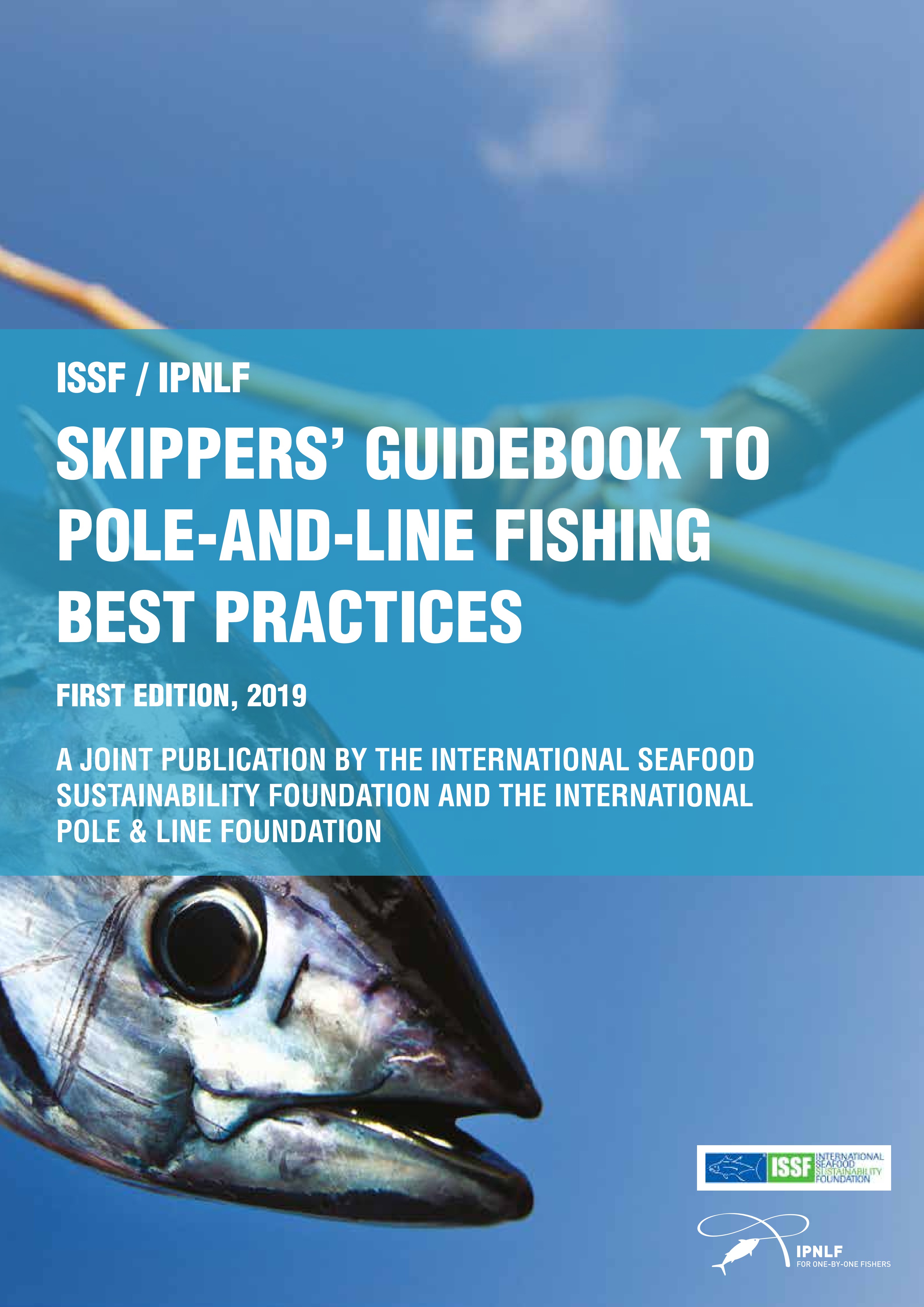

ISSF / IPNLF

SKIPPERS' GUIDEBOOK TO POLE-AND-LINE FISHING BEST PRACTICES

FIRST EDITION, 2019

A JOINT PUBLICATION BY THE INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION AND THE INTERNATIONAL POLE & LINE FOUNDATION

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

IPNLF FOR ONE-BY-ONE FISHERS

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Indonesia © IPNLF

ABBREVIATIONS USED IN THIS REPORT

aFADs: anchored fish aggregating devices

CPUE: catch per unit of effort

dFADs: drifting fish aggregating devices

ETP species: endangered, threatened or protected (ETP) species

EEZ: Exclusive Economic Zone

FADs: fish aggregating devices

GRT: gross registered tonnage

IMO: International Maritime Organization

IPNLF: International Pole & Line Foundation

ISSF: International Seafood Sustainability Foundation

NMI: Nano-Multi-Ice

RFMOs: Regional Fisheries Management Organizations

RSW: refrigerated seawater

t/yr: tonnes per year

ULT: ultra-low temperature

WCPFC: Western and Central Pacific Fisheries Commission

WWF: World Wildlife Fund

Maldives © IPNLF


St Helena © IPNLF

Chapter 1: Introduction

Welcome to the guide to best practices in pole-and-line tuna fishing. Our goals with this publication are:

- To share the knowledge on the pole-and-line fishing technique, which is receiving attention as an ecologically responsible method for tuna fishing that often delivers social benefits to coastal communities connected to them.
- To provide a summary of good practices to avoid, or at least minimize, the environmental impacts of these fisheries.

About ISSF

ISSF is a global coalition of scientists, the tuna industry, and World Wildlife Fund (WWF) — the world's leading conservation organization. ISSF promotes science-based initiatives for the long-term conservation and sustainable use of tuna stocks, reducing bycatch and promoting ecosystem health.

ISSF offers customized sustainability outreach programs and materials for skippers in purse seine, longline, and pole-and-line fleets. It also has a guidebook for observers on purse seine vessels.

ISSF also:

- Conducts scientific research to inform tuna companies, Regional Fisheries Management Organizations (RFMOs), fishing vessels, and other groups.
- Recommends fishing policies and sustainable practices to RFMOs and their member nations.
- Develops conservation measures and tracks and reports participating companies' compliance.

To learn more, visit ISSF online:

ISSF website

About IPNLF

The International Pole & Line Foundation (IPNLF) works to develop, support and promote socially and environmentally responsible pole-and-line, handline and troll tuna fisheries around the world. IPNLF's ambition is to contribute to thriving coastal fisheries, including the people, communities, businesses and seas connected with them. IPNLF is an international charity working across science, policy and the seafood sector that uses the influence of the market to develop and demonstrate the value of one-by-one caught tuna to thriving coastal fisheries, and the people and seas they connect. IPNLF officially registered as a charity in the UK in early 2012.

To learn more, visit IPNLF online:

IPNLF website

Picture 1. Pole-and-line-tuna fishing in Bitung, Indonesia, 2015 (Photo: P. Hilton & IPNLF)

About Pole-and-Line Fishing

Pole-and-line fishing is a simple approach where tuna are caught one-by-one using a hook attached to a line and pole. This fishing gear has gained increasing attention in recent years as a responsible method of harvesting tuna. Although this fishing gear makes a small contribution to global tuna catches — currently estimated at 9% of global tuna landings — growing consumer awareness about the sustainability of seafood resources is raising the demand for pole-and-line caught tuna.

Pole-and-line fisheries operate around the world, typically targeting skipjack and albacore tuna. Some are technologically advanced commercial operations while some are more artisanal in nature (Picture 1). Regardless of size, pole-and-line fisheries share common characteristics, including operating techniques and environmental impacts.

While the environmental and social benefits of pole-and-line are widely lauded, like any fishing method, they can be improved further. This guidebook focuses on tuna and livebait fishing operations, from capture to handling and storage methods, all of which can reduce unnecessary waste of both tuna and baitfish harvested within these fisheries.

Sustainability of Pole-and-Line Fishing

- **Bycatch**

Pole-and-line fishing is a very selective technique, with very low levels of bycatch compared to other major tuna fishing methods (Miller et al. 2017b). Studies into the interactions between pole-and-line fisheries and endangered, threatened or protected (ETP) species (Cruz et al. 2016; Miller et al. 2017b) indicate that these fisheries have the lowest interaction rate compared to other commercial tuna fishing gears.

- **Fuel efficiency and carbon emissions**

Current concern about climate change has drawn attention to the energy efficiency of the fishing industry. Different studies have shown varied results regarding the fuel efficiency of pole-and-line vessels that have depended on the fishing strategies employed and the species being targeted. For example, Miller et al. (2017a) recently estimated a lower value for the Maldivian pole-and-line fishery relative to purse seine fisheries which target skipjack, whereas Tydemers and Parker (2012) found pole-and-line vessels, targeting albacore and bluefin tuna in Spain, to be less fuel efficient than purse seiners per tonne of catch. It is important to consider the fuel efficiency and carbon footprint of fishing vessels, and this guidebook aims to address this by identifying fishing strategies that minimize fuel consumption.

- **Baitfish sustainability**

A key aspect of pole-and-line fishing is that it requires live baitfish to attract tuna schools. In general, it is recognized that small baitfish species such as the ones used in the pole-and-line fishery, are highly fecund with rapid growth and high turnover rates and therefore have a high resilience to fishing pressure. While the drivers of baitfish population changes may not be fully understood, it is important for pole-and-line fisheries to contribute to the monitoring of bait stocks, especially in cases where these stocks are being used for multiple purposes (e.g. human consumption, fish meal, etc.) in order to facilitate their management as needed.

Transparency and Traceability Initiatives for Pole-and-Line Fisheries

Data regarding who, what, when, where, and how seafood is caught determines whether it was done so legally and sustainably. Increasingly, markets are requiring such information and a number of tools have been developed to provide it. Traceability enables food products to be closely tracked forwards and backwards through the supply chain (from harvest to consumer), while transparency provides information on the methods and practices involved in bringing a product from source to market. Both traceability and transparency are needed. The range of traceability and transparency tools available to fisheries continues to grow, providing many opportunities for small to medium-scale pole-and-line operations around the world. Examples include:

- ProActive Vessel Register (PVR): An initiative by ISSF as a way for vessel owners to identify themselves as active participants in meaningful sustainability efforts. The PVR provides third-party validated information to tuna purchasers of the positive steps each vessel is taking in implementing a series of commitments designed to bring responsible practices to tuna fishing.
- Fisheries Information System (FIS): A web-enabled database / traceability system used in the Maldives that integrates vessel licensing information, logbook catch data, fish purchase data, and processor lot numbers to generate official catch certificates for export. FIS makes some of its high-level data accessible to Trace Register, allowing suppliers, retailers, and consumers to access important traceability information.
- FishPanel: A vessel registry system for Indonesian pole-and-line and handline vessels. Via a mobile-enabled web application, vessels can be audited at the quayside or at sea, enabling vessel details and supporting documents to be checked against a vessel database.
- ThisFish: A traceability tool that offers harvesters, processors and buyers a way to supply their customers with trusted, verifiable product information. Fish harvesters use an online traceability tool to upload their catch information, including the unique codes that follow products through the supply chain and are ultimately used by consumers to trace their catch.
- Trace Register: Links information from source of catch all the way through the supply chain as products undergo changes in product form, location and ownership to provide the complete product story. Trace Register makes it possible to link logistics and transaction data plus documents throughout the supply chain.

In addition, it is becoming increasingly important for fishing vessels to have unique identifiers that do not change with a change in ownership or flag. The IMO (International Maritime Organization) number is the most widely used unique vessel identifier in the world. But IMO numbers are generally only issued for larger vessels or smaller vessels that fish in the high seas or in more than one EEZ. For smaller tuna fishing vessels that do not qualify for an IMO number, it is key that vessels register with local authorities in line with domestic regulations. In addition, ISSF offers the possibility of issuing an ISSF unique vessel identifier.

About the Pole-and-Line Skippers Guidebook

This guidebook was written for pole-and-line skippers by fishers, marine scientists and managers who have expertise in the pole-and-line fishing method. It is published jointly by the International Seafood Sustainability Foundation (ISSF) and the International Pole & Line Foundation (IPNLF).

The guidebook covers these topics:

- Tuna species targeted by pole-and-line fisheries
- Fishing operations in pole-and-line tuna fishing
- Tuna catch handling and storage
- Baitfish management in pole-and-line fisheries
- Tuna baitfish species and fishing methods
- Tuna baitfish best practices for capture and utilization

Maldives © Monika Flueckiger

Chapter 2: Target Tuna Species in Pole-and-Line Fishing

Tuna fishing by pole-and-line gear originated independently in different cultures, from the Pacific and Indian Ocean Islands to the Eastern Atlantic Ocean coastal regions. Nowadays, the range of tuna species caught by pole-and-line vessels mainly depends on the latitude where fishing operations take place. The end markets, the evolution of vessel designs, and fishing techniques employed in different parts of the world, also influence the final targeted species of these fisheries.

Chapter Objectives

1. Summarize the main target tuna species in pole-and-line fishing by ocean and by country, along with annual catch estimates.
2. Briefly describe those tuna species targeted by the pole-and-line fishery.

Overview

The target species of pole-and-line fisheries are surface swimming skipjack and younger age classes of yellowfin, albacore and bigeye tuna. Specifically, current tuna pole-and-line fisheries mainly target:

- Skipjack tuna in tropical waters, taking smaller proportions of yellowfin and bigeye tuna
- Albacore and bluefin tuna and some seasonal (summer) skipjack at higher latitude fisheries

Table 1 is a compilation of information from various sources on estimated annual tuna production from the most significant pole-and-line fisheries spread throughout the Indian, Pacific and Atlantic Oceans, sorted by country; where the main targeted tuna species are also specified.

From Table 1 it can be seen that skipjack and yellowfin are the main target species in both the Pacific and Indian Oceans. In the Atlantic Ocean, these two species also represent the main catch of pole-and-line fleets in the west, while the east fisheries target temperate tunas in addition to the tropical tunas.

Regarding catch levels, annual pole-and-line landings for the period of 2011-2016 were estimated to be approximately 360,500 t/yr, which roughly represents close to 9% of total global tuna catch. These estimates attribute almost 75% of global catches to Japan (100,000 t/yr), Indonesia (90,000 t/yr), and the Maldives (76,000 t/yr). Brazil and Senegal represent other important pole-and-line fleets whose annual landings have been estimated at 25,000 and 14,000 t/yr respectively. The remaining catch is landed by many smaller domestic fisheries spread throughout the Indian, Pacific and Atlantic Oceans (Table 1).

Tuna Species

Five species of tunas are of major commercial importance in pole-and-line fishing on a global scale. Due to differences in their distributions, the species are generally classified as "temperate" or "tropical."

- The **tropical tunas** are **skipjack** and **yellowfin** because they are found in waters with temperatures greater than 18°C, although they can dive into colder waters.
- **Bigeye** could be classified as **intermediate** but is often treated as a tropical species in fishery statistics.
- The **temperate** tunas are **bluefin** (3 species) and **albacore** since they are found in waters as cold as 10°C, although can also be found in tropical waters.

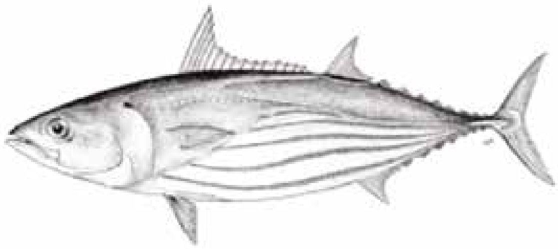
Table 1. Target species and estimates of annual tuna catches for the 2011-2016 period in the main pole-and-line fisheries of the world (t/yr = tonnes per year)

Ocean	Country / Area	Target species	Pole-and-line landings (t/yr)	Source
Western and Central Pacific Ocean	Japan	Skipjack and albacore	100,000	Uosaki et al. (2015), OFP (2016), McCoy (2014), Gillett (2016)
	Indonesia	Skipjack, yellowfin and bigeye	90,000	Williams and Terewasi (2015), Lewis (2015), Anon (2015), Gillett (2016)
	Solomon Islands	Skipjack and yellowfin	1,300	MFMR (2015), OFP (2016), Gillett (2016)
	French Polynesia	Skipjack and yellowfin	400	OFP (2016)
	USA Hawaii	Skipjack (domestic fresh market)	200	Gillett (2016)
	Palau	Skipjack	100	BOFM (2015), Gillett (2016)
Eastern Pacific Ocean	USA West Coast	Large yellowfin and albacore seasonally	7,000	Gillett (2016)
	Ecuador	Skipjack and yellowfin	650	Scott (2014), Gillett (2016)
Indian Ocean	Maldives	Skipjack and yellowfin	76,000	Adam et al. (2014), Gillett (2016)
	India Lakshadweep	Skipjack and yellowfin	13,500	Gillett (2016)
Eastern Atlantic Ocean	Senegal	Skipjack, yellowfin and bigeye	14,000	Hickman (2015), Gillett (2016)
	Spain Canary Islands	Albacore and seasonally bluefin, yellowfin, bigeye and skipjack	8,000	ICCAT (2015), Gillett (2016)
	Portugal Azores Islands	Albacore and seasonally bluefin, yellowfin, bigeye and skipjack	6,000	Pham et al. (2013), Gillett (2016)
	Spain Basque Country and Cantabria	Albacore and bluefin	5,000	Gillett (2016)
	Ghana	Albacore and seasonally bluefin, yellowfin, bigeye and skipjack	4,300	Gillett (2016)
	South Africa	Albacore	3,400	West et al. (2014), Gillett (2016)
	Namibia	Albacore	2,500	Gillett (2016)
	Portugal Madeira	Albacore and seasonally bluefin, yellowfin, bigeye and skipjack	2,000	Gillett (2016)
	France Basque Country	Albacore and Bluefin	80	Gillett (2016)
	Cape Verde	Albacore and seasonally bluefin, yellowfin, bigeye and skipjack	80	Gillett (2016)
Western Atlantic Ocean	Brazil	Skipjack and yellowfin	25,000	ICCAT (2015), Gillett (2016)
	Venezuela	Yellowfin	1,000	Gillett (2016)
Total			**360,510**	

Skipjack (*Katsuwonus pelamis*)

These tunas are highly migratory and are found mainly in the tropical areas of the Atlantic, Indian, and Pacific Oceans. Their geographic limits are 55–60°N and 45–50°S, with their greatest abundance in equatorial waters. This species usually swims near the surface and exhibits a strong tendency to school by size (Picture 2). Large schools of adult skipjack tuna often mix with albacore and juvenile yellowfin and bigeye tuna. Skipjack form both free-swimming schools and schools associated with floating objects and are the principal species associated with fish aggregating devices (FADs). Skipjack (Picture 3) are the smallest of the major commercial tuna species, with a common size range of 40 to 80 cm.

Picture 2. Schooling skipjack tuna (Photo: F. Forget)

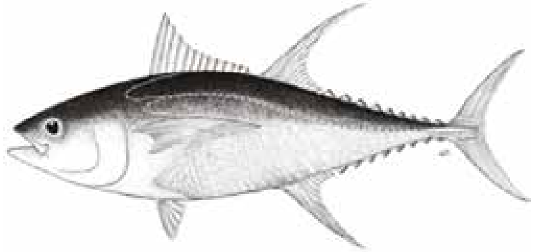


Picture 3. Skipjack tuna (courtesy of Fisheries and Aquaculture Department/FAO)

Yellowfin (*Thunnus albacares*)

Yellowfin are found in the tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans, between 40°N and 40°S, although in the Pacific they occur mainly within 20° of the Equator. Yellowfin form both free-swimming and associated schools, with adults generally forming schools of similarly sized individuals (Picture 4). The free-swimming schools tend to contain large individuals and comprise yellowfin only. As for juveniles, they can form schools with skipjack and juvenile bigeye tuna. These mixed schools may also occur in association with floating objects. Yellowfin tuna (Picture 5) are among the larger tuna species and generally reach sizes similar to those of bigeye, with a common range of 40 to 150 cm.

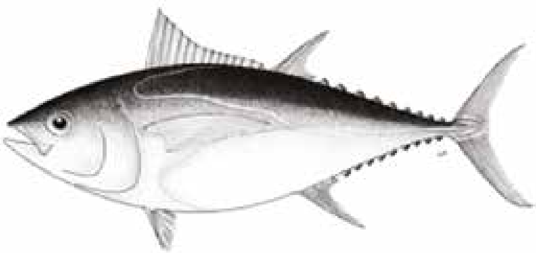
Picture 4. Schooling yellowfin (Photo: D. Itano)



Picture 5. Yellowfin tuna (courtesy of Fisheries and Aquaculture Department/FAO)

Bigeye (*Thunnus obesus*)

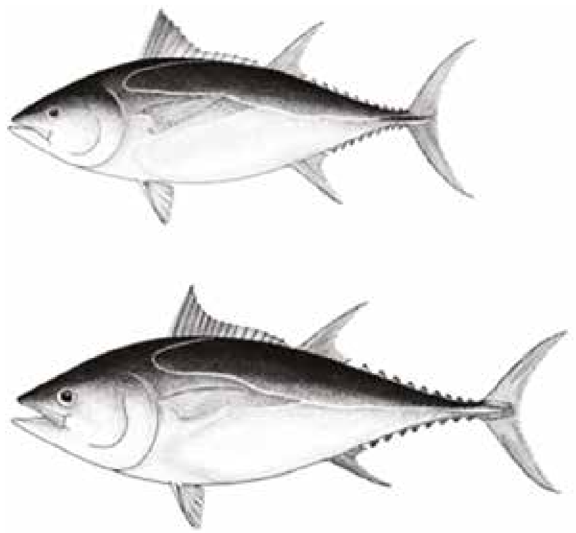
Bigeye are found in the subtropical and tropical areas of the Atlantic (but not the Mediterranean), Indian, and Pacific Oceans. Their geographical limits range from 55–60°N to 45–50°S. Juveniles and reproductively active adults are found in equatorial waters as well as at higher latitudes. Bigeye rarely form free-swimming schools and are usually associated with floating objects as juveniles. Small bigeye can form schools with juvenile yellowfin and skipjack tunas. They can reach similar maximum sizes to those of yellowfin (over 200 cm). Individuals as large as 150 cm occur in some fisheries, but it is common to find the size range down to 40 cm (Picture 6).



Picture 6. Bigeye tuna (courtesy of Fisheries and Aquaculture Department/FAO)

Bluefin tuna (*Thunnus spp.*)

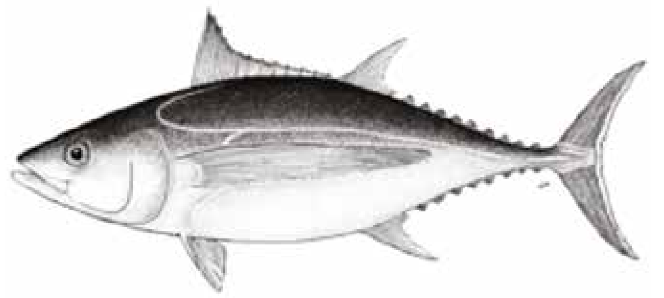
Bluefin is the common name used to refer the group comprised of three different temperate water species of the genus *Thunnus* (Picture 7). They are found in tropical, subtropical and temperate waters and have the widest geographical distribution of all tunas: Atlantic bluefin (*T. thynnus*) in the North and South Atlantic Oceans, including the Mediterranean; Pacific bluefin (*T. orientalis*) is found mainly in the North Pacific Ocean but ranges into the South Pacific, from the East Asian coast to the western coast of North America and south to New Zealand and French Polynesia, although it also spawns in tropical waters and seasonally comes close to the shore; and Southern bluefin (*T. maccoyii*) occurs throughout the Atlantic, Pacific and Indian Oceans, in temperate and cold seas, mainly between 30°–50°S to nearly 60°S. They are all highly migratory species and travel long distances between juvenile rearing, feeding and spawning grounds, tending to school by size, sometimes with other tuna species. Bluefin are the largest of tuna species that can reach three meters in length, although the common size ranges 80–200 cm.



Picture 7. Southern (top) and Pacific/Atlantic (bottom) bluefin tunas (courtesy of Fisheries and Aquaculture Department/FAO)

Albacore tuna (*Thunnus alalunga*)

Albacore is a temperate species widely distributed in temperate and tropical waters throughout all oceans and the Mediterranean Sea. It ranges from 5°N to 40°S in the Indian Ocean, and from 45–50°N and 30–40°S in the Atlantic Ocean. Albacore tuna tend to travel in single species schools and their association with floating objects is not common. They are also one of the smaller tuna species (40–100 cm length), generally larger than skipjack, but smaller than yellowfin tuna (Picture 8).



Picture 8. Albacore tuna (courtesy of Fisheries and Aquaculture Department/FAO)

Maldives © Woolworths South Africa

Chapter 3: Tuna Fishing Operations

Pole-and-line fishing, also known as "baitboat fishing", is a simple fishing technique based on the use of a pole (bamboo, fiberglass or carbon fiber) attached to a short line with a barbless hook (a lure or baited) to catch tuna one-by-one. Although there are several vessel configurations and fishing techniques, there are some common features to all pole-and-line fisheries in the world:

- When a school of target fish is located, live baitfish are scattered onto the surface of the water (chumming), to create a feeding frenzy.
- The fishing area is sprayed with water to obscure the fishing line and the hook and further excite tuna, creating the illusion and sound of a large school of small fish near the surface.

Therefore, there are three key stages of pole-and-line fishing operations: school locating, chumming of baitfish/water spraying, and poling the fish.

Chapter Objectives

1. Summarize the strategies for locating different types of tuna schools.
2. Outline some considerations for tuna fishing depending on the school type.
3. Introduce the concept and role of chumming in pole-and-line fishing.
4. Review the importance of water spray or splashing during pole-and-line fishing.
5. Highlight important safety recommendations for pole-and-line fishers.

Identification of Tuna Schools

Free-swimming schools

Schools of tuna found in the open ocean and not associated with any structure or floating object are called "free" or "un-associated" schools. In fact, free-swimming schools are often chasing wild baitfish of some kind so their location is usually indicated by the presence of seabirds (Picture 9) or by jumping and rolling tuna that are feeding on wild baitfish (Picture 10).

Picture 9. A breezing/splashing surface school of tuna indicated by birds and a rough appearance on the sea surface (Photo: D. Itano)

Picture 10. Pole-and-line boat approaching a "boiler" surface school of tuna actively feeding on wild baitfish with water sprayers activated (Photo: D. Itano)

- In the case of feeding free-swimming schools marked by a **flock of seabirds**, the size and species of bird provide important clues about the size of the wild baitfish and the species of tuna underneath. Practical knowledge of seabird species and behavior is a key component of a successful pole-and-line fishing operation. Free-swimming schools may be detected from long distances using binoculars (of various range) and bird detecting radar (Picture 11).

Picture 11. Image of a Maldivian pole-and-line tuna fishing vessel with bird radar installed, 2017 (Photo: IPNLF)

- As for tuna schools that are visible by their **feeding activity**, experienced fishers are able to characterize the type of tuna school based on how visible the tuna are and how actively they are feeding. Consequently, the fishing strategy will vary depending on how fast a school is moving and if it is close enough to the surface to respond to chumming. Typical school-type descriptions include **subsurface**, **breezer**, **jumper**, **boiler** and **foamer** (Scott and Flittner 1972).

1) Subsurface schools: those schools that are not visible at all but may be indicated by birds or located using sonar or echo sounder gear.
2) Breezer schools: the presence of tuna is indicated by a rippling on the surface, caused by fish swimming sub-surface in the same direction. This situation signals very often the presence of large schools.
3) Jumper schools: single fish jump out of the water and dive headfirst, possibly as a consequence of feeding.
4) Boiler or foamer: this term is used when the preceding situation becomes highly accentuated and is usually caused by tuna actively preying on surface concentrations of baitfish, small juvenile tuna or euphausiids. Even from a distance the fish can be seen to churn the water in a disorderly fashion causing the water to foam white.

Sometimes a non-feeding surface breezer or jumper school will respond better to chumming and poling than actively feeding boiler or foamer schools.

If feeding activity is noted in the chum line, the vessel is slowed down or put in neutral, sprayers are engaged, and chumming is increased. The objective is to attract the school and bring it close to the spraying water so to retain the school close enough to the vessel that they can be poled onto the deck.

Associated schools

- **Logs, anchored and drifting FADs**

Tuna are naturally attracted to any floating object in the open ocean (Picture 12) — whether natural (such as a log or dead floating whale), or man-made (like a wooden palette or a pile of discarded rope). Some pole-and-line vessels utilize floating objects to achieve more productive fishing and some fisheries depend almost entirely on anchored FADs (aFADs). With large numbers of drifting FADs (dFADs) set by purse seine fleets in most tropical regions, they can drift into EEZs and thus provide fishing opportunities to coastal pole-and-line fishers. However, there are also environmental and fishery impacts associated with dFADs which must be addressed. All fishing gears need to be properly monitored and managed.

Picture 12. Natural log found free drifting with an associated tuna school (Photo: D. Itano)

- When these objects are specially designed to attract tuna and are not tethered to the bottom of the ocean, they are called drifting fish aggregation devices (dFADs). dFADs can be a man-made object as well as any natural floating object that has a structure added to them.

- dFADs usually consist of a surface raft or float and some underwater structure, such as old netting, rope, or natural material like palm fronds or leaves.
- A satellite buoy that reports information to the fishers like GPS position, drift speed, water temperature and battery state is usually attached to dFADs (Picture 13).
- In recent years, the use of satellite buoys equipped with an echo-sounder or sonar-like function that gives an estimate of the aggregated biomass underneath the FAD have become popular with purse seine vessels.
- dFADS are commonly used in purse seine fisheries but much less frequently in pole-and-line fisheries. However, some pole and line vessels in West Africa also use dFADs.

- **Anchored FADs**

Rafts or floats can be moored to the bottom and aggregate pelagic fish to assist fisheries. Deployment sites for aggregating tuna are often in depths exceeding 2,000 m.

Anchored FADs have been set in many areas specifically to benefit pole-and-line fisheries, e.g., the Solomon Islands, Indonesia and the Maldives (Picture 14). In the case of the Maldives, an anchored FAD-array has proven to be indispensable in increasing pole-and-line catch while decreasing vessel search time and carbon footprint.

Picture 13. Free drifting FAD set to attract tuna with GPS buoy attached (Photo: ISSF/2015, D. Itano)

Picture 14. Maldives pole-and-line vessels fishing from an anchored FAD, 2016 (Photo: IPNLF)

- **Other aggregation types**

Skipjack, yellowfin and bigeye tuna sometimes associate with large, slow-moving animals such as whale sharks and manta rays. In some regions, this kind of school is considered to be like a FAD-associated school, whereas in other regions they are seen as more similar to free-swimming schools.

Tuna fishing can also be highly productive close to isolated seamounts, reefs, and small oceanic islands.

Fishing Strategy

Free-swimming schools

The strategy to fish a moving tuna school should follow a series of recommendations:

- When a free-swimming school is sighted, the vessel must attempt to intercept the lead portion of the school while considering the species behavior, wind speed/direction, currents, sea state, and speed and location of the school.
- Running through the school should be avoided at all costs (Figure 1), as that can cause the fish to sound into the depths only to surface some distance from the vessel.
- Birds can be a useful indicator of the speed and direction of the school, allowing the vessel to skirt around the edge and present a live chum line ahead of the lead fish.
- The objective is to intercept a moving school and bring it to feed at the boat, not to run the school over.

The technique varies depending on school type:

- **Breezing and splashing schools** often respond well to chumming and can be effectively fished with a suitable baitfish species.
- **Actively boiling or foaming schools** can be very difficult to stop and be successfully fished due to the abundance of wild baitfish. The captain must evaluate his options and use the limited baitfish supplies onboard to greatest advantage.

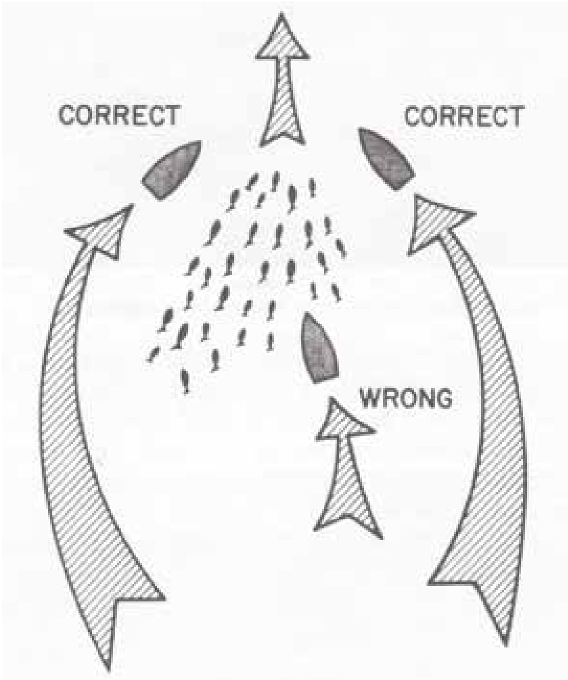


Figure 1. Correct approach and chumming strategy to fish a moving tuna school (from Ben-Yami, 1980)

Floating object-associated schools

Fishing on a floating object is very different from fishing on a free-swimming school. Tuna schools often hold up-current of an anchored FAD but may be down-current or located at some distance from a floating object. Using a sonar or echo sounder can assist with school location and chumming strategy. Additionally, the activity of birds, visual cues, or trial and error can help locate the fish.

In this type of fishing, consideration also needs to be given to other vessels due to limited maneuvering and fishing area around the floating object. As a general rule, vessels approaching a FAD should give way to a vessel already fishing the object, and thereafter they should take turns making drifts or approaches (Picture 15).

Picture 15. Fishing can become crowded and contentious when vessels compete for the best area close to an anchored FAD (Photo: D. Itano)

Other aggregation types

In the case of tuna associations with whale sharks, dolphins, whales, etc. casting livebait ahead or to the side of the animal(s) can produce a strong biting response from associated tuna schools.

However, fishing in close association with cetaceans, whale sharks or manta rays may be subject to restrictions, so fishers need to consult locally applicable regulations. It is also crucial to take special care in this kind of fishing to stay clear of the animals and avoid collision during fishing operations.

Chumming

The chumming or throwing of livebait to keep the school within reach of the vessel is one of the most important components of pole-and-line tuna fishing.

- The primary chummer is often one of the most experienced crewmen on deck.
- The chummer must be constantly aware of his bait supplies, species composition, and baitfish behavior and size in relation to tuna size and biting response.
- His job is to create a positive biting response and keep the school under the spraying perimeter while using as little bait as necessary.
- Several deck arrangements exist, but the idea is for the chummer to have immediate access to the livebait. Some-

times a small quantity of livebait is transferred to the chummer from the livebait tanks / wells to chumming tanks or containers located within the reach of the chummer. The simplest bait tanks are self-contained wood or fiberglass boxes that can be moved to any location but must be manually filled with seawater (Picture 16).
- Unused baitfish that have been transferred to chumming tanks may be weak or dead. Purpose-built chum tanks that have access to pumped seawater can keep baitfish healthy for longer periods, reducing waste (Picture 17).

Picture 16. Live baitfish being transferred to a portable chumming tank on an Indonesian pole-and-line vessel (Photo: D. Itano)

Picture 17. Chumming livebait being held in a permanent bow chumming tank with seawater circulation (Photo: D. Itano)

Baitfish characteristics

The best tuna baitfish species are:

- Naturally attractive to tuna
- Often silvery colored
- Hardy in captivity
- Those that swim towards the boat and water spray when thrown into the ocean
- Small varieties, about 5–7 cm long

Other considerations:

- Sensitive species need to be handled with care to minimize handling injury and mortality.
- Baitfish that tend to swim away from the vessel are of low value, as the tuna school will follow them and quickly leave the fishing vessel.
  - These baitfish, however, may be effectively used if the chummer knows how to gently squeeze and stun the bait before release, causing them to spin on the surface within the perimeter of the spraying area.

Later chapters in this Guidebook will focus on best practices for maintenance and ecologically-responsible utilization of baitfish.

Water Spraying

Splashing water close to the fishing boat has been a standard practice since the beginning of pole-and-line fisheries. It is believed that the splashing sound resembles the sound of baitfish when they are chased by tuna and thus attracts them to the boat. On the other hand, water splashing or spraying creates a foamy surface, which serves to mask the vessel and fishers and hide the lures from view.

Whatever the reason, splashing and spraying the water surface enhances the biting response on the lures and helps to bring the school close to the fishing boat and fishers.

Manual splashing

- Artisanal pole-and-line fisheries have used various styles of wooden scoops to splash water around the fishing area.
- Fishers also use their poles to strike and splash the surface of the water to entice fish to strike their lures.

Mechanical spray

Modern pole-and-line vessels are equipped with high-pressure seawater lines that lead to spray nozzles mounted along the gunwale or hull where poling operations take place (Picture 18). Spray nozzles are regularly spaced to provide a complete coverage that roils the surface area accessible to the poles and lures.

- Simple nozzles can be made using PVC pipe, with the tips melted together and a small notch cut to create a fine spray pattern.
- More sophisticated nozzles are adjustable to spray volume and direction and can be shut off completely if that station is not needed.

Picture 18. Seawater spray system on a Spanish Basque pole-and-line vessel (Photo: I. Onandia)

Safety Considerations

Poling tuna is a potentially dangerous activity, especially when fish become unhooked during the haulback or a poler fails to control the fish in mid-air. There are some important considerations that should be taken into account:

- Fishers should not enter the lineup without adequate footwear, protective clothing, and a hardhat or helmet. Some hardhats are equipped with steel mesh or a plastic grid that covers the face to prevent injury from uncontrolled hooks (Picture 19).
- Polers need to consider their right- or left-hand poling preference when lining up and consistently bring fish onboard between themselves and their neighboring poler. High flipping or uncontrolled poling of fish should be discouraged.
- Fishers should never walk behind a line of polers within range of the poles and barbless lures.
- Many pole-and-line boats erect a temporary net or tarpaulin on deck to keep fish close to the storage holds and prevent accidental injury from airborne tuna.

Picture 19. Protective headgear and visor for pole-and-line fishing (Photo: H. Arrizabalaga)

Tuna fishing operations are characterized by the identification of schools and related fishing strategy, chumming, water spraying, and safety considerations. Evaluation of these different aspects could help improve operational effectiveness.

St Helena © IPNLF


Indonesia © Paul Hilton & IPNLF

Chapter 4: Catch Handling, Preservation and Quality Issues

Poor handling practices reduce the shelf life and texture of tuna flesh, resulting in poor quality fish, low prices, and poor market reputation. Gaining the greatest benefit and value from every tuna that is harvested should be the end goal of responsible and sustainability-focused fishers. Good handling should start from the time of catch to the landing point.

Chapter Objectives

1. Provide general considerations regarding catch handling and preservation procedures.
2. Summarize preventive measures and best practices to minimize capture damage during fishing operations and subsequent transfer of catch to storage holds.
3. Detail practical recommendations for fish storage according to available installations and equipment in different vessel types.

Overview

Fish quality is determined at each step between capture and unloading, which ultimately determines the shelf life and value of the catch. Responsible fishing should:

- Maximize the value of every harvested resource
- Minimize damage and spoilage

Here are some general considerations:

- Procedures for catch handling and preservation vary from doing little, other than washing the fish off and bleeding whole, to blast freezing catch to −40°C or colder, which preserves tuna at sashimi grade for extended periods.
- Careful handling and refrigeration can take advantage of the fact that pole-and-line gear captures tuna in a near perfect condition, one fish at a time with little or no fight time. Care should be taken to minimize bruising, skin abrasions, extended struggling on deck, and prolonged exposure to sun and highly saline brine solutions.
- Tuna are endothermic, meaning they can elevate their core body temperatures well above the temperature of the water in which they live. Excessive heat generated by struggling and stress can damage meat quality.

Poling and Landing Fish

Maximizing fish quality begins well before the first hook enters the water. To ensure fish quality during landing, it is necessary to take some preventive measures:

- The area where fish will be landed should be as free of angles, ledges, and obstructions as possible to reduce tuna bruising and damage during capture.
- A smooth vinyl tarpaulin or sheet can be spread across the landing area to reduce scratching, skin abrasions, and bruising (Picture 20 and Picture 21).

Picture 20. Landing area for poled tuna covered with a smooth vinyl tarp wetted with seawater (Photo: D. Itano)

Picture 21. On this pole-and-line boat, tuna is landed in a smooth, wetted area where crewmen stun each fish to minimize struggling before it is placed in a seawater and ice slurry (Photo: D. Itano)

- Bin boards and netting can be set up to keep the fish in desired areas of the work deck and also protect the chummer and bait handlers from being struck by flying tuna.
- The landing area for poled tuna should be as smooth as possible and ideally should be kept wet and cool with a saltwater deck hose.
- If poling heavier fish, have a gaffer standing by to help bring it onboard.

There are different techniques for landing tuna and reducing capture damage:

1. During the fishing operation, experienced polers can lift fish from the water and gently lay them on the deck, after which they can free the barbless lure with a flick of the pole.
2. Another technique often seen in albacore tuna fisheries is to "wing" poled tuna under one arm, unhook the fish, and gently deposit it onto the deck. This is also practiced in the Azorean pole-and-line fishery for skipjack.
3. However, both techniques can slow down catch rates. If the school is biting quickly, the fishers prefer to flick the fish off in mid-air to return their barbless lures to the water as quickly as possible. Obviously, the higher a tuna is poled, the harder it will land on deck which could have quality implications. Experienced polers are however able to land fish at a low angle or deposit them gently on the deck.
4. Japanese pole-and-line boats string a tarpaulin behind their fishers that acts as a cushioned landing pad (Picture 22 and Picture 23). The pad also uses gravity to direct catch to chutes or conveyor belts leading directly to refrigerated fish holds. Fish being landed on the foredeck of Japanese style vessels (bow poling), for example, flow by gravity to metal or fiberglass fish chutes and then directly into brine wells.

Catch Handling and Stowage

If tuna are landed onto hot, dry decks, they can develop elevated lactic acid levels and stress hormones that can reduce flesh quality, resulting in a lower market value.

When fish are landed on the boats, it is highly desirable that they can be placed on a cool, wetted deck and then dispatched, rinsed, and chilled as quickly as possible.

Depending on the vessel type, there are different ways to move fish to storage holds:

- The ideal setup uses gravity to move poled fish to iced or refrigerated holds after being landed on smooth or padded surfaces as described above.

Picture 22. Poling skipjack on a Japanese vessel onto tarp to prevent bruising (Photo: T. Kawamoto)

Picture 23. Skipjack flow by gravity to conveyor belt that transports fish directly to refrigerated brine well (Photo: T. Kawamoto)

Picture 24. Tuna can spoil quickly if allowed to remain on a dry deck for prolonged periods in tropical areas (Photo: D. Itano)

- On vessels that pole to a flat afterdeck, such as the larger Maldivian and Hawaiian-style vessels, gravity feeding into holds might not be possible and manual labor is used to move them to storage holds (Picture 24).
- Some vessels direct specific crewmen to dispatch tuna with a bat and transfer them immediately to iced or refrigerated well storage (Picture 25).

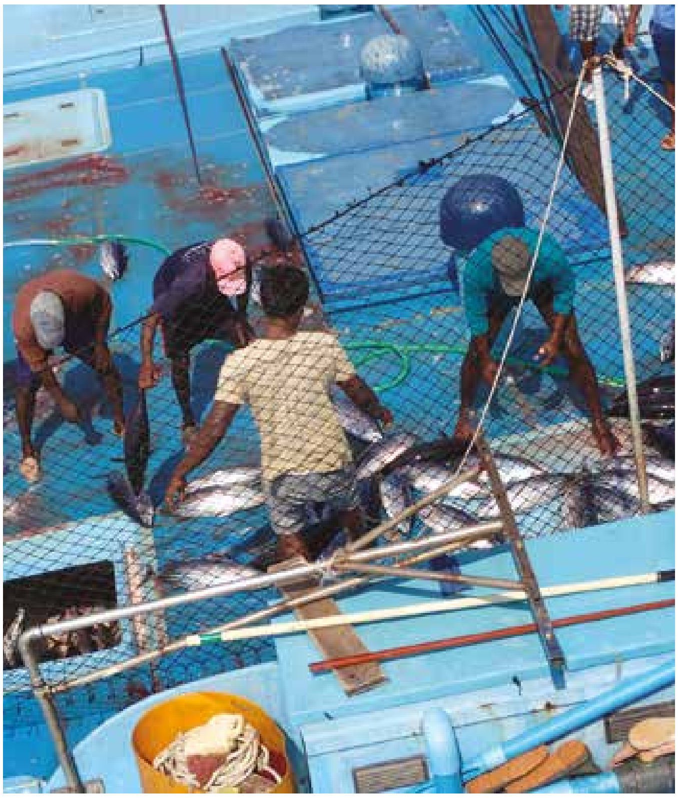
To maintain highest quality product, identify ways to get fish chilled as soon as possible.

Catch Storage

Artisanal vessels

Artisanal vessels that operate single day trips may simply rinse their catch prior to landing to fresh fish markets. If the fish is entering international markets, artisanal vessels will generally keep the fish on ice until offloading.

For **multiple day trips**, an array of storage techniques can be implemented to maintain high quality fish until unloading at port (Picture 26):



Picture 25. Manually moving catch to a storage hold where the fish will be kept in a solution of seawater and ice (Photo: D. Itano)

- Storage in ice is highly recommended. Reducing the core temperature of tuna as quickly as possible is necessary to maintain a high-quality product.
- A mixture of seawater and crushed ice (slurry) cools tuna far quicker than ice alone and a slushy brine also acts as a cushion to crushing and abrasion.
- Ice brine is commonly stored in emptied bait holds or purpose-built insulated holds.
- The ice brine system can keep tuna in decent condition for about four days, after which quality reduces rapidly.

Picture 26. Storage hold where the fish are kept in a solution of seawater and ice, 2013 (Photo: IPNLF)

Refrigerated coils – RSW (refrigerated seawater)

Vessels equipped with this type of system need to first identify the way fish is going to be sold:

- **Fresh fish**. Fish holds can also be lined with metal coils cooled with a compressed refrigerant such as ammonia or Freon (as allowed by local regulation). The coils can maintain seawater in refrigerated seawater (RSW) systems for fresh and fresh sashimi markets, as well as for canned products. For these markets, it is important to maintain tuna close to the freezing point without actually freezing the flesh.
- **Frozen fish**. Freezer coils can also chill a hyper-saline solution of seawater and salt that remains in a liquid state but is cold enough to freeze the whole tuna solid. Whole tuna are transferred to the brine freezing wells that circulate the high-density brine at −18°C to −20°C. When the brine hold is filled with frozen tuna, the brine is pumped out and the fish kept in a dry, frozen state usually at a lower temperature — either in the same hold or sorted and transferred to other refrigerated holds.

Spray brine systems

Fish can be also frozen in storage wells using a simple spray brine system: refrigerated brine solution is recirculated from the bottom of the well and sprayed over the top of the fish. The catch is loaded whole from the capture deck, and chilled brine runs by gravity over the fish, which freeze solid at the temperature of the brine (−18°C to −20°C).

It is important to bear in mind that inconsistency in fish quality and salt loading can occur since the fish in the bottom of the well will be constantly submerged in brine. However, the system is adequate for **canning-grade tuna**.

Air blast dry freezers

Large Japanese pole-and-line vessels use dry-blast freezing technology to preserve **high-quality frozen tuna** at an ultra-low temperature (ULT) of −45°C to −60°C. ULT frozen tuna can be held for extended periods while maintaining suitable quality for sashimi, seared tuna and high-grade markets (Picture 27). A combination of bleeding, pre-chilling in RSW, or brine cooling may be used prior to dry blast freezing.

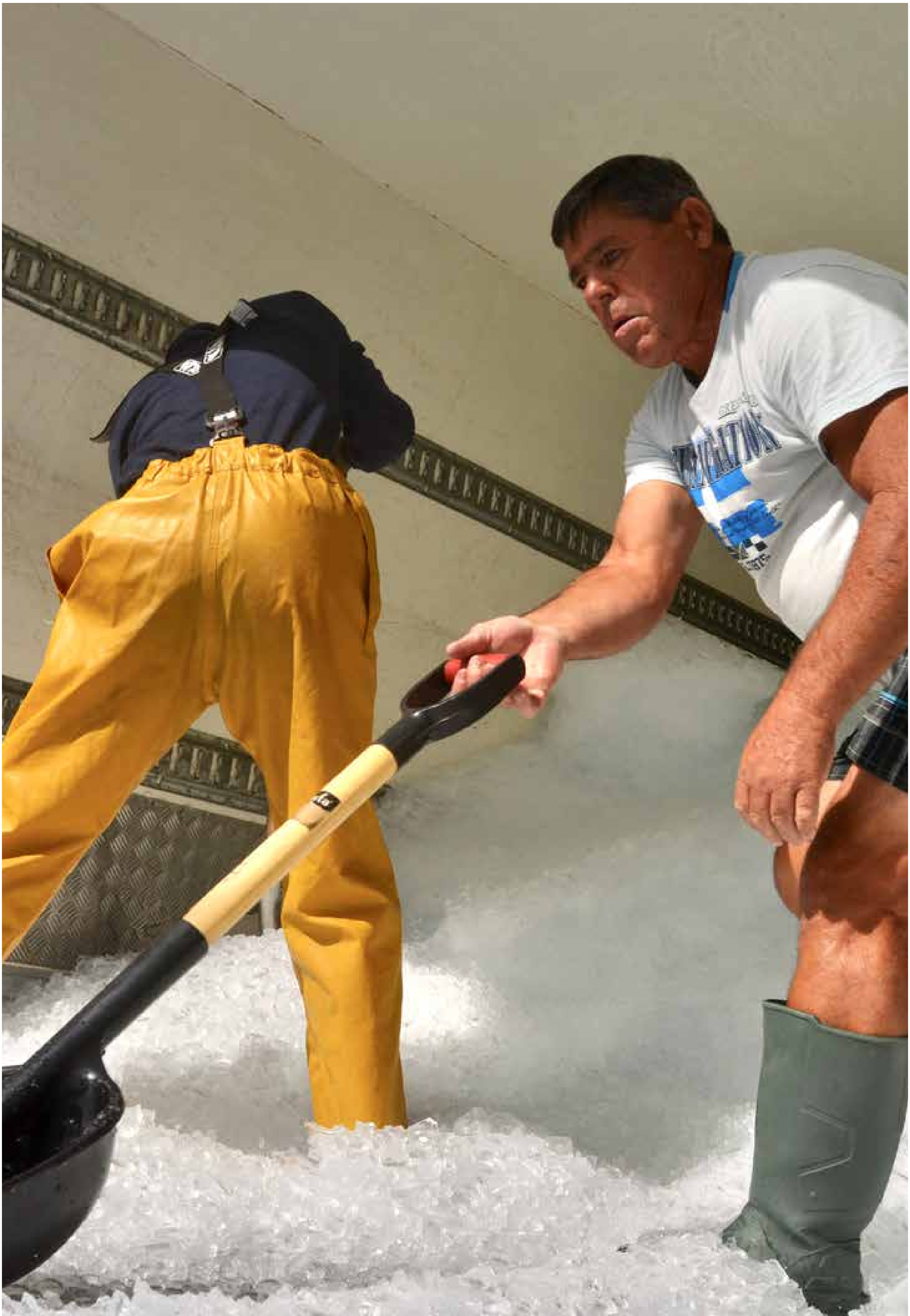
Picture 27. Japanese distant-water pole-and-line boat unloading sashimi-quality blast-frozen skipjack in Yaizu, Japan (Photo: D. Itano)

Use of Nano-Multi-Ice (NMI)

This is a new technology that is currently being trialed in the Maldivian pole-and-line fishery. NMI is a very fine silky ice solution that is proving to be effective in bringing core temperatures of pole-and-line caught tuna down quite rapidly. It has several refrigerating benefits with substantial time savings (up to 20x faster cooling of fish), much improved fish quality, small size, light weight, extremely low refrigerant charge and relatively low power consumption.

To maintain the highest quality product:

- Evaluate and implement measures on deck that allow for a soft landing of poled tuna
- Land tuna on a cool, wetted deck to reduce flesh damage and abrasion
- Identify ways to get fish chilled as soon as possible
- Assess the array of available cooling and freezing methods



Canary Islands © IPNLF

Indonesia © Paul Hilton & IPNLF

Chapter 5: Baitfish Management in Pole-and-Line Fisheries

Pole-and-line fishing requires live baitfish (i.e., small pelagic, coastal and coral reef varieties), which is cast into the sea to attract tuna schools. Thus, baitfishing is an integral part of pole-and-line tuna fishing and several strategies to ensure responsible management and efficient use of the resources should be part of the overall fishing strategy.

Many baitfish species used by pole-and-line fisheries display relatively high productivity and resilience to fishing due to their high fecundity, high turnover due to rapid growth, and relatively short life spans. However, baitfishing can still have environmental impacts, such as the reduction in the amount of forage available for larger fish, overexploitation of some baitfish species, and bycatch of non-target species (IPNLF 2012; Gillett 2012).

Management for baitfisheries as well as the ongoing collection of data on baitfishing activities (species composition, total catch, catch-per-unit-effort) are key components for ensuring this aspect of pole-and-line fisheries is sustainably managed. Proper management of baitfisheries should consider: ecosystem impacts, avoidance of over-exploitation due to technological innovation, and user conflicts between fisher groups (IPNLF 2012; Gillett 2012).

Understanding these concerns in the context of the pole-and-line fisheries is key to developing appropriate management regimes.

Chapter Objectives

1. Review the importance of bait management for pole-and-line fisheries.
2. Introduce the concept of bait management framework.
3. Provide guidance on implementing simple monitoring systems for bait fisheries.

Overview

Introducing baitfish management plans will improve the management of this resource, by establishing regular assessments of baitfish stocks and managing baitfish resources (IPNLF, 2012). Specifically, management plans could address:

- Sustainability of target baitfish resources
- Mitigation of negative interactions with other forms of fishing (especially small-scale fishing)
- Reduction of bycatch

Baitfishery Management Framework

Whereas baitfish management plans are very useful, their practical use and implementation is a complex subject, since it is not always clear which elements they should include, what difficulties may appear when implementing the measures proposed, or how effective they would be in the different areas.

For this reason, the concept of "fisheries management frameworks" is recommended as a starting point to improve the management of baitfisheries. Such a framework would feature:

- Monitoring of the fishery, i.e., collecting, reporting and making use of the data
- A formal statement of rules or regulations
- A code of conduct to encourage efficient bait usage and minimize waste
- A mechanism (regulatory framework) for applying and implementing those rules

Important Aspects of Baitfish Management

For many centuries, fishers from traditional pole-and-line cultures have harvested baitfish with very low impact on their bio-ecological resilience. Thus, there is a widespread perception of unlimited availability of bait resources and, in many areas, fishers have little awareness of the need for, and benefits of, baitfisheries management (Gillett et al. 2013).

To change this mindset it is crucial that, when implementing management plans or frameworks, a large emphasis is placed on raising the awareness of fishers on the need for management, and the importance of their collaboration to ensure the sustainability of baitfisheries.

The fishing crew should understand the importance of:

- Ecological value of baitfishes
- Correct identification of baitfish species
- Recording of interactions with ETP species during baitfishing operations
- Standardizing how baitfish catches are measured (use of standardized scoop/buckets with known weights by species)
- Measuring fishing effort in the baitfishery
- Estimating baitfish mortality throughout the baitfishing and fishing process

Baitfishery Monitoring

Monitoring the baitfish population is the primary first step of a "management framework" and is one of the main improvements that can be broadly applicable to the management of most baitfisheries (Gillett 2012).

To encourage fishers to participate in data collection activities, a data-collection form should be as simple as possible and, at the same time, efficient. Fisheries are expected to tailor their needs based on existing system of data collections. The types of data that should be collected are as follows:

- **General Information:**
  1) Date
  2) Skipper name / contact details
  3) Port of departure
  4) Vessel identification
     i. Vessel name
     ii. National registration number
     iii. IMO number
     iv. Unique vessel identification number (UVI such as IMO)
  5) Nested fishery / dedicated bait fishery ?[1]
- **Livebait catch location**
  1) Local name
  2) GPS position (for multiple positions provide average location)
  3) Grid code on the map (in case where maps with grids are provided)
  4) Fishing depth
- **Gear for livebait catch**
  1) Day time or night time
  2) Use of SCUBA (daytime)
  3) Net
     i. Lift net
     ii. Beach seine
     iii. Surround net
     iv. Scoop net
- **Livebait catch**
  1) Number of sets / hauls / buckets / scoops
  2) Average weight of set /haul / bucket/scoop
  3) Estimated weight of bait collected (may not require if 1 and 2 are reported)
  4) Names of primary species caught (at least three most common species in the catch)

[1] Baitfishing may be a discrete, stand-alone activity (e.g. in Maldives and Solomon Islands), or it can be a component of the total amount of fishing on the species used as bait. In the later, baitfisheries are "nested" inside a larger fishery.

- **Livebait fishing effort**
  1) Duration of fishing (start time and end time)
  2) Number of fishers onboard
- **Bycatch/Discards/ETP Interaction**
  1) Bycatch
     i. Common names
     ii. Numbers / weight
  2) Discards
     i. Common names
     ii. Numbers / weight
  3) ETP Interaction
     i. Common names
     ii. Numbers
     iii. Fate (alive, not determined | alive, swam away | alive, minor injuries | alive, life threatening | alive, severe stress unlikely to survive | dead | unknown).

The catch per unit of effort (CPUE), for example, can be used to estimate the quantity of fish caught (in weight) per one standard unit of fishing effort. This indicator has the great advantage of being readily understood by the crew who can recognize the real use of their data for management planning and decision-making and to track baitfish abundance/catch-ability over time.

Baitfishing catch-and-effort data are not only are important to the dedicated baitfisheries (e.g. in the Maldives) but are also of great value in the "nested baitfishery" component of pole-and-line fisheries.


Indonesia © Paul Hilton & IPNLF

Chapter 6: Common Baitfish Species

The correct identification of baitfish species used in pole-and-line tuna fishing is an important aspect, not only for monitoring the impact that this fishing has on ecosystems, but also for adapting the different species of baitfish to the target tuna species. A general knowledge of the ecology and biology of these species is also essential when looking to improve on-board survival and fishing success.

Chapter Objectives

1. Provide a general overview on the various ways pole-and-line fisheries meet baitfish demands.
2. Describe key baitfish species for pole-and-line fisheries according to target tuna species.
3. Outline the most commonly used fishing techniques for baitfish capture.
4. Highlight some important aspects on the use of cultured baitfish by pole-and-line fisheries.

Overview

Pole-and-line vessels either **capture** their own baitfish, **purchase** baitfish from other fisheries, **use cultured baitfish**, or gain a baitfish supply through a **combination** of these activities. For example:

- Maldivian tuna boats capture their own wild baitfish similarly to how the pole-and-line boats of the Azores, Canary Islands, Lakshadweep, Brazil, and others.
- In Japan, baitfish are purchased from separate baitfishing operations, which can be a component of larger fisheries harvesting the baitfish species for various purposes, including human consumption.
- Some pole-and-line fisheries, including the Solomon Islands and US west coast pole-and-line fishery, obtain bait in some combination of the two methods.

The ability to **purchase baitfish** has several advantages, aside from allowing the catcher vessels to concentrate solely on harvesting the target tuna catch. Captured baitfish can be transferred to floating pens, where the weak or injured are eliminated and the survivors become accustomed to confinement and captive feeding. The "hardened" bait adapts quickly to onboard baitwells, with a low mortality useful

Picture 28. An assortment of baitfish species taken from one night haul in the tropical western Pacific (Photo: D. Itano)

Picture 29. Indonesian lift net "bagans" harvest a variety of coastal baitfish species for human consumption and to supply pole-and-line vessels (Photo: D. Itano)

Picture 30. Pole-and-line fishers buying baitfish from liftnet "bagans" (Photo: P Hilton & IPNLF)

for extended trips. For instance, **Japanese** distant-water pole-and-line boats are able to load and transport hardened Japanese anchovy in temperature-controlled baitwells over long distance trips of more than 4,000 km for use in the equatorial fishing grounds.

However, other markets for the baitfish species can compete with the needs of a fishery. This currently occurs in **Indonesia**, where higher-value markets for human consumption of fresh and dried baitfish co-exist.

The composition of baitfish species (Picture 28) that pole-and-line fisheries use, also depends on the target tuna species and the location of the fishery:

- **Higher latitude** pole-and-line fisheries that target the temperate tuna species (albacore and bluefin tunas) generally harvest a small number of hardy baitfish species, e.g., temperate anchovies, sardines, herrings, and scads.
- **Temperate water** fisheries often rely on one or two dominant species.
- **Tropical fisheries** targeting skipjack and yellowfin tuna (Picture 29 and Picture 30) rely on a large assortment of nearshore and reef-associated species that are often delicate and difficult to maintain in captivity. Tropical bait fisheries may encounter over 15 useable species per haul, although the catch is normally dominated by fewer than five species.

Table 2 provides a list of common bait species used in three major geographic regions, namely (i) Atlantic, (ii) Eastern Pacific and (iii) Indian and Western Pacific Ocean.

Table 2. Common livebait species used in three major ocean regions of the world

Atlantic, Mediterranean and Red Sea

Group	Family / Genus	Species / Notes
Anchovies (Engraulidae)	Engraulis	European anchovy, *Engraulis encrasicholus* is one of the most common species
Sardines and herrings (Clupeidae)	Sardinella	Round sardine, *Sardinella aurita* and Madeiran sardinella, *Sardinella maderensis* important in the Senegal and Ghana fisheries Brazilian sardine, *Sardinellazbrasiliensis*: main baitfish of Brazil fishery
	Sardinops	Southern African pilchard, *Sardinops ocellatus*
	Sardina	European pilchard, *Sardina pilchardus*: important baitfish of the Spanish Basque, Azores and Canary Island fisheries

Trevallies, scads, jack mackerels (Carangidae)	*Decapterus spp*. Mackerel scads are widely distributed throughout the Atlantic, Mediterranean, and the Red Sea and often used as livebait	
	Scads	Bigeye scad, *Selar cruemenophthalmus*: distributed worldwide, makes excellent livebait for pole-and-line or handline operations for large tuna Atlantic horse mackerel (Picture 31), *Trachurus trachurus*: used as a livebait for pole-and-line and handline fishing for Atlantic bluefin tuna by the Spanish Basque fleet  *Picture 31. Atlantic horse mackerel (Photo: I. Onandia)* Blue jack mackerel, *Trachurus picturatus*: preferred bait for bigeye tuna in the Azores fishery. False scad, *Caranx rhonchus*: Eastern Atlantic species along the African coast, one of the main bait species of the Senegal pole-and-line fishery
	Tuna-like species	Atlantic mackerel, *Scomber scombrus*: are used by the Spanish Basque fishery as livebait for Atlantic bluefin tuna
Fish families of lesser importance	Many fish species appear regularly during tuna baitfish harvesting operations but make up a small component of overall catches. In the Atlantic Ocean, these include: Barracudas (Sphyraenidae), Mullets (Mugilidae), Goatfish (Mullidae), Mojarras (Gerreidae), Damselfish (Pomacentridae)	

Eastern Pacific Ocean

Group	Family / Genus	Species / Notes
Anchovies - Engraulidae	Engraulis	California anchovy, *Engraulis mordax*: important to U.S. West Coast fishery. Peruvian anchoveta, *Engraulis ringens*: supported U.S. West Coast fishery operating off central and South America; very hardy
	Encrasicholina	Nehu, *Encrasicholina purpurea* (Picture 32): endemic to Hawaii, supported the Hawaiian pole-and-line fishery, coastal distribution in clean water, strong  *Picture 32. Nehu (Photo: D. Itano)*
Sardines and herrings - Clupeidae	Clupeidae / Sardinops	California sardine, South American pilchard, *Sardinops sagax caerulea*.
Trevallies, scads, jack mackerels -Carangidae	Bigeye scads, jacks and mackerel	Bigeye scad, *Selar cruemenophthalmus*: distributed worldwide, makes excellent livebait for pole-and-line or handline operations
Fish families of lesser importance	Many fish species appear regularly during tuna baitfish harvesting operations but make up a very small component of overall catches. These include. Barracudas (Sphyraenidae), Mullets (Mugilidae), Goatfish (Mullidae), Mojarras (Gerreidae), Damselfish (Pomacentridae)	

Indian and Western Pacific Oceans

Group	Family / Genus	Species / Notes
Anchovies - Engraulidae	Engraulis	Japanese anchovy, *Engraulis japonicus* - most common livebait supporting the Japanese skipjack pole-and-line fishery
	Encrasicholina	Golden anchovy, *Encrasicholina devisi*: important tuna baitfish of the Western Pacific and Indian Ocean, inshore, medium strong Blue anchovy, *Encrasicholina heterolobus*: important tuna baitfish of the Western Pacific and Indian Ocean, more offshore, clean water. They are medium to strong Ocean anchovy, *Encrasicholina punctifer* (Picture 33): important tuna baitfish of the Western Pacific and Indian Ocean, oceanic but can occur inshore in clean water, strong species  *Picture 33. Ocean anchovy (Photo: D. Itano)*
	Stolephorus	Several species taken in bait hauls in the Western tropical Pacific, including *Stolephorus indicus*, *S. waitei*, *S. commersonii*. Inshore, weak, poor baitfish
	Thryssa	Little Priest, *Thryssa baelama* (Picture 34): Commonly occurs in bait hauls in Western Pacific. Hardy bait but may swim away from vessel  *Picture 34. Little priest (Photo: D. Itano)*
Sardines and herrings (Clupeidae)	Amblygaster	Spotted pilchard, *Amblygaster sirm* (Picture 35): Loose scales, short survival in baitwells but good bait when live, weak. It is found in the Indo-West Pacific regions from Mozambique to the Philippines, and towards north Taiwan and Japan to the far east of Australia and Fiji  *Picture 35. Spotted pilchard (Photo: D. Itano)*
	Herklotsichthys	Gold spot herring, *Herklotsichthys quadrimaculatus* (Picture 37): Inshore, good for yellowfin, strong  *Picture 36. Gold spot herring (Photo: D. Itano)*
	Pellona	Indian pellona, *Pellona ditchela:* inshore, medium hardiness
	Sardinella	Fringe-scaled sardine, *Sardinella fimbriata*: Indonesian fishery Gold-striped sardine, *Sardinella gibbosa*: Indonesian fishery
	Sardinops	Japanese pilchard, *Sardinops melanostictus*

<table>
<tr>
<td>Sprats (Dussumieriidae)</td>
<td>Spratelloides</td>
<td>Silver sprat, Spratelloides gracilis (Picture 37): strong attractive bait, important in Western Pacific and Maldives fisheries, clear water near coral reefs

Picture 37. Silver sprat (Photo: D. Itano)

Blue sprat, Spratelloides delicatulus (Picture 38): attractive bait, loses scales easily requiring careful handling, important in Western Pacific and Maldives fisheries, clear water near coral reefs

Picture 38. Blue sprat (Photo: D. Itano)</td>
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<tr>
<td>Cardinalfish (Apogonidae)</td>
<td colspan="2">Several species of cardinalfish are used in several pole-and-line fisheries, especially in the Maldives, these included Apogon spp., Archamia spp., Cheilodipterus spp., Rhabdamia spp. (Picture 39 and Picture 40), most commonly R. cypselurus, R. gracilis

Picture 39. Cardinalfish R. cypselurus (Photo: D. Itano)

Picture 40. Cardinalfish, R. gracilis (Photo: D. Itano)</td>
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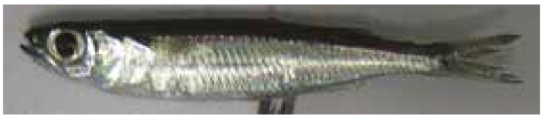
<table>
<tr><td>Silversides (Atherinidae)</td><td colspan="2">Broad-banded silverside, Atherinomorus lacunosus, Fijian silverside, Hypoatherina ovalaua, Crescent silverside, Stenatherina panatela (Picture 41)

Picture 41. Crescent silverside (Photo: D. Itano)</td></tr>
<tr><td>Fusiliers (Caesionidae), relativelu commonly</td><td colspan="2">Gold and blue fusilier, (Picture 42 top) Caesio caerulaurea.
Slender fusilier, Gymnocaesio gymnopterus
Mottled fusilier (Picture 42 bottom), Dipterygonotus balteatus.
Banana fusilier, Pterocaesio pisang
Dark banded fusilier, Pterocaesio tile

Picture 42. Gold and blue fusilier (top) and mottled fusilier (bottom) (Photo: D. Itano)</td></tr>
<tr><td>Trevallies, scads, jack mackerels (Carangidae)</td><td>Scads and jack mackerels</td><td>Decapterus spp. Mackerel scads are widely distributed also throughout the Indo-Pacific region
Bigeye scad, Selar cruemenophthalmus: distributed worldwide, makes excellent livebait for pole-and-line or handline operations
Oxeye scad, Selar boops (Picture 43): similar, slightly smaller Western Pacific species with a yellow lateral bar

Picture 43. Oxeye scad (Photo: D. Itano)</td></tr>
<tr><td colspan="3">Tunas, mackerels: Indian mackerel (Picture 44), Rastrelliger spp., most commonly Rastrelliger kanagurta: an Indo-Pacific species complex useful for chum when small, and for livebait at larger sizes

Picture 44. Indian mackerel (Photo: D. Itano)</td></tr>
<tr><td colspan="3">Fish families of lesser importance; Barracudas (Sphyraenidae), Ponyfish (Leiognathidae), Mullets (Mugilidae), Goatfish (Mullidae) and Damselfish (Pomacentridae)</td></tr>
</table>

Baitfishing Methods

A wide variety of net types are used to collect tuna baitfish, both by the tuna fishing vessels themselves and by other fisheries that supply live baitfish to pole-and-line operations.

The most common baitfish nets used by pole-and-line vessels include beach seines, boat-operated seines (lampara nets, purse seines, ringnets), drive-in type nets, and many styles of liftnet. The most critical factor relates to **mesh size**, which must be small enough to avoid gilling a large proportion of the haul while remaining efficient for pursing and hauling.

Baiting operations can be generally divided into:

- **Daytime methods**, which are the most common. Beach seine or surround nets and drive-in nets are usually operated during daylight hours.
- **Night-time activities**, where the use of artificial bait-attraction lights is needed. Liftnets are an example of nets often used at night.

The type of net and whether it is hauled in the day or at night depends on several factors, such as:

- depth of the fishing ground
- bottom type (smooth or rough)
- behavior of targeted baitfish species

Cultured Baitfish

Using cultured fish for pole-and-line chum may be an option as an environmentally responsible alternative to harvesting wild coastal species or when wild baitfish are not seasonally available.

For cultured chum, species judged to be the most effective tuna baitfish meet the following requirements:

- Are bright or silvery in color
- Move in a rapid, erratic manner when chummed
- Return to the boat and spray after being cast out
- Hold up well to handling and captivity for extended periods
- Lack spines
- Are suitably sized for the targeted tuna species

When considering the mass culture and practical considerations of using cultured baitfish, the desirable species should also have the following characteristics:

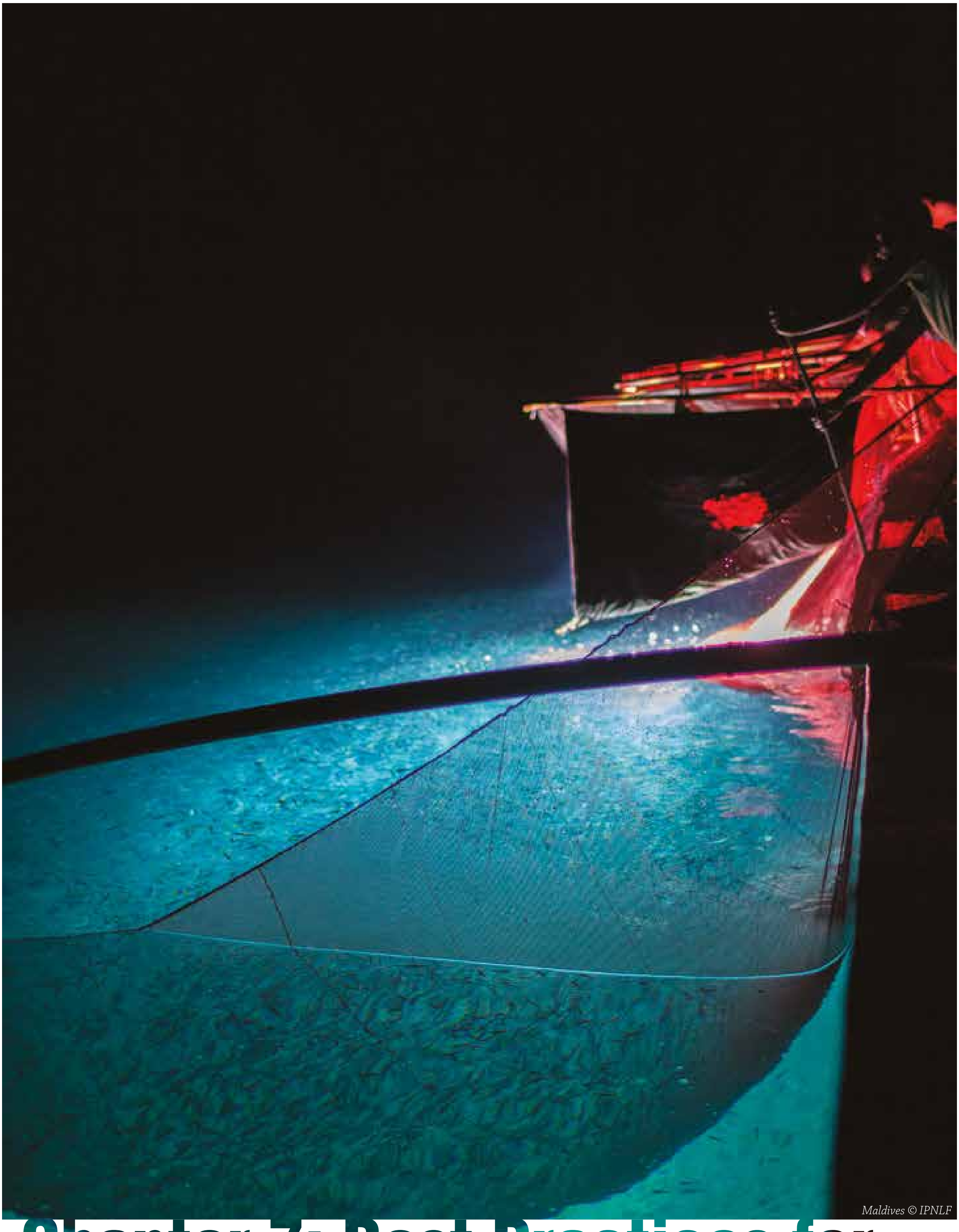
1) High reproductive potential
2) Breed easily in captivity
3) Feed cheaply and low on the food chain
4) Tolerate crowding and low water quality
5) Have disease resistance
6) Are euryhaline, or able to tolerate a range of salinity conditions
7) Are omnivorous but not cannibalistic
8) Are attractive to tuna

Projects and studies on the effectiveness of cultured chum peaked in the 1970s but were discontinued when pole-and-line fisheries declined as purse seining became the predominant surface tuna fishing method worldwide.

These studies concentrated on two species thought to have the greatest potential for tuna fisheries: mollies (*Poecilia mexicana*) and milkfish (*Chanos chanos*). Pole-and-line field trial results suggested that **milkfish** are a superior tuna chum due to their bright silvery color and rapid, erratic movements back to the vessel if properly handled. Even though both species are highly productive and robust in captivity, mollies' dark color and slow movements proved to be unappealing to tuna.

Other species have been tested with less encouraging results, including **tilapia** (*Tilapia mossambica*), **threadfin shad** (*Dorosoma petenense*), and **Hawaiian flagtail** (*Kuhlia sandvicensis*).

There is renewed interest in culturing baitfish species in some regions to support pole-and-line fisheries as an environmentally responsible alternative to wild baitfish harvest. This can relieve pressure on wild stocks and nearshore resources.



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Chapter 7: Best Practices for Livebait Capture and Utilization

A key strategy for a pole-and-line fishery is to minimize on-board baitfish mortality. This improves the overall efficiency and reduces the environmental impact of pole-and-line fishing operations. Baitfish will start to die off from the time it is first caught and continue to do so until after it is required for fishing operations (Hester 1974). Capture, transfer and handling, bait-well design and environmental conditions all influence baitfish survival (Baldwin 1977; Bryan 1980). Poor survival is typically due to overcrowding, inadequate holding facilities and rough handling (Baldwin 1977).

Implementing sustainable management practices in combination with efforts to minimize post-harvest mortality and waste help to ensure the long-term success of pole-and-line fisheries.

Chapter Objectives

1. Address fishing and loading strategies for reducing stress-induced mortality of baitfish and increase its longevity onboard.
2. Provide some recommendations on the design and maintenance of bait wells to maximize the onboard longevity of captured baitfish.
3. Offer different options for managing the remaining baitfish after fishing operations.
4. Provide guidance on using baitfish during tuna fishing on the basis of efficiency principle.
5. Highlight other important ecological issues that bait fisheries must consider.

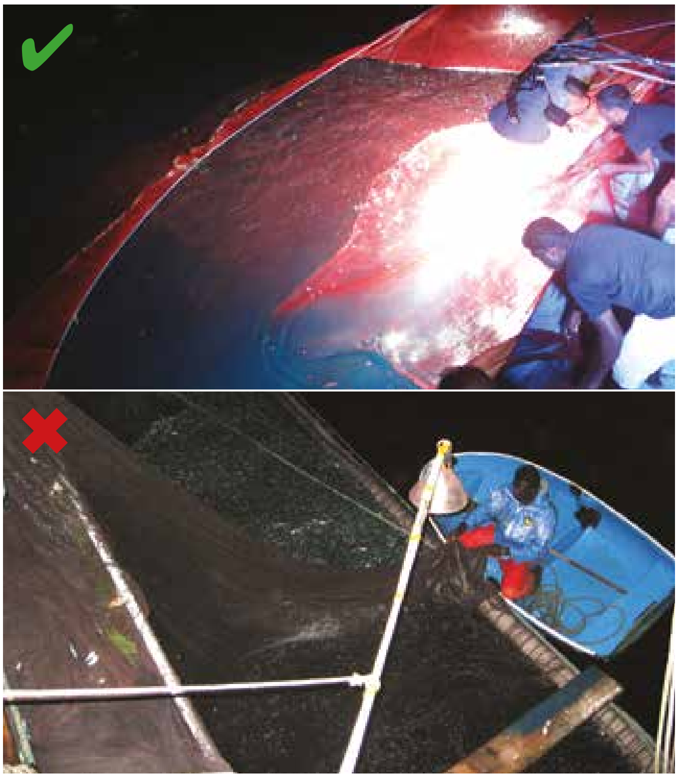
Baitfish Capture and Loading

Responsible pole-and-line fishing begins during bait capture and loading to the vessel or during bait loading for vessels that purchase live baitfish supplies. In this regard, there are a few considerations that must be taken into account:

- Crowding baitfish in the net prior to loading can cause weakness or mortality from lack of oxygen (Picture 45).
- Large bait hauls should be split, with only a portion of the haul crowded and loaded at a time.
- Larger predatory fish that may be mixed in the haul need to be isolated and removed as quickly as possible to avoid panicking the bait and causing added stress and mortality.
- For night baiting, a low wattage light source should be suspended over the area where baitfish have been concentrated next to the boat for loading, which has a calming effect and allows the baitfish to see and avoid the net.
- Whenever possible, allowing the bait to settle down under the light before final crowding and transfer can reduce stress-induced mortality.
- Scooping and transferring baitfish to the vessel should

take place quickly but without overcrowding the scoop nets or loading buckets.

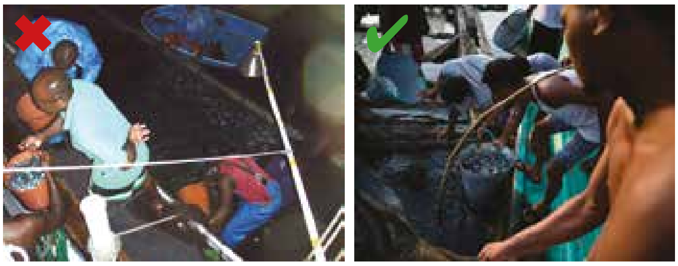
Some baitfish species are very delicate and should not be "dry scooped," which causes scale loss and early mortality. Baitfish should be carefully crowded in-water with a hand-held dip net into buckets filled with seawater, then emptied into the baitwells.



Picture 45. Low wattage light source suspended over an area where baitfish are loaded from a bouke-ami bait haul. In the picture above, upper, (Photo: K. Miller & IPNLF), the baitfish are concentrated next to the boat but the net is not too crowded. In the picture above, lower (Photo: D. Itano), it is noticeable that the net is overcrowded, which may lead to baitfish mortality due to the lack of oxygen

Other important points:

- Some species, particularly those harvested in cool waters at higher latitudes with strongly adherent scales, can be "dry scooped" with dipnets and quickly transferred to the bait wells.
- Delicate species should not be "dry scooped", but loaded within buckets of seawater, taking care not to overcrowd each bucket (Picture 46). Wet-loading of bait is more difficult but will pay off with hardier, healthier bait with a higher survival rate and longevity onboard.
- Loading bait in this manner usually requires a plank to be suspended next to the vessel so a crewman can load buckets from sea level. While buckets are partially submerged into the bait crowding area, a small scoop net gently guides the baitfish into the partially filled bucket. Filled buckets are passed hand to hand to the baitwells, where they are submerged and gently inverted to allow the baitfish to swim out in the same direction of the circling bait mass.
- It is well known that survival and condition of night-caught baitfish that are allowed to settle, or calm down in the net, and loaded during daylight hours are higher than for night-loaded bait.
- For multiple day trips or when the distance to fishing grounds is relatively far, it may be worthwhile to delay loading a large bait haul until daylight hours.



Picture 46. Loading buckets of baitfish from a bouke-ami haul. Note that in the left panel the net and bucket are overly crowded, which may contribute to weakened bait and higher mortality levels. (Photo, left: D. Itano). Daylight loading of baitfish in the right panel is being done properly with a less crowded net and bucket (Photo: P. Hilton & IPNLF)

Best practices must be applied at every stage of the fishing process starting with the bait capture and loading operations, where some important aspects — net manipulation, predatory species dismissal, artificial light supply and transferring time — must be considered.

It is also very important that the baitfish population in the baitwell is controlled to avoid overcrowding, both during the net trawling and the loading of the buckets.

These simple measures help to reduce stress-induced mortality and increase the longevity of the baitfish onboard.

Picture 47. A simple method to enhance baitwell circulation is to drill holes through the hull to allow direct transfer of seawater to the open ocean (Photo: D. Itano)

Baitfish Holding and Maintenance

Small-scale and artisanal pole-and-line vessels hold baitfish in baitwells or compartments in the boat that circulate seawater through holes in the hull (Picture 47), such as the second generation Maldivian masdhoni. Larger vessels without mechanical seawater circulation may have large, purpose-built baitwells that form an integral part of the boat's structure. In both cases, little circulation takes place when the vessel is drifting, which necessitates the rapid loading of bait to maximize survival.

To increase baitwell water circulation, there are different methods:

1. Circulation of fresh seawater can be encouraged by inserting bamboo or PVC scoops through the holes in the hull while underway (Picture 48 and Picture 49).

Picture 48. A bamboo pole split in half and thrust through a hole in the bottom of a baitwell helps to upwell and circulate seawater when the vessel is underway (Photo: D. Itano)

Picture 49. Manual circulation tubes are also constructed from PVC piping but also function only when the vessel is underway (Photo: D. Itano)

2. Supplementary oxygen can be pumped into wells using porous airstones, but caution is advised: too much oxygen can clog the gills of baitfish and cause mortality.

3. Mechanical pumps driven by small diesel engines can be used to circulate water in baitwells, some of which were not originally equipped with pumps (Picture 50).

Picture 50. Electric, diesel, or gasoline-powered motors drive powerful water pumps to deliver fresh seawater to baitwells (Photo: Maldives Marine Research Centre)

Picture 51. Six livebait wells on a pole-and-line vessel. Seawater circulation pumps maintain water levels up into the combings that discourage water sloshing out of the tanks (Photo: D. Itano)

Picture 52. Small electric light positioned to keep the bait calm and prevent it from striking the sides of the well

Recommendations for the design of baitwells:

- Baitwells should be designed with a raised combing that is kept filled with seawater, which prevents water from sloshing back and forth in the baitwell and injuring the baitfish. The height of the baitwell and combing is not as critical for vessels equipped with mechanical pumping systems, as the pumps can maintain water in the tanks well above sea level (Picture 51).
- Baitfish should be quickly transferred to baitwells filled with clean, well-oxygenated seawater. Baitwells should be as free of obstructions and sharp corners as possible and painted a uniform white, pale blue or neutral color.
- Baitwells should be lit with a low wattage light either above or submerged inside the baitwell during hours of darkness (Picture 52). Lights should not be allowed to swing back and forth. They should be fixed above the well or inside the well about 1/3 distance from the surface by attachment to a line attached to the center bottom of the well. Red or green underwater lights are said to calm the bait, but additional work is required to assess optimal light color by species.
- Ideally, baitwells should be equipped with a mechanical pumping system that introduces clean seawater near the bottom or edge of the well and overflows near the top to flow overboard through deck scuppers. Some systems direct inflowing water to cause a gentle circular pattern in the well, which encourages the baitfish to settle into a circular pattern flowing against the current (Picture 53).

Several recommendations for the turnover rate of seawater in baitwells have been made. However, optimal pumping rates will vary widely depending on many factors, such as the baitfish species, stocking density, and water temperature. Generally, higher stocking densities are possible at lower water temperatures and with cooler-water species.

Moreover, it is necessary to bear in mind some other factors during the fishing operations:

- For multiple-day trips, a daily routine should be followed to maximize the longevity of available baitfish. Dead fish sink to the bottom of the tank and can rot and spoil

Picture 53. Anchovy livebait circling in a clean, well-constructed baitwell with mechanical seawater circulating system (Photo D. Itano)

Whatever the design of the vessel, the compartments where the baitfish is held must ensure clean and well-oxygenated seawater circulation.

To increase this water circulation, several methods can be used such as inserting bamboo scoops in the hull and using mechanical pumps.

Baitwells should be fitted with a dim light to keep the bait calm and avoid striking the well sides at night.

The baitwells should be constructed with a top combing smaller than the entire tank with the water level maintained at a level mid-way up the combing to avoid water sloshing back and forth and causing injury to the baitfish.

Baitwells should be made of a smooth material without sharp corners or obstructions and painted in a uniform and neutral color.

water quality. They should be regularly removed from the tanks. An efficient way to clean large baitwells is to set up a siphon system using a large 10–12 cm diameter plastic hose attached to a long fishing pole.

- Holding baitfish for extended periods in a healthy condition may require regular feeding. Baitfish will normally not want to feed for some time after capture, but they can adjust to captive feeding easily when they are ready. Fish eggs, such as those from a spawning condition dolphinfish or tuna, are an easy way to get them started. Mashed tuna flesh strained through a nylon stocking can also be used for filter-feeding species.

After the fishing trip, for ecologically responsible behavior:

- Keep the baitfish in the baitwells if the water quality in the port is suitable.
- Release the bait close to where it was captured if practical.

Baitfish Use During Tuna Fishing Operations

Chummers often attempt to produce the strongest biting response possible, but less bait can still generate a positive biting response. The idea of producing the highest catch for a given amount of bait should be stressed and ultimately is controlled by the fishing master.

Conserve livebait as much as possible during fishing operations by using sparingly.

Here are some important considerations to bear in mind during tuna chumming:

- Baitfish conservation begins with a careful assessment of the type of tuna school and behavior. Where practical schools with the higher likelihood of responding positively to the chum size and species onboard should be chosen.
- Chumming should be halted if the school does not respond in a reasonable amount of time. Likewise, chumming should be stopped when the school is dispersed from the spray perimeter. A balance must be reached between trying to bring the fish up and into the sprayers or stopping fishing, conserving available bait, and moving on to another school.
- Baitfish that escape being eaten can gain shelter close to the hull. Before moving on, this bait can be flushed out by placing the vessel temporarily in reverse, which can trigger positive biting response, particularly for bow-poling vessels.

If the tuna school does not respond in a reasonable amount of time, it could be better to stop fishing, conserve bait, and move on to another school.

Other Ecological Considerations for Baitfishing Activities

It is critical that pole-and-line fisheries proactively avoid negative impacts on baitground habitat and on other forms of marine life. In particular, fishers need to appreciate the following:

- Baitfishing can have negative impacts on **baitground habitat** and on **other marine species**. Fishers should make every attempt to avoid such impacts.
- Caution should be exercised with any baitfishing method where the fishing gear comes in close proximity to

coral reefs. Weighted scare lines or nets should not be allowed to contact the reef. Coral damage can occur, which can reduce baitground productivity over time.

- If the same baitgrounds are used repeatedly over coral reefs, the installation of permanent mooring buoys should be encouraged to minimize reef damage from vessel anchoring.
- Night fishing with bait attraction lights can attract endangered, threatened and protected (ETP) species and species of special concern. In many areas, marine mammals, whale sharks, and manta rays are under specific protection. Fishers need to be aware of the national and international regulations and policies that protect ETP species and habitats in their fishing regions and abide by them strictly.
- Fishers can find this information by consulting local regulations approved by their governments and the international protection measures to which their countries have adhered. Moreover, the IUCN Red List of Threatened Species (IUCN 2017) represents a comprehensive, up-to-date, and science-based record where fishers can look up for detailed information on the threatened marine species in their regions.

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Chapter 8: Conclusions

While pole-and-line fishing may cause fewer environmental impacts (namely highly selective form of fishing, with little to no bycatch) than other commercial fishing gears, it is important to identify any possible negative impacts and implement practices to avoid them.

This Guidebook presents a series of examples and recommendations to help pole-and-line fishers optimize efficiency of operations, maximize catch quality, and recognize and address environmental impacts of their activities. Specific key elements for pole-and-line fisheries to consider include:

- Addressing fuel efficiency and related carbon footprint by improving operational efficiency through effective:
  - Identification of tuna schools and related fishing strategies
  - Chumming and water spraying
  - Use of anchored FADs to reduce fuel costs and concentrate fishing activity in known locations
- Poling can be a potentially dangerous activity, fishers should therefore review safety measures such as protective gear, fisher's positioning in the line-up, and other complementary measures to avoid injury from barbless lures and airborne tuna.
- Ensuring a high-quality tuna catch to maximize the value of each fish harvested through good handling and conservation practices, as the best way to be ecologically responsible, by considering:
  - Preventative measures on deck that allow for a soft landing of poled tuna
  - Landing on a cool, wetted deck
  - Dispatching, rinsing, and chilling as quick as possible
  - Rapid cooling and freezing – evaluating the array of existing techniques for implementation
- Monitoring baitfishing activities associated with pole-and-line tuna fishing to gain information on the major trends of baitfish population and help decision-making on management interventions.
- Evaluating and managing baitfishing operations — including bait capture and loading, its maintenance onboard, and its use during chumming — to increase operational efficiency and limit possible negative effects on baitfish populations and habitats.

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