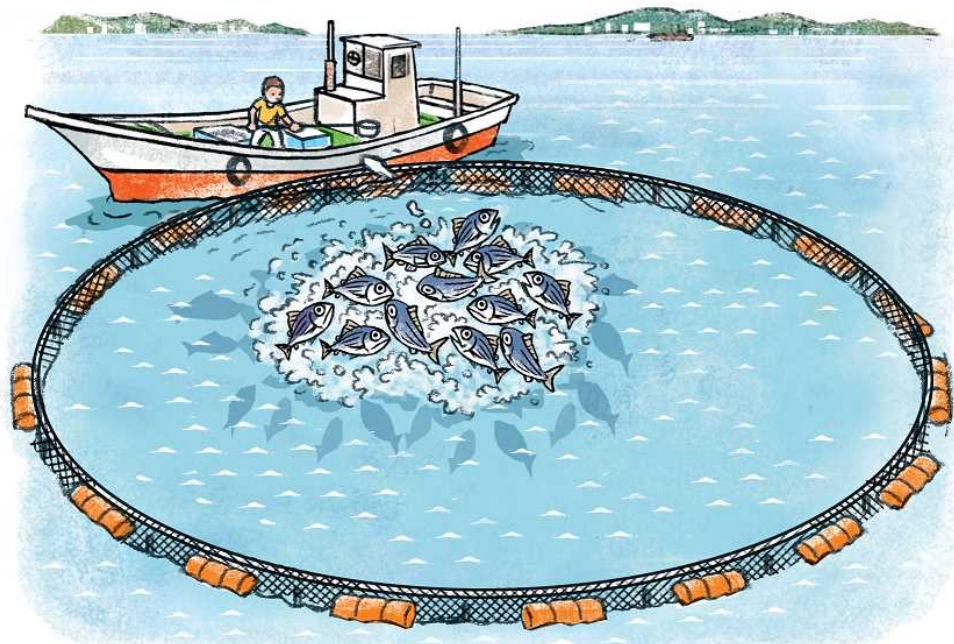
2. Aquaculture

"Aquaculture" refers to a method in which a facility (breeding facility) that can be managed by people is built, seeds for cultivation are introduced to the facility, a favorable environment is created through the adjustment of feeding and breeding conditions, net replacement and pond cleaning, the movement of tanks and rafts, and the selection of the depth for lowering into the water, and the seeds are healthfully cultivated and grown to a sellable size.

In accordance with national law, people who conduct aquaculture must have obtained licenses for rights of demarcated fishery (the right to conduct aquaculture), and must endeavor to create products that can deliver safety and peace of mind.

Only licensed locations can be used as cultivation spots. Those who wish to conduct aquaculture cannot simply do so wherever they please.

In addition, conducting cultivation for a period of days or months, using the same method as aquaculture to adjust prices, increase the weight of the organism, or wait until shellfish poisons have depleted is called farming.



3. Seeds

Securing seeds is essential to conduct aquaculture.

"Seeds" refer to young fish and shellfish that can be cultivated at an aquaculture facility for organisms. There are both natural seeds and artificial seeds.

- (1) Natural seeds: Species that have a characteristic of gathering in a certain place at a certain time period and can be caught in a sizable number are caught and used as aquaculture seeds. Examples include creatures born in the sea, rivers, and lakes, such as scallops, Pacific oysters, yellowtail, tuna, eels, and sweetfish. For the collection of these natural resources, there are specific time periods, methods, and locations used, and permission is required for each type or region.
- (2) Artificial seeds: These seeds are created by applying sperm to eggs of the same species inside an aquarium, tank, or other enclosure. The eggs are fertilized, and the seeds are grown to a size suitable for aquaculture cultivation. These are organisms created with technology and human effort, and this type of seed is used when natural seeds are difficult to catch or when artificial seeds have advantages such as faster growth or lower production costs. Some examples of aquatic life cultivated as artificial seeds are shown below.

- Saltwater fish: Red sea bream, flounder, yellowtail, tuna, tiger puffer, etc.
- Freshwater fish: Sweetfish, salmon, carp, catfish, etc.
- Shrimp and crab species: Tiger shrimp, blue crabs, etc.

- Shellfish species: Pacific oysters, abalone, mother-of-pearl, etc.
- Seaweed: Laver, wakame, kelp, etc.
- Other: Sea urchin, sea cucumber, etc.

*Natural seeds are used for yellowtail and tuna aquaculture, but the usage of artificial seeds has also increased recently.

Seeds spawned in aquariums from parent fish or shellfish that live in the water and seeds spawned in natural waters are used as seeds for aquaculture. For this reason, it is important to protect fish and shellfish that lay eggs in the water so that they remain abundant. It is particularly important to be careful to not overfish. This is called "managing resources." By continuing such management, we can stably procure robust seeds long into the future.

When fish and shellfish are newly spawned eggs, fry, or spat, most are eaten or die due to lack of food. As they grow, fish gain improved swimming ability, shellfish develop tougher shells, and the proportion of deaths decreases.

However, no matter how big they grow, sea creatures will die if the water quality suffers. Thus, in addition to the management of fishing resources, improvement of water quality is also essential for stable operation of aquaculture.

4. Aquaculture Techniques

Newly spawned fish and shellfish are extremely small and weak, and have very little ability to escape from predators, eat, and digest food. Accordingly, seeds are cultivated in the early stages by adding seawater filtered through a land-based aquarium to adjust the temperature and an ample supply of easily-digestible feed with portions sized appropriately for their growth. The facilities necessary for these operations differ from those used for aquaculture, so early-stage cultivation is conducted by a fishery cooperative with a specialized technician, seed producer, or similar specialist.

In aquaculture, the seed is procured, cared for, and grown. The most important elements in such care are ensuring that oxygen-rich, sanitary seawater and nutrient-rich feed are thoroughly dispersed and that healthy growth is achieved without the incidence of disease until shipment. In order to achieve this, care must be taken to ensure that seeds do not suffer illness by keeping them from becoming too densely packed, providing high-quality feed in the necessary amounts and at appropriate intervals, and maintaining a favorable environment through changing tank nets and/or ponds. At first, the seeds are small, so many hatchlings are introduced to the cultivating facility (the cage, aquarium, or tank). However, in order to grow fish or shellfish, it is also important to conduct management to gradually reduce the numbers kept in the cultivating facility (the cage, aquarium, or tank) as the fish or shellfish grow. In addition, it is also important to ensure no attached matter is introduced when adding seawater so that its freshness can be maintained.

In aquaculture, considering the number of seeds first introduced to the cultivating facility (the cage, aquarium, or tank) as 100%, production plans to achieve over 80% of this quantity unloaded 2 to 3 years later.

5. Aquaculture Environments

(1) Sea Contamination

The seas (or rivers) must always be kept in a clean state, but the amount of nutrient salt and harmful substances that flows in from houses, plants, and fields where humans live on land is extremely high, and this is said to be the cause of the majority of sea contamination.

In aquaculture, this contamination can cause fish or shellfish being cultivated to suffer illnesses or die. Moreover, cultivators must also be careful to avoid raising seeds in contaminated environments because this can negatively affect the health of consumers (people).

[Types of Contamination]

- Contamination from land:

Detergents that flow in from places where people live, sewage (contaminated water) and factory wastewater, fertilizers and livestock feces and urine that flow in from fields and ranches, and leftover feed and excrement (urine and feces) from places where fish and shellfish are cultivated

- Contamination resulting from waste thrown into seas or rivers
- Contamination resulting from oil (there is a great deal of damage from oil that leaks from ship accidents)
- Chemical substances: contamination resulting from chemicals such as dioxin, mercury, and cadmium (there have been cases of humans being harmed in the past, so it is necessary to take precautions against such contaminants)
- Contamination resulting from the flow of mud and/or sand from development in locations such as mountains and along the coasts



(2) Eutrophication and Red Tide

Eutrophication refers to an excessive increase in minerals such as nitrogen (N), phosphorus (P), and silicon (Si) which become nutrients for phytoplankton. This is caused by from sources such as factories and households disposing of water which contains an abundance of these elements.

Red tide refers to a state in which certain types of phytoplankton become excessive due to eutrophication, causing the color of the water to change to red or brown.

Eutrophication and red tide cause oxygen in the water to decrease and phytoplankton to become stuck in the gills of fish, killing them. As a result, these conditions exert a major impact on fishing and aquaculture.



6. Observation

There water at the coast is always in motion due to the oceanic currents and the rise and fall of the tide. Due to this flow, water is exchanged at aquaculture locations so that hatchlings can sufficiently breathe, and various types of phytoplankton enter these facilities. However, the seawater can become contaminated due to harmful substances from land, and if the exchange of water is insufficient, there is a negative impact on growth and maturation.

At aquaculture locations, water for cultivation is drawn, the water temperature, salinity, and oxygen content are tested, and observations are carried out to verify whether there is an unpleasant odor or the color of the water has changed. In particular, at times when a typhoon has passed by or a large amount of rain has fallen, etc., the salinity may be low (the water may be sweet) over a large range or water may be clouded by soil, so it is necessary to be cautious.

7. Stormy Weather Precautions

When strong winds or high waves occur due to large low pressure systems or typhoons, aquaculture facilities may be destroyed. It is important to pay close attention to weather forecasts, look into the strength of strong winds and high waves and the direction of low pressure systems and typhoons that are approaching, and endeavor to minimize the damage to aquaculture facilities. When there is a possibility of a typhoon approaching, rafts must be moved inside the bay and preparations such as increasing mooring ropes and inspecting the facilities are required.

In addition, tsunamis are one example of a frightening disaster. Japan has the highest incidence of earthquakes in the world, and people who live close to the sea must be aware that a tsunami could occur as a result of an earthquake and take precautions accordingly.

If you are close to the epicenter of an earthquake, you should assume a tsunamis will occur immediately. On the coast of Okushiri Island in Hokkaido and the coastal areas of Iwate Prefecture and Miyagi Prefecture, tsunamis occurred within 10 minutes of nearby earthquakes, and many people were killed. Moreover, there is a risk even for earthquake that did

not occur in Japan. When the Valdivia earthquake occurred in South America, a tsunami reached the Japanese coast after some time and suddenly increased in height, causing massive damage to ships and culturing rafts.

When a tsunami comes, there are extremely long intervals between waves, and particularly due to the energy of waves in shallow waters, the ocean level suddenly rises, potentially engulfing people, ships, and buildings. The strength with which a tsunami strikes the coast is extremely high, so much so that even if the water level is only up to a person's knees, it is still impossible to move.

When a tsunami comes, a tsunami warning is issued by simultaneous broadcast throughout the town or city. If you feel an earthquake, it is important to assume that a tsunami will strike immediately and make a plan to evacuate to an elevated area far away from the coast.

8. Fundamental Fishing Knowledge

(1) Fundamentals

- Pay attention to your health on a daily basis in order to work safely.
- In the event of an illness or injury, be certain to report it to the captain.
- Give yourself extra time so that you are not late to board the ship.
- On the ship, avoid feuding with other crew members and disturb the order.
- The unnecessary use of open flames is prohibited. Also be cautious of smoking.
- When on the ship, refrain from walking around with your hands in your pockets.

- After using tools for various operations on the ship, quickly put them away.
- When the ship is moving, be careful not to stick your hands or feet outside of it.
- Be careful not to obstruct the view of the people steering the ship.

(2) Safety

○ Clothing (Fig. 8)

- When working on the water (on deck), be sure to wear a work-use life jacket. Life jackets are required when aboard a ship.
- Wear a hard hat (helmet) to protect your head.
- When performing dangerous work, use a safety belt and a lifeline.
- Wear proper clothing to avoid getting caught in moving machinery and ropes.
- When handling wires, ropes, and similar materials, wear safety gloves.

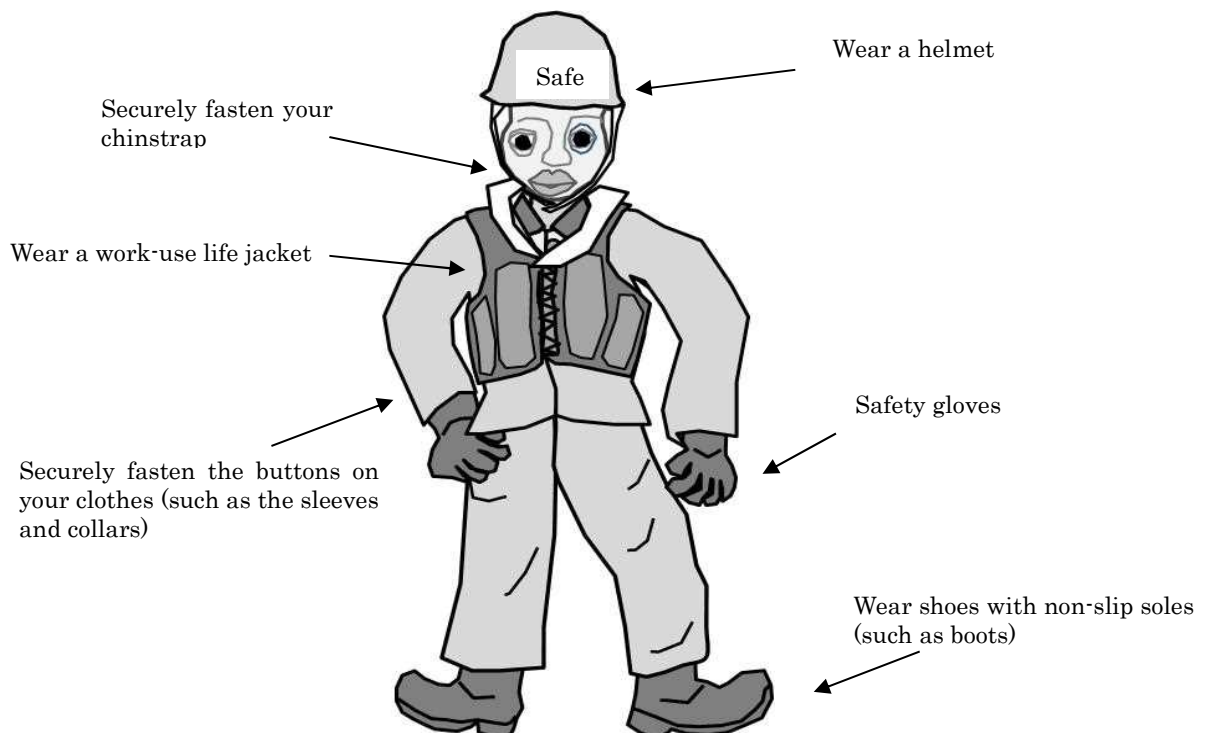
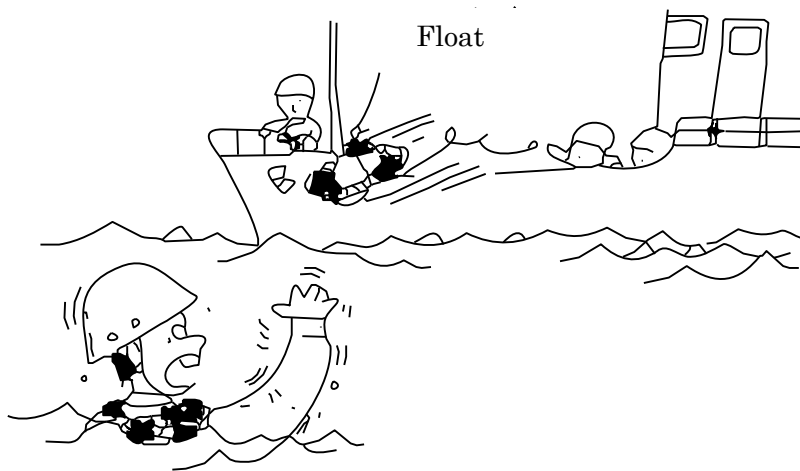


Fig. 8: Safe clothing for work operations

○Precautions when on the water

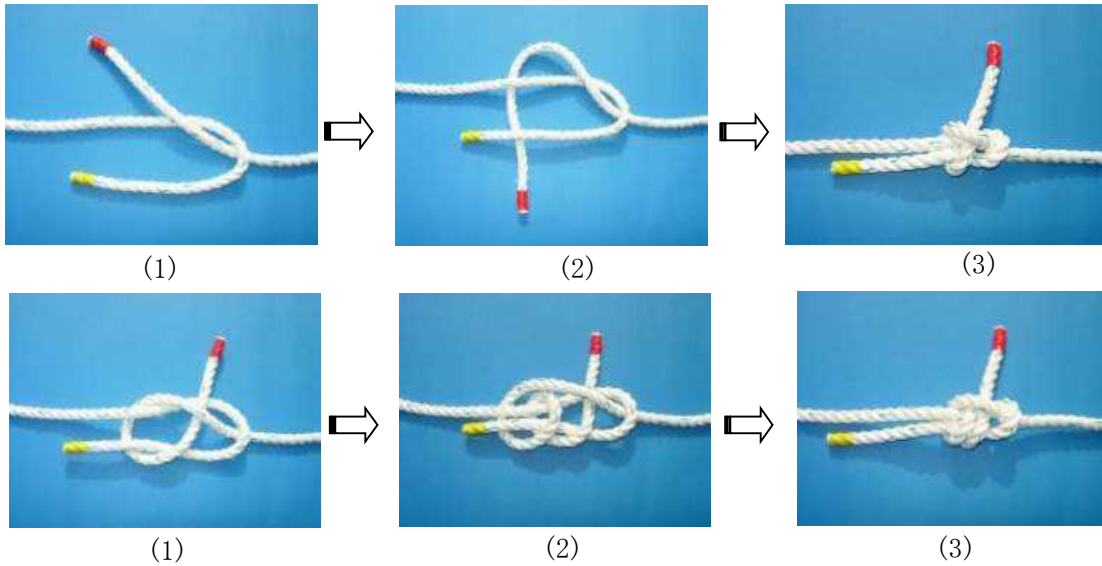
- Before commencing work, ensure you have a grasp of the work details and sufficient time to complete the operations.
- When the work area is contaminated with oil or fish blood, clean it.
- If you witness someone fall into the sea, notify those around you in a loud voice and cast something that floats, such as a life preserver (life buoy), into the sea. Do not attempt to save the person by yourself.



- Be careful not to approach moving machinery.
- Be careful not to carelessly approach ropes or wires being used. Be careful that your legs do not get tangled in wrapped ropes.
- When you arrive at a work location, confirm the locations of steps and where ropes are arranged.
- Be especially careful when it is dark, when you are getting on and off the ship, and when you are moving to another ship. Also be careful when crossing planks.
- When hoisting a heavy object using a crane, confirm that there are no people under the load. Never carelessly approach the area under a crane, even when it is not moving. In addition, a special license is necessary to operate a crane.

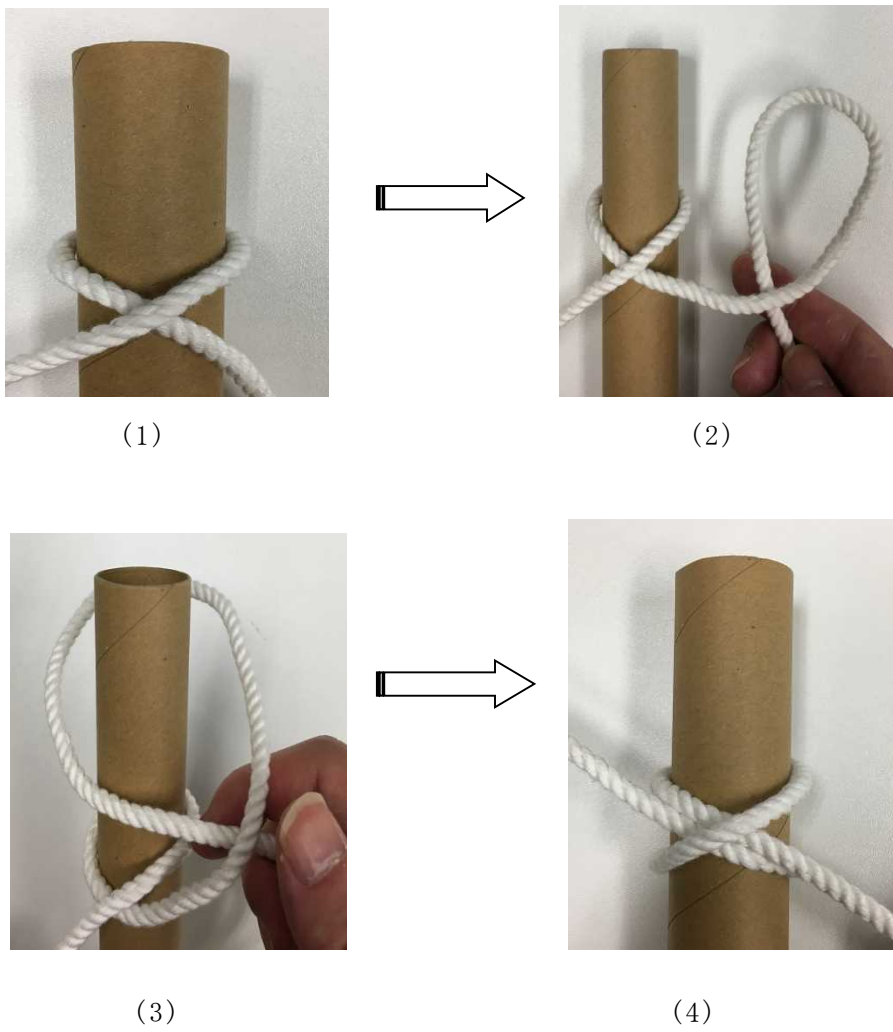
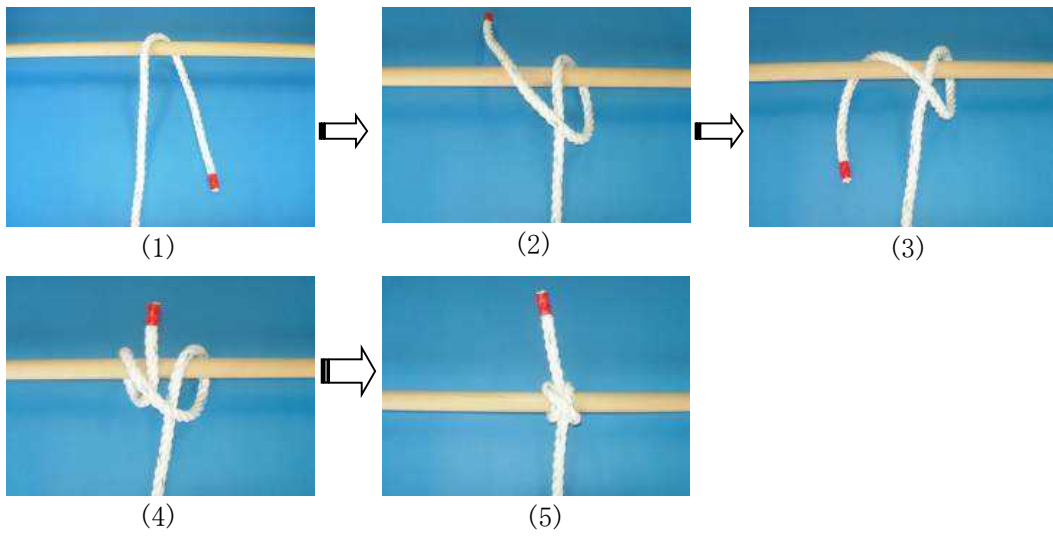
(3) Rope Tying Methods

- Sheet bend knot, double sheet bend knot: Also referred to as an Englishman's knot. This knot is used when tying the ends of two ropes of the same thickness. The knot does not easily come undone, and it is also used when sewing nets. When tying ropes with different thicknesses or ropes that tend to slip, a double sheet bend is used.

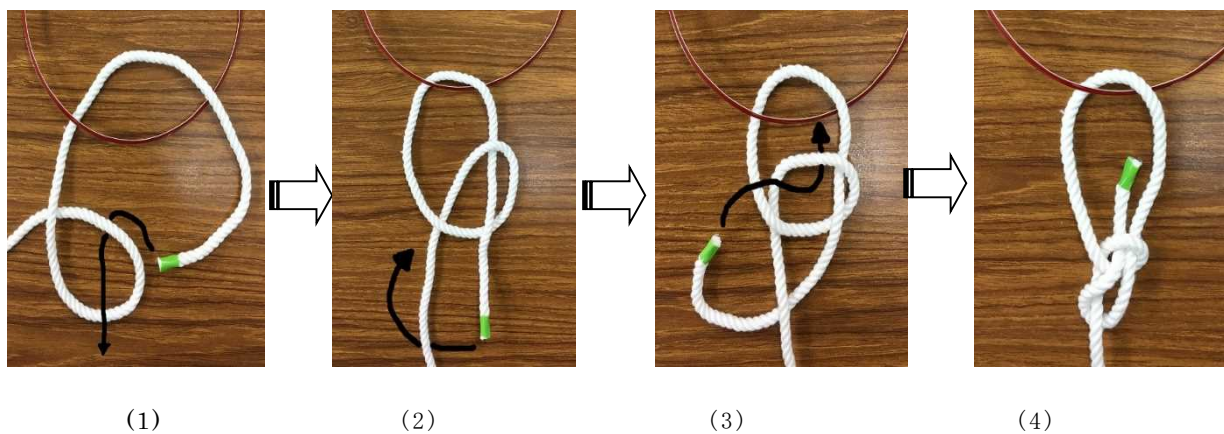
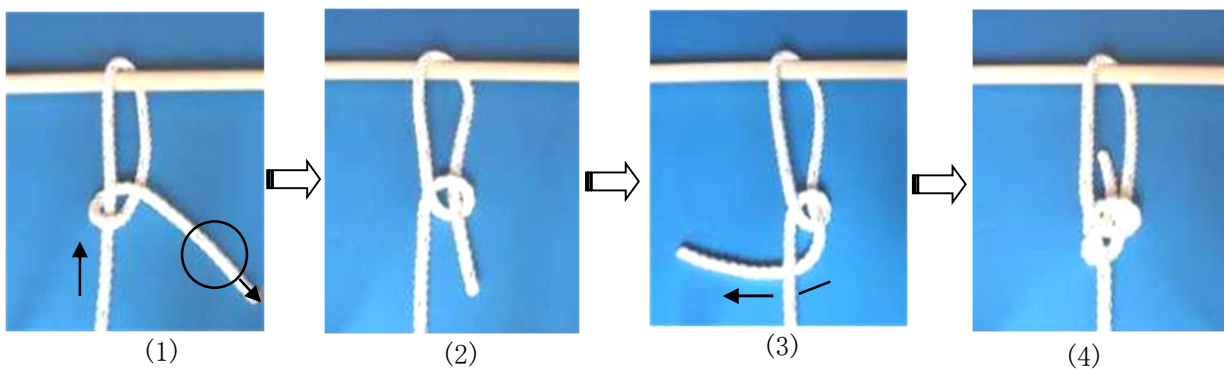
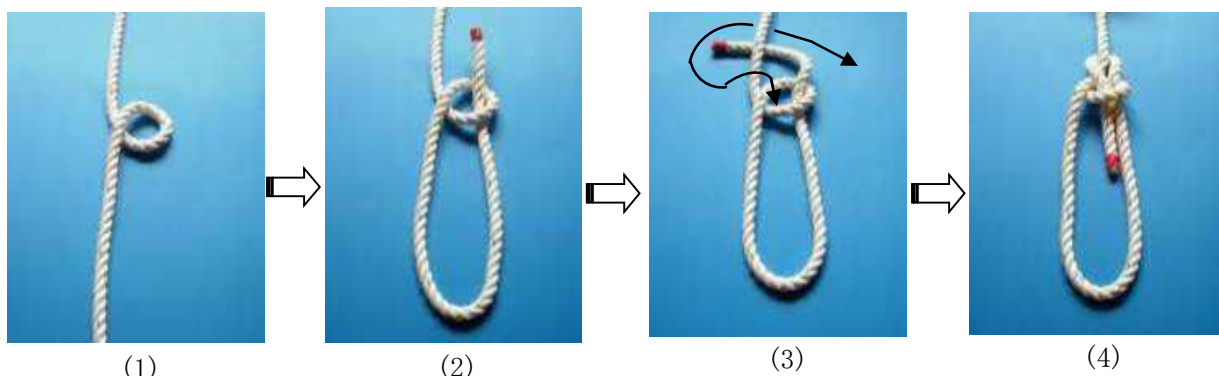


* The upper images show how to tie a sheet bend knot, and the lower images show a double sheet bend knot.

• Clove hitch: Used when tying the end of a rope to another object.



• Bowline knot: an important tying method used for applications such as anchoring. The process differs depending on whether the knot is being draped over an object or not.



- Anchor bend: this is a safe, dependable knot used in situations such as when tying a rope to an anchor and lowering it into the water.

