CHAPTER 1

Fish behaviour and light

A. Natural light – the sun

B. Natural light – the moon

C. Natural light – bioluminescence

D. Artificial light

E. How do marine organisms respond to light

All marine animals and plants depend on light for survival. Without light, photosynthesis cannot take place, and without photosynthesis there would be no food production. Sunlight, however, is limited to the upper 200 metres (m) (656 ft) of the water column in the sea, depending on the clarity of the water. This is the layer where photosynthesis takes place, and is called the photic zone ("photic" meaning light). Below this is the aphotic zone ("aphotic" meaning no light), where very little or no light penetrates and so photosynthesis cannot take place. Most marine species live in the photic zone. Many marine species also live in the aphotic zone but they depend on food from the photic zone to survive.

Most marine animals also depend on sight to survive. Fish and squid, for example, have very keen senses of vision, which helps them to find food, shelter, mates, and to avoid predators. Like humans, many fish can see colours, and some can see in extremely dim light. Squid, on the other hand, cannot see colour. Fish and squid that live in deep water have big eyes. Nocturnal fish (those that are active at night) tend to have larger eyes then diurnal fish (those that are active during the day). Some fish have eyes that amplify light and glow at night when light hits them. This is why some fish eyes reflect light when a diver shines his light on them.

Besides photosynthesis, light has another very important role in the lives of marine organisms. Ambient light – the surrounding light in the environment – has a big influence on where and when marine animals eat and rest. Many marine species regularly spend daylight hours in deep water but come up to surface waters at night. Generally, fish and other marine animals feed at certain times of the day or night, usually at dawn and dusk – the two times of a day when ambient light is low.

Some species, particularly ones that live in very deep water, produce their own light to attract prey, attract mates, or frighten away predators, although this kind of light can also attract predators.

Marine animals respond to light in a variety of ways. Some scurry away from light while some may stop moving as soon as light hits them. Others crawl or swim toward a light and gather around it in great numbers. Marine animals also react differently to differing colours and intensities of light. Some, for example, cannot see anything that is red coloured. This is why some deep-sea species themselves are red in colour – so they cannot be seen by predators. It is also why deep-sea fishing gear is often dyed red –so the fish cannot see it.

Fishermen often use fish and squid (and other species) behaviour to increase their catch. They also concentrate their efforts during certain times of the day or during certain moon phases in order to catch fish that are affected by natural light. Fishermen often use artificial lights to catch fish that are attracted to light, and also use small lights attached to baited hooks or nets to mimic the light produced by baitfish species.

This manual discusses some methods and gear used for catching fish with light. Fishing methods that use light make fishing too easy and so may be banned in some Pacific Island countries. Fishermen who use light to increase their catch should always fish responsibly by reading and following the regulations and catch quota for the target species.

A. Natural light — the sun

The behaviour of fish and other marine animals varies with the time of the day. Most fishermen know that fishing is best in the morning just before and after sunrise, and at dusk just before and after sunset. This is when fish feed. At these times of the day when there is little natural light, baitfish and other prey species are more likely to be caught by fishermen or attacked by marine predators. This may be because they are in the process of descending or rising in the water column (see deep scattering layer below), or it may be that predators can see better than prey in the limited light conditions of dawn and dusk, which is when they feed. This in turn is when fishermen are most likely to catch predator fish species, such as tuna.

B. Natural light — the moon

Like the sun, the moon also affects fish behaviour. Ancient Polynesians knew that fishing was better just before and just after moonrise and moonset, and that the phases of the moon affected fishing. Part of the moon's influence may be due to its gravitational pull, which causes tides, and which is strongest during a full and new moon.

There is much less light during a new moon than during a full moon, and this affects the behaviour and catchability of marine species differently. For example, the best time to catch broadbill swordfish (*Xiphias gladius*) is around a full moon, while the best time to catch yellowfin tuna (*Thunnus albacores*) is around a new moon. The reasons for these differences are unknown. The catchability of other marine species is affected by moon phases as well. For example, lobster fishermen often concentrate their effort around the time of a new moon because they are more likely to catch them then.

Ancient Polynesians made fishing calendars based on seasons and moon phases. It was often forbidden (*kapu* or *tabu*) to fish in lagoons and on reef flats during times when fish were most likely to be caught. These *kapus* were usually just before a full moon; just before, during and after a new moon; and during the last quarter of a moon, which amounted to about 10 days out of a month when fishing was not allowed. There were no restrictions during other times of the month.

C. Natural light — bioluminescence

Bioluminescence is a light that is produced by a chemical reaction within certain marine organisms. Squid, fish and bacteria emit bioluminescence to:

- see at night,
- communicate,
- attract prey,
- attract a mate, or
- repel predators.

In the very deep sea, bioluminescent light is the only light there is.

D. Artificial light

Artificial (or human-made) light is often used to find or attract fish. Fishermen long ago used the light from torches to find or attract fish and other marine species. Ancient Polynesians used torches made from bamboo or the nuts from the candlenut tree to light up the lagoon bottom and reef flats while they searched for fish, lobsters and octopus. Modern-day Pacific Island fishermen use kerosene, gas or electric lanterns. Underwater torches (flashlights) are used by divers to find nocturnal animals such as lobsters and certain fish. Many species of lagoon and reef fish sleep at night and are easy prey for divers armed with a torch and a spear. This type of fishing may not be allowed in some countries (always check the fishing regulations for your island). Light can also be used from a boat to attract fish to a baited hook, or to a net.

Artificial light at night attracts and aggregates fish and squid because it mimics light produced by bioluminescent marine animals. For example, chemical light sticks are often used to attract swordfish to pelagic longlines. The bait used in the swordfish fishery is generally dead squid or finfish that can no longer emit bioluminescent light. The light sticks mimic the light that the bait species usually produces. Some large commercial fishing boats use light to attract small pelagic fish or squid that are then harvested from the boat with nets or mechanised fishing rigs that use multiple lures. Fish can also be lured to a boat with underwater lights that are submerged several metres below the boat or over a net. These lights attract fish that can be netted or caught with a hook and line.

E. How do marine organisms respond to light?

Photomovement

Photomovement refers to the way an animal moves in response to light. In the sea, there are four main types of movements that marine animals make: 1) they form a group or cluster called an aggregation; 2) they freeze or continue to move until they no longer sense light (called photokinesis); they move either away or toward a light source (called phototaxis); or they move up and down in the water column throughout the day (called vertical diurnal migration). These are explained in greater detail in the text box entitled "How fish and other marine animals move in response to light".

General fishing methods using light to attract fish and other marine animals

Torch fishing

- Hawaiian torch fishing in lagoons and on reef flats
- Fishing with a lantern and a "look box"

Night diving

- Skin diving with a torch
- Scuba diving with a torch

How fish and other marine animals move in response to light

Aggregation

A fish aggregation is a mass grouping of fish. Fish come together to form an aggregation in order to feed and spawn, and as protection against predators. It is not known why light causes fish to aggregate, but it may be because light attracts very small organisms – called plankton – that the fish feed on, or the fish may be attracted to larger organisms that feed on the plankton. Once fish form an aggregation, they can easily be caught using lures, baited hooks or nets.

Photokinesis – positive and negative

Photokinesis is the way a marine animal moves in response to light. Positive photokinesis is when light causes an animal to move until there is no more light, or until it arrives in a dark place. The animal does not move away from or toward the light, it moves randomly until it is out of the light. Negative photokinesis is when a moving animal in the dark stops when it is hit by light. This behaviour is used by skin and scuba divers to easily spear or grab fish and lobsters while night diving.

Phototaxis – positive and negative

Phototaxis is when a marine animal moves toward or away from light. If the movement is toward light it is called positive phototaxis, and if it is away from light it is called negative phototaxis. Positive phototaxis is what initially causes marine organisms to aggregate around a light source. They move toward the light and then stay in the vicinity of the light source after arriving there. Positive phototaxis may also cause large pelagic fish to move in the direction of a chemical or electric light stick.

Vertical diurnal migration – the deep scattering layer

Large aggregations of marine animals migrate vertically in the water column daily. During the day, they are in deep water (below 200 m [656 ft]) where there is little or no light. At night, they come toward the surface where there is also little light. In other words, they prefer to stay in the dark. This area is called the deep scattering layer or DSC. Certain large pelagic fish, such as bigeye tuna and broadbill swordfish, follow DSC daily. Fishermen take advantage of this diurnal behaviour by fishing for bigeye tuna in deep water during the day, and fishing for swordfish nearer the surface at night.

Using lights on a boat

- Poti marara fishing for flyingfish
- Net fishing for saury
- Squid fishing

Using underwater lights from a boat

- Ika shibi fishing
- Bait fishing for pole-and-line fishing

Using lights on longlines

- Cuban-style swordfish fishing with kerosene lamps
- Cyalume light sticks for tuna and swordfish
- Electrolume LED lights for tuna and swordfish

Choosing the right equipment

- Liquid fuel lamps
- Gas powered lamps
- Electric lamps
- Electric underwater lights
- Batteries
- Colour
- Intensity

Responsible fishing with lights

- Comply with regulations
- Avoid disturbing non-target species
- Avoid bycatch
- Do not discard used light sticks or batteries into the sea
- Avoid using lights near sea turtle nesting beaches
- Avoid fishing on spawning aggregations