



All About Nets

GhostNets
Australia™ 





The purpose of this booklet

The purpose of this booklet is to provide some background information about types of fishing; why fishers use the nets they do, what is important to them when selecting the material they use in their nets, and briefly, how nets are made.

This booklet is designed to work in conjunction with the Ghost Net ID Guide. The purpose of the ID Guide is to identify and record ghost nets (abandoned, lost and discarded fishing nets). All About Nets will help users of the Ghost Net ID Guide understand the relevance of each bit of information required to identifying the net use.



Ghost Net ID Guide

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GhostNets Australia

GhostNets Australia (GNA) was established in 2004, as an alliance of Indigenous communities in north Australia to deal with a growing ghost net issue.

GNA resourced and trained local rangers to clean up the nets as well as collect data. To date, rangers have removed over 14,000 nets or pieces of netting. The data from these ghost nets has enabled GNA to determine the abundance, distribution (Figure 1), major impacts, physical source of the problem and causes for ghost nets occurring.

This research is supporting GNA's efforts to stop the flow of nets from their origins. This is preferred to continually having to deal with the ghost nets at the end of their destructive journey.

Stopping the nets involves supporting fishers, who are known to contribute to this ghost net issue, to make significant changes in their behaviour and fishing practices. This means that GNA needs to be able to identify the specific fisheries they work in; hence the Ghost Net ID Guide.

For more information about the various projects that GNA has done in the past and is planning in the future visit: www.ghostnets.com.au

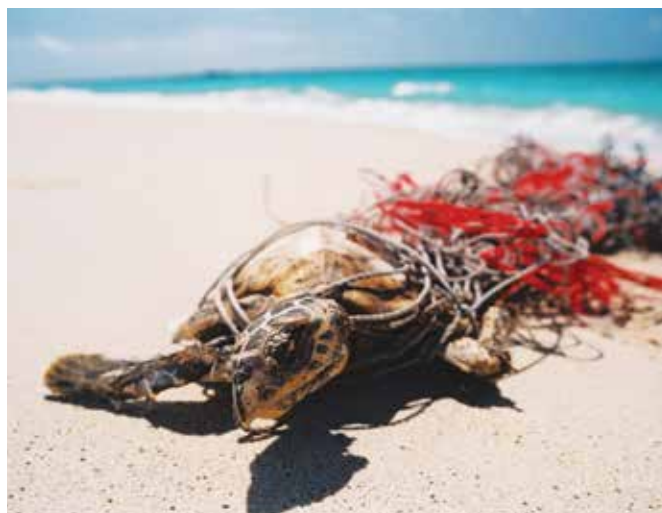
Note on terminology

As some of the terms used in this booklet would be unfamiliar, a small glossary has been provided at the rear of this booklet. Of note are the definitions of 'net' and 'netting':

- A net is the finished product after it has been designed and fitted for use i.e. cut, shaped, ropes added.
- Netting, on the other hand, is twine that is knitted to form a sheet of material, also known as webbing.



Local rangers Geiza Ahmat and Tim White cataloguing ghost net data.



Turtles are often the innocent victims of ghost nets.



Figure 1: Concentrations of ghost nets that have been cleaned up by Indigenous rangers 2004-2012. Red showing areas of most nets.

Fishing methods



Fishing nets are designed to catch fish (and other marine animals) while they are hunting, eating or sleeping. There are four basic methods to catch fish: sieving the water, entangling, herding and surrounding the fish.

Water sieving nets are mostly a static (passive) net that is occasionally lifted to sieve the water and scoop the catch out. Entangling nets are also passive, and include a broad range of designs based around the principle of creating a fence of netting that entangles fish. Herding nets do exactly that; they herd the target species into an enclosure, bag or shallow water, while surrounding nets use the schooling behaviour of the fish to trap them.

As fishing techniques have evolved over the millennia there are lots of variations and even combinations of these four basic principles. In this booklet we have tried to keep to the basics.

Water sieving nets

The most common form of water sieving net is the **lift net**. Lift nets are attached to a fixed frame such as a floating platform (Figure 2), and left for a period of time like a trap. When the net is hauled it is slowly lifted so the water passes through like a sieve or a leaf net used in a swimming pool. Some of these types of contraptions have more than one layer of netting so that nothing that enters the net is lost.

In Indonesia there is a more complex type of lift net, called a bouke ami, that is worked from the side of a large vessel.

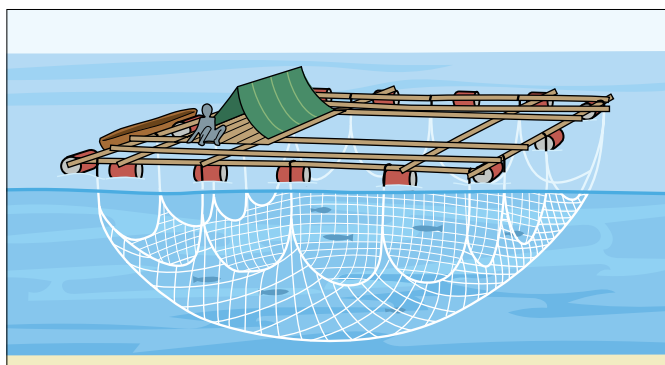


Figure 2: Lift Net suspended from a floating bamboo platform.

Entangling nets

Entangling nets are a rectangular shaped net that is set (fixed at both ends) to create a wall that stops the fish in their tracks, like a barbed wire fence. The head of the fish passes through the mesh of the net but the body cannot. Due to the construction of the fish's gills, the fish cannot back out, hence these nets are generally referred to as **gill nets** as the fish are trapped by their gills (Figure 3).

A gill net that is only fixed to a boat at one end while the opposite end drifts with the currents is called a **drift net** (Figure 3).

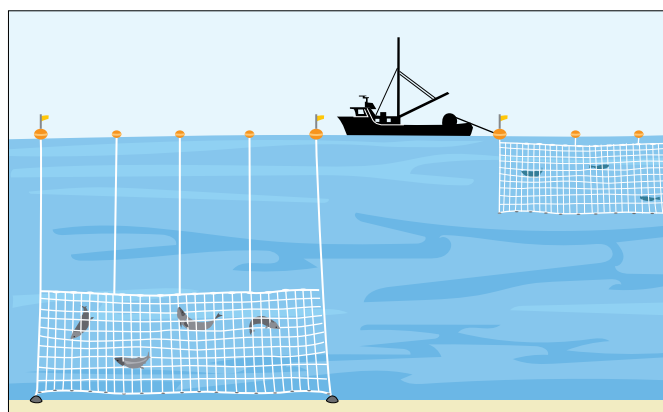


Figure 3: A bottom set gill net in the foreground (left), with a drift net in the background.

Trammel, pocket or tangle nets, have two or three walls of different types of netting to ensure the fish is captured. Any fish that passes through the larger meshed outer wall(s) get caught up in a pocket of finer meshed net in the middle (Figure 4). This design ensures all fish are caught, no matter the size.

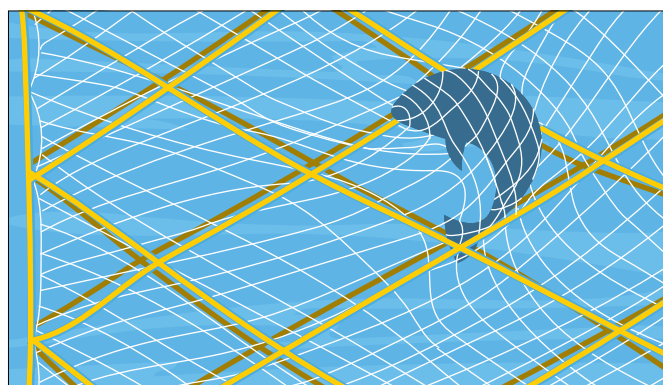


Figure 4: A trammel or pocket net showing the fish entangled in pockets of netting.

Herding nets

Herding the fish can be done in a variety of ways from using a fixed contraption that utilises the currents and tides (Figure 5), to a complex system of setting a net, herding the fish and hauling it on board a large vessel in the open ocean.

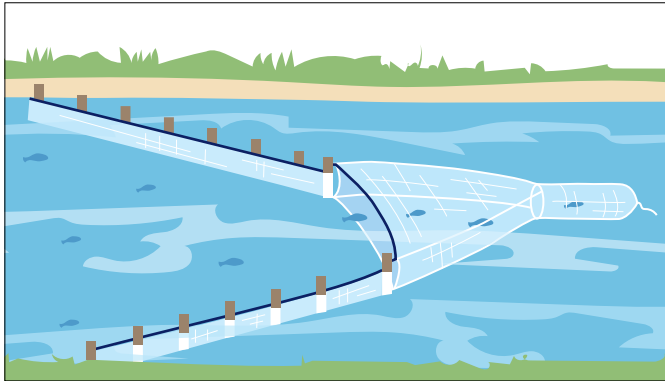


Figure 5: Design of a tunnel net that utilises the current.

The simplest form of active herding is the **beach seine**. Active nets move through the water to catch their fish (in contrast to the passive fishing of a gill net or lift net). To operate a beach seine, two or more people guide the net from out in the water towards the shore, herding the fish as they go (Figure 6) so they can be easily scooped out. Alternatively they will set the net further out using a small craft and then haul it from the beach with ropes.

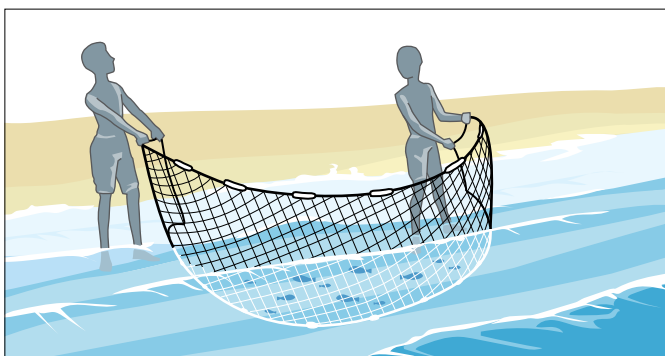


Figure 6: Two people guiding fish towards the shore using a beach seine.

A more complex version of the herding technique is the **danish seine**, used in the open ocean (Figure 7). This net has two long wings that herd the fish into a part of the net called a codend which is a bag that retains the fish. The wings are attached to the vessel by way of long ropes that are slowly hauled into the boat as shown through steps 1-4 in the diagrams. As the ropes are hauled on board, the net continues to herd the fish towards the vessel.

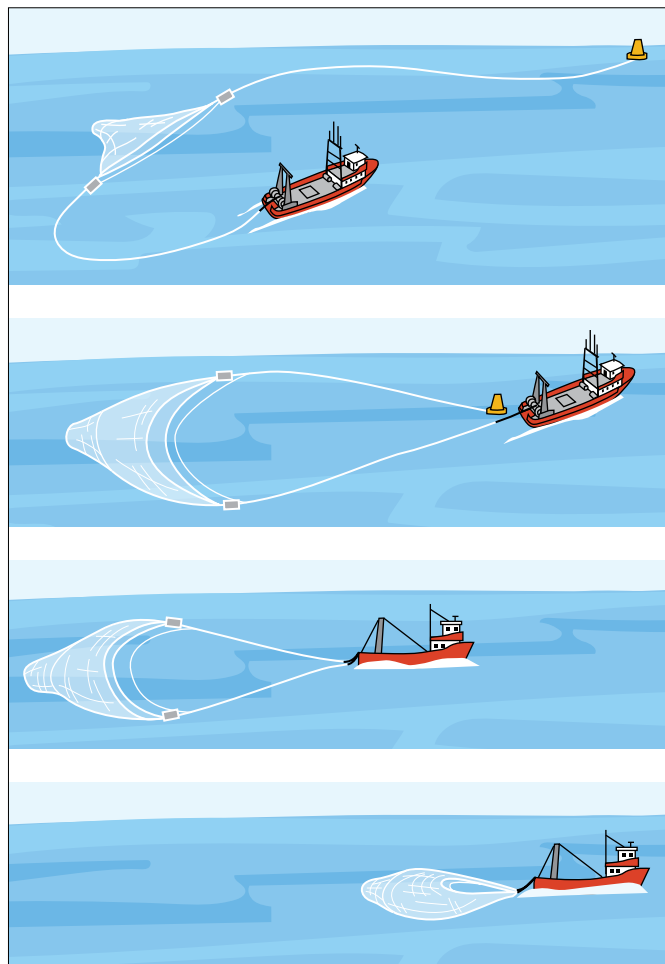


Figure 7: A danish seine net in operation. Step one (top) is setting the net. Step two is gathering the buoy and guide rope onto the vessel. Steps three and four shows hauling the net to the vessel.

Surrounding nets

One type of surround net that is in common use by recreational fishers in Australia is a large circle of net that is thrown into the water by hand. This is called a **throw** or **cast net** (Figure 8).

Lead weights on the outer edge of the net help the edge of the net sink while the centre remains attached, via a rope, to the thrower. As the net sinks it surrounds the fish and closes in on them so they can be hauled out of the water with the net.

A more widely used surround net by commercial fishers throughout the world is an adaptation of the danish seine net that is called a **purse seine**.

This net is set around a school of fish (Figure 9 top). Once the school is surrounded, a rope which passes through rings along the bottom edge of the net, is tightened (Figure 9 bottom). This action resembles the pulling of 'purse' strings. Once the fish are contained the net is gradually hauled closer to the boat so the fish can be scooped out.

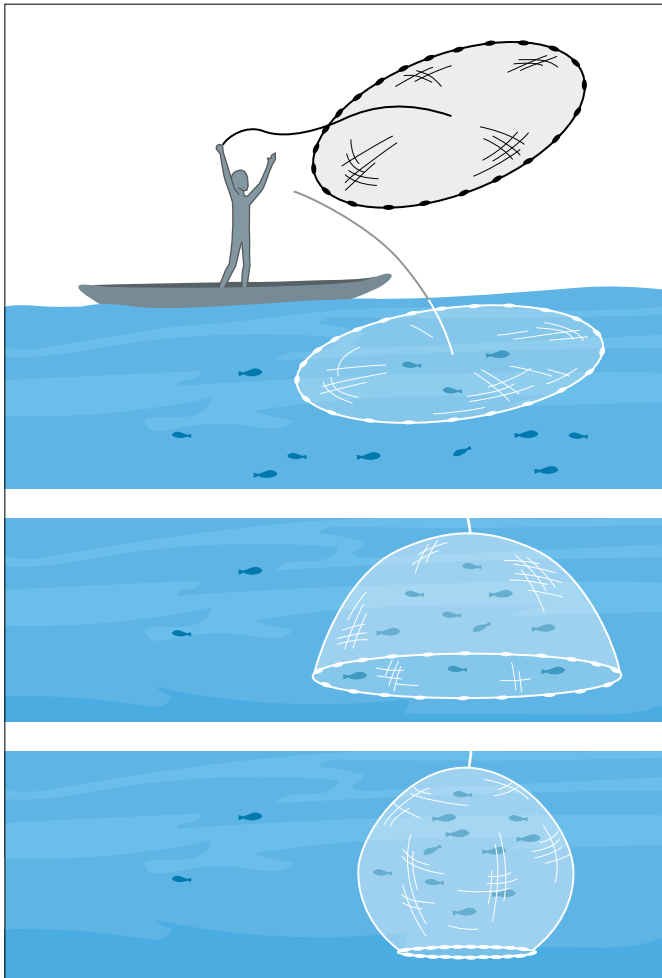


Figure 8: The action (top to bottom) of a cast net as it is thrown then surrounds the fish before being hauled to the surface.

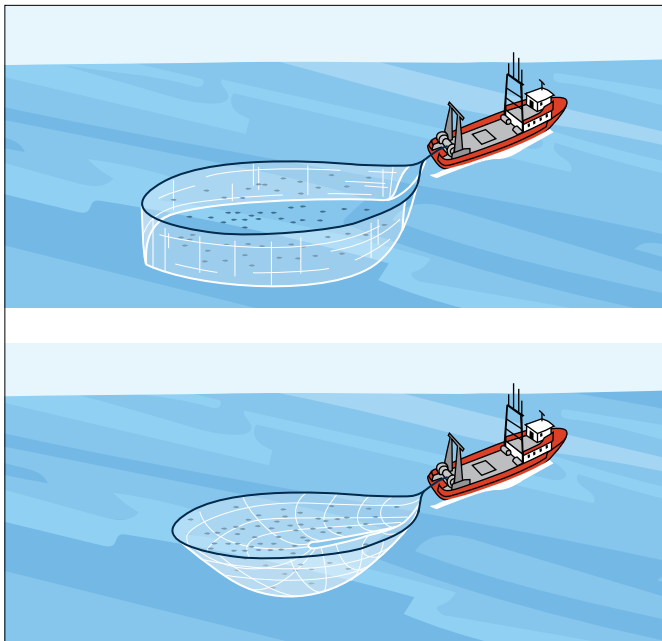


Figure 9: (Top) Setting a Purse Seine Net and (bottom) drawing the purse strings of the net, enclosing the fish from below.



Combined methods

The most complex but also the most common type of commercial fishing is **trawl**. This method of fishing combines several techniques and, similar to purse seine fishing, can be used by all scales of fishing from tiny operations in shallow water to large industrial scale vessels far out to sea (as shown in Figure 11 next page).

Trawl nets are towed behind boats, harvesting their catch as they move slowly through the water. Trawling is a form of sieving as the boat and net move, like running a leaf scoop from one end of a swimming pool to the other. But like the seine net, the large trawl net used to catch demersal fish has wings either side of the mouth of the net that herd the fish into the belly of the net. These wings are attached to two large heavy 'boards' that use the hydrodynamics of the water and the speed of the vessel to spread the net while it is fishing (Figure 10).

Apart from a single net, called a stern trawl, (due to the action of it being hauled onto the back of the boat, rather than the side), trawlers can also tow multiple nets at one time.

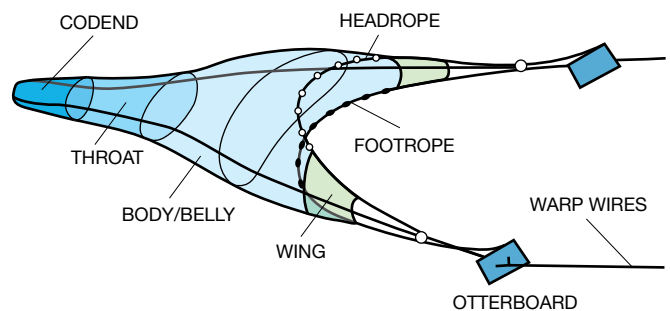


Figure 10: Basic Trawl gear design showing the structure of the gear: warp wires to attach and haul net to vessel; otter boards or doors to weight and spread the net with its foot ropes that also include some sort of weighting device and head ropes that have some sort of flotation devices to keep the net open. The net itself is constructed of wings, a body and codend.

How a fisher decides

The decision as to which type of fishing method to use is contingent on many factors from environmental constraints to traditions of the region and ultimately costs of the operation. This in turn affects the choice of gear deployed. In this section we describe some of these choices.

The marine environment consists of a huge variety of ecosystems such as coral reefs, mangrove forests and deep ocean trenches that support an incredible array of biodiversity, all of which are exploited by fisheries to varying degrees.

This diverse range of ecosystems can be reduced to three primary fishing zones: the inshore, coastal and off-shore or deep water zones (Figure 11) that are suitable for differing fishing methods.

Choice of fishing method

Apart from the characteristics of the fishing grounds, (e.g. rocky ground), some other considerations that fishers take into account are:

- **The prevailing weather conditions on the grounds**
Does the wind blow strongly at certain times of the year? Is there a strong current or other limiting conditions?
- **Use of a vessel, or not**
If there is no vessel, then the gear must be easy to use by hand. The number of people involved in the activity effects what equipment can be used.
- **Size and power of the vessel**
This will influence the towing ability of the vessel, i.e. the size of a net, and which marine zone it can operate in (Figure 11).
- **The auxiliary equipment on the vessel**
Is there refrigeration or winches? The presence of these would determine how long a vessel can remain at sea and the size of gear to be hauled.
- **Habits and traditions of the fishers**
Many fishers learn from their ancestors or peers.
- **Cost of gear.**



Thai fishermen at Benjina Harbour, Aru Islands Indonesia.

Choice of netting

Once the fishing method is decided then the choice of gear design and materials is critical to the effectiveness of the operation. This is not a straightforward procedure as there can be multiple properties of the materials, especially netting, to consider.

For example many nets, such as hand held nets, need to be very light and flexible for ease of handling. But not all uses for lightweight materials are the same: cast nets need to also have negative buoyancy so they can sink and surround the fish quickly, while drift nets are the opposite as they are operated near the ocean surface. A towed net needs to be lightweight to reduce drag but has to be strong and resistant to abrasion. These types of netting all require twine with different chemical and physical properties.

Figure 11: Marine zones showing different fishing techniques using nets. (Diagram inspired by the FAO website: www.fao.org.)

IN-SHORE

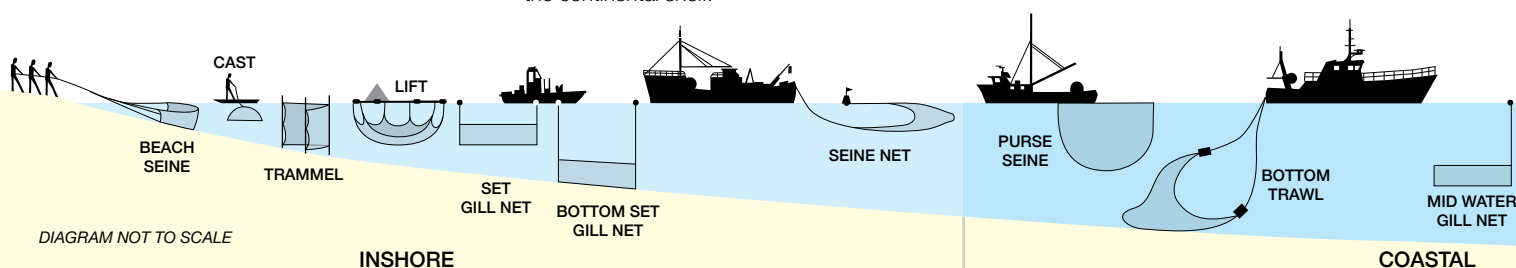
The shallow coastal water within the tidal range that provide nursery habitat for many species.

COASTAL

Beyond the tidal zone, but still within the influence of freshwater and nutrient runoff from the land is the comparatively shallow waters of the continental shelf.

OFF-SHORE

Includes the continental slope and the oceanic deep waters over 200m where pelagic fish feed.



Net construction

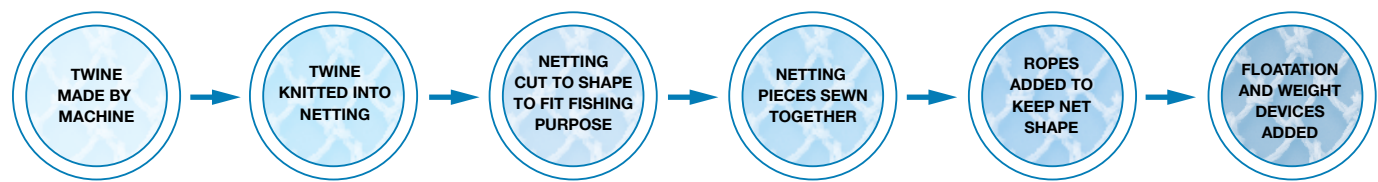


Figure 12: The basic steps in netting manufacture and design.

A fishing net goes through several stages of construction before it becomes ready for use (Figure 12). Firstly twine is extruded from plastic pellets. Then it is knitted into a sheet of netting which is cut and shaped depending on the use for the netting. Finally attachments are added. Not all stages are done by the same factories or people. The following section details this process.

Twine properties

The variation in twines used in netting is down to the choice of fibres used to make the twine. Most fibres used in fishing these days are various forms of plastic although natural fibres (mostly cotton) are still used occasionally.

Cotton absorbs water making it very heavy. Therefore it is mainly used for bottom set gill nets to catch large animals such as bottom feeding sharks and rays.

Plastic twine is made from long strings of filaments bunched into strands and twisted like rope or braided like a shoelace to give it extra strength. Twine constructed of a single filament is called monofilament (Figure 13).

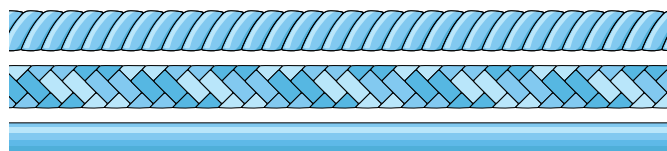


Figure 13: Three types of twine construction from top to bottom; twisted, braided and monofilament.

Twine is available in a whole range of colours and shades. Colour is not always a property of the twine that fishers specify, except in isolated cases. What is important for fishers is the strength, durability and cost of the twine. In surrounding nets, bright colours such as red can be used to 'scare' fish into the centre of the ring. Alternatively the lack of colour e.g. clear, pale greens and blues, can help a net 'disappear' into its surrounding environment. The predominant colours are those that are more UV resistant i.e. blues and greens.

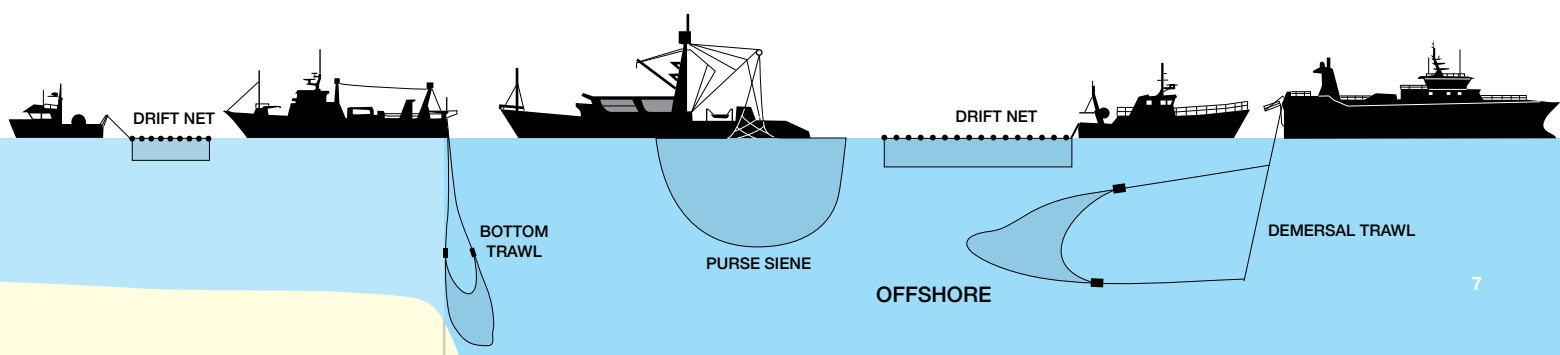
This reduces the speed that a net disintegrates for, due to their high costs, fishermen want their nets to last.

There is one instance, though, where a specific colour was used by a fishing company in northern Australia to distinguish their nets from others. This was done to determine the proportion of their contribution to the ghost net issue, and relative duration in the environment. Even though that experiment concluded a decade ago, GNA is still finding an occasional ghost net of that colour.

Not all plastics have the same chemical composition. The composition determines the certain properties required such as buoyancy, UV resistance, abrasion resistance and cost for the fishing operation. Unfortunately the chemical composition of plastic is difficult to discern by the naked eye but there are four distinguishable groups of plastics found on north Australian shores:

- PET is the most common plastic used for all manner of trawl fishing. This plastic can be twisted into a hard twine. 
- Nylon 6 is distinctive as it is always monofilament and resembles a toothbrush bristle. These are usually found in clear or very pale colours. As nylon has negative buoyancy it is most often used in set gill nets. 
- Nylon 6.6 is a very fine thread (like used in nylon stockings) that makes a soft, extremely flexible netting sometimes compared to silk. It is used in small purse seine nets. 
- Spectra™ and Dyneema™, although expensive, are popular in Australian fishing activities that use a lot of force (e.g. demersal trawl). They have less stretch than PET, and are strong and abrasion resistant. They are distinctive because they are often multicoloured and braided, not twisted. 

There are other kinds, though they are less easy to discern.



Netting manufacture

The twine, which is made by one machine, is then knitted into a sheet of netting (average size: 500m x 12m) by another machine. Where the twine intersects itself, usually a knot is created (Figure 14) but there are knotless types of netting where the twines are woven through each other.



Figure 14: Knotted netting.

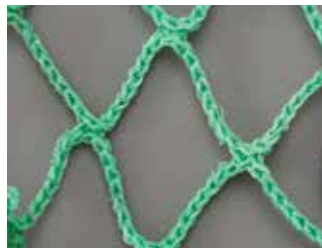


Figure 15: Knotless netting.

Reducing fuel costs is one of the reasons for the few occasions that knotless netting (Figure 15) has been used. The lack of knots helps to ease the friction created by towing the net through the water. It is not in common use so possibly the cost of the netting outweighs the savings in fuel expenses. In rare cases this netting is used to reduce bruising of the fish.

The knitting process creates meshes that vary in size according to the setup of the machine. The mesh size is important to the fishing operation as it primarily determines the type and/or size of species that will be captured.

Traditionally made netting has diamond shaped meshes. This means the mesh can virtually close up when pulled one way but remains more open when pulled in the opposite direction.

The modern alternative to diamond mesh is square mesh, where the meshes stay open. They look the same whichever way the mesh is pulled. As well as gill nets, square meshed netting is used in the codends of modern trawl nets as they enable small unwanted species to escape (Figure 16).

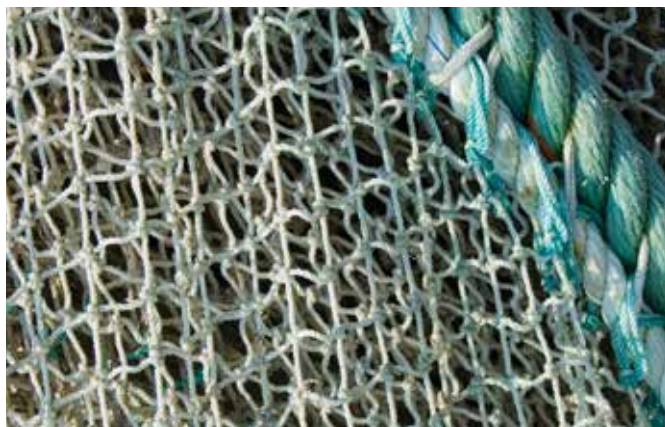


Figure 16: A modern square meshed net.

Net design

Before a sheet of netting becomes a net it has to be designed for specific fishing requirements and then constructed. A simple design (e.g. a gill net), is two or three sheets of netting sewn together to make the desired length.

A trawl net is more complex. By good net design, the significant drag created from towed gear can be reduced. This keeps fuel costs down which is an important consideration for a fishing operation.

One design feature for trawl nets is the use of mixed netting types in the construction (Figure 17). Starting at the wings (mouth) of the net, it is divided into several sections each with decreasing mesh size, through the belly to the throat and then finally ending up at the codend. As the purpose of the wings is only to herd the fish they do not need to be of the same smaller mesh as the codend, where all the fish is retained. Some trawl wings have meshes of over a metre.

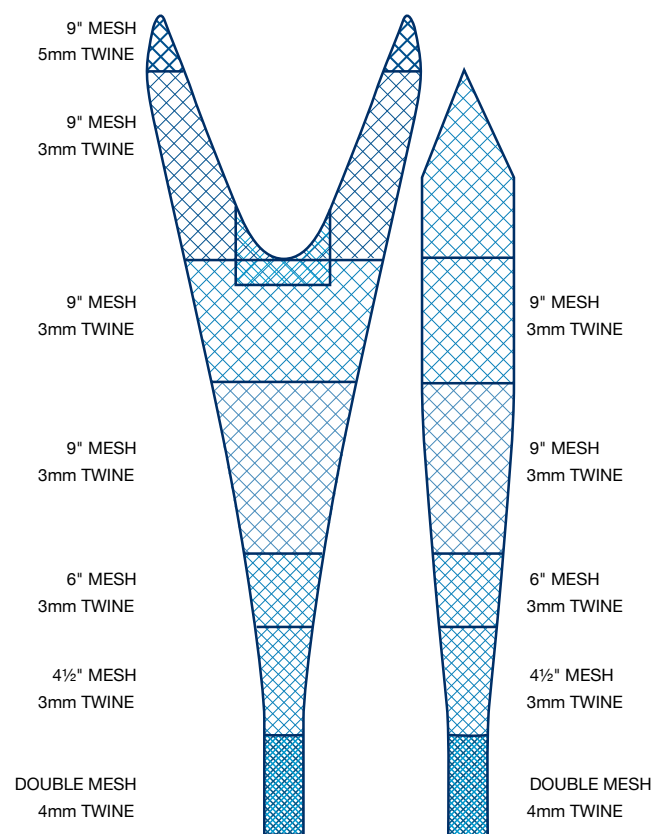


Figure 17: Design of a demersal trawl net showing all the various panels of netting and shapes of the design. The numbers to the sides of the diagram show the netting dimensions (mesh in inches and twine in mm).



A fishing trawler empties its catch on board. The floatation devices, ropes and otter boards used to keep the mouth of the net open are clearly visible.

Assembling the net

As netting can stretch and distort easily once it is constructed, it is attached to (hung on) a head rope and foot rope. This helps to reduce distortion, strengthen the net and optimise its shape and position in the water as it provides a strong base to which floats and weights can be added.

Flotation devices come in a variety of sizes, colours and materials, all depending on the actual use of the net. The basic shapes though are torpedo, round or disc shaped.

Similarly, weights and leads can be added and these come in a huge range of shapes and sizes although few are found as ghost gear (for obvious reasons).

Depending on the complexity of the gear there may be other attachments and ropes for strengthening or other purposes. For example, purse seine nets have rings sewn to the foot rope for the draw string to pass through.



A ghost net with flotation devices still attached.

From fishing to ghost nets



Fishing can be dangerous and risky as it has to contend with operating equipment in varying environmental and climatic conditions. Sometimes gear becomes lost or damaged, although there are occasions where gear is deliberately discarded at sea. If the fishers have lost or damaged gear in extreme weather events or other environmental constraints, such as strong currents, then it becomes very difficult for them to retrieve it.

Identifying ghost nets

When a net becomes a ghost net it is difficult to identify who was responsible for the loss because the pieces retrieved are often only a portion of the original gear.

Because of this dilemma most solutions to identifying ghost nets propose inventing a way to mark the nets, or specifically the twine, so it is linked to a particular fishery or factory. Unfortunately, this is something not in practice at the present time, so this approach will only work for future ghost nets, not the ones already littering our shores.

But identification of ghost nets is already possible as there are clues available to us. These clues come in the many metrics (measurable characteristics) of the netting, e.g. mesh size, twine diameter, colour. The challenge is working out which of these variables are indicative of specific fisheries.

Identifying the fisheries

The key to identifying fisheries is understanding the various properties, or specifications, of the netting the fishers require in their fishing operation e.g. visibility, strength and buoyancy. It is through this lens that we can review the various metrics available to us.

The example (Figure 18) shows the pathway to identifying a drift net targeting small tunas which are a pelagic fish. A drift net is a wall of netting deployed near the surface of the ocean and therefore requires positive buoyancy and low visibility. It is often an activity performed by artisanal fishers so costs need to be low and the net easy to handle.

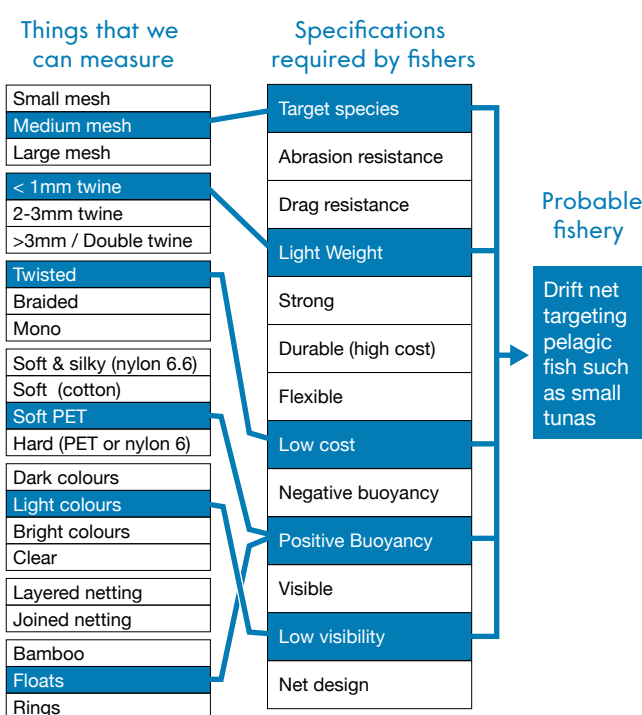


Figure 18: Identification pathway for a drift net targeting small tunas.

The more variables that we can quantify the better becomes the identification as many fisheries have specifications in common e.g. strength, low cost and target species.

Conclusion

At GhostNets Australia we believe that the solution to the ghost net issue is to work directly with fishers. The clues we gather from ghost nets washed up on shore will not give us individual fishers. However, using this information in conjunction with local knowledge about the currents, tides and fisheries that work in the region, it is possible to determine the fisheries responsible. Once that information is available then we can investigate the main causes for their loss or damage and together find ways to reduce the problem of ghost nets.

Website

GhostNets Australia is committed to providing information such as the content of this booklet on its website for greater public access. We have worked with the team at Picta Creative to create a site with:

- critical data entry and storage facilities
- an interactive “What Net is That?” tool
- educational material with suggestions for activities on both the ghost net issue and related topics
- stories of our work with Indigenous rangers over the past decade.

Please visit www.ghostnets.com.au or follow us on Facebook to keep up to date with current events and achievements.

If you have any comments or ideas that you wish to share with us, please contact us via email at info@ghostnets.com.au.



Glossary of terms

Term	Description
Artisanal Fishing	These are small scale commercial fishing operations often crewed by family.
Benthic	Ocean floor.
Braided twine (B)	Twine that consists of fine filaments bunched into strands that are plaited like a shoelace.
Belly	Body of a net, sometimes divided into sections of different netting to enable efficient movement through the water.
Cast Net	In common use by recreational fishers in Australia this is a large circle of net that is thrown into the water and surrounds the fish as the outer edges sink.
Coastal	Within the continental shelf outside the tidal zone.
Codend	Bag end of a net to retain fish. Often small mesh with strong twine. Sometimes the twine is doubled to increase strength.
Demersal	Midwater or near the ocean floor.
Filaments	Fine continuous thread of plastic that forms the basis of twine.
Diamond mesh	The construction of standard net material creates diamond shaped meshes. These will close up when pulled in the right direction.
Drift Net	A gill net that is only anchored to a boat one end while the opposite end drifts with the currents.
Foot and Head Ropes	Top and bottom ropes the netting is hung on. These create the shape and structure of the net.
Gear	Other parts of fishing apparatus, such as lifting ropes, warp wires, otter boards or dahn buoys, where relevant.
Ghost Gear	Fishing apparatus e.g. pots, traps, hooks and baskets as well as ghost nets.
Gill net or Set net	A rectangular shaped net that is set (fixed at both ends) to create a wall that stops the fish in their tracks, entangling them by their gills.
Gross Tonnage (GT)	This is a complex calculation of a vessel that includes the length, engine power and volume of the hull. It is used to give a comparison of fishing capacity. E.g. a 5-10GT vessel is a small low (outboard) or no powered vessel that can only work inshore but a 250GT vessel would be between 20-30 metres in length with an engine capacity of >300hp.
HP	Horse Power.
Industrial scale	These are the large scale commercial operations with a crew who may or may not be associated with the ownership of the vessel or company.
Inshore	Shallow water within the tidal range. Also includes estuaries and parts of rivers.

Term	Description
Lift Net	Lift nets are attached to a fixed frame such as a floating platform, and left for a period of time like a trap, then hauled in occasionally to remove catch.
Mesh	The opening created by knotted or woven twine that forms the structure of netting.
Mono(filament) twine (M)	Twine that consists of only one filament, like fishing line.
(Fishing) Net	The netting after it has been cut, shaped, joined, hung on ropes and attached with chains and floats.
Netting	Twine that is knitted to form a sheet of material. Also known as webbing.
Offshore	Includes the continental slope and oceanic deep waters.
Pelagic	Fish that swim in the open water, often near the surface.
Purse seine	This net is set around a school of fish. Once the school is surrounded, a rope that passes through rings along the bottom edge of the net is tightened. This action resembles the pulling of 'purse strings'.
Skirt	Outer layer of netting over a codend to protect it from predators attacking the catch retained in the bag and to prevent damage. Often bigger mesh but much heavier twine than the codend and/or made of scraps.
Strands	Fine filaments of the twine that are bunched together before twisting or braiding. The more strands there are, the stronger the twine.
Square Mesh	A mesh that keeps its square shape when fishing. The knots are aligned differently to the diamond mesh.
Subsistence Fishing	These are the fishers that only catch enough to eat and barter with. They usually work alone or in small family units. Their vessels (if they have one) have little to no mechanical aids. They operate inshore.
Tangle and Trammel Nets	These nets have two or three walls of different types of netting to ensure the fish is captured. The fish that passes through the larger meshed outer walls still get caught up in a pocket of finer meshed net in the middle.
Trawl Nets	These are nets shaped like a windsock and are dragged behind a vessel either at various depths. Stern trawl is one large net that is hauled on board the vessel via the back of the boat. Twin rig is two nets one each side and multi-rig is any other combination.





GhostNets Australia is supported by:



Australian Government

