# Great Barrier Reef Source Reduction Plan

for

Professional fishing related chemical light sticks

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# PART 1

## 1.1 Rationale

One of Australia's leaders in removing and documenting marine debris from the shorelines of Australia is the Tangaroa Blue Foundation (TBF). Debris information is stored within the Australian Marine Debris Initiative (AMDI) Database. The AMDI's goal is primarily to reduce the amount of marine debris that is washed into the ocean and remove any debris that has already made its way into the marine system (Tangaroa Blue 2016). A strategy being employed, to cut the debris at the source, is termed working on source reduction. A source reduction plan documents the process of investigation of the debris information, tracks it to a source and puts in place steps to mitigate the likelihood of that type of debris entering the system. For the purposes of this report, "marine debris" has been defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (UN Environment Program, 2009).

The TBF is a non-government organisation (NGO) that largely relies on trained volunteers to remove debris from beaches around Australia and classify that debris using a template and associated ID manual. This citizen science project informs source reduction plans; however, when looking further at specific items such as light sticks, it does have its limitations. There are challenges in accessing remote areas which can limit the regularity of cleanups and data collection activities; and data rely on volunteers' understanding and willingness to complete the sorting and classification of debris to a standard.

Through funding, in this instance the Australian Government's Reef Trust marine debris tender, the ReefClean Program gave Tangaroa Blue and its partners the ability to focus their effort on a particular geographic region with support from paid staff. OceanWatch has partnered with Tangaroa Blue Foundation in the ReefClean program to utilise its extensive knowledge and contacts within the Australian Seafood Industry to compose this source reduction plan. OceanWatch, as the Marine Natural Resource Management (NRM) Group, works with the seafood industry and the community to ensure Australia's marine environment is healthy, productive, valued and used in a responsible way.

OceanWatch has successfully involved industry in solutions and practice change and has embraced the principle that a high level of end-user participation in the research and development phase is likely to result in higher levels of acceptance and adoption of the project results and associated products (Jennings and Pakula 2011). Accordingly, a concerted effort was made to utilise fishers' knowledge and experience as an integral and foundational component of the source reduction plan.

## 1.2 Source reduction plan project justification - defining the problem

This project was done to document the occurrence of CLS use within the Australian Professional Fishing Industry to minimise CLS debris in the marine environment, with a geographic focus on the Great Barrier Reef in Queensland. It starts by utilising the citizen science data that exists in the AMDI Database and takes a regional approach to the source reduction task given the random nature of light stick density recorded on beaches.

To date, background source reduction-type studies on this issue are a mix of student research and anecdotal evidence that point towards the occurrences of light sticks found on beaches being linked to professional fishing. However, this research lacks strong evidence of their origin, loss group demographic or means of loss. It is felt the Pelagic longline industry as a user group is contributing to these occurrences; nevertheless, the quantity and circumstances behind these assumptions are yet to be determined (Oliveira, T., da Silva, A., de Moura, R., 2014).

## 1.3 Study Area

The Great Barrier Reef stretches from the Torres Strait in the north to Bundaberg in the south of the eastern coast of Queensland, Australia (Figure 1).

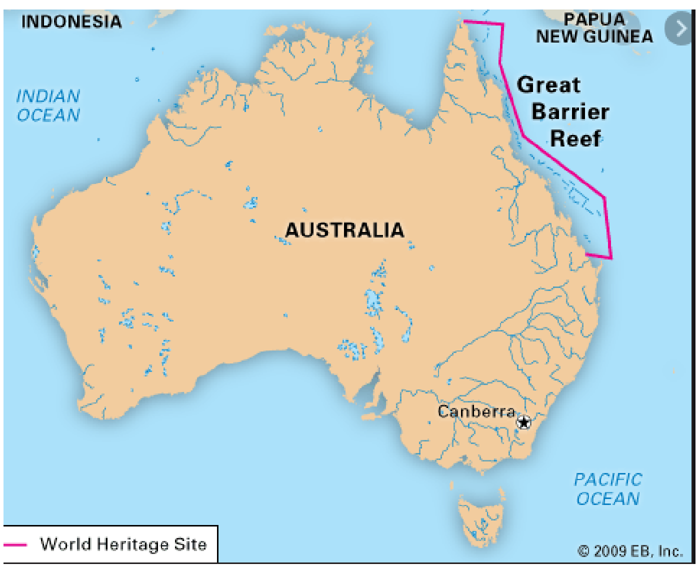



**Figure 1. Area of the Great Barrier Reef**
*Source: Encyclopedia Britannica*

Currents mix waters off the Australian continent, meaning the potential sources of CLS origin are numerous (Figure 2). For the GBR region, they could originate from a land base, the Pacific Ocean or Pacific Islands, or come from the North from PNG and Indonesia. Therefore, in investigating sources it is required to look at numerous factors within the GBR, and also externally.

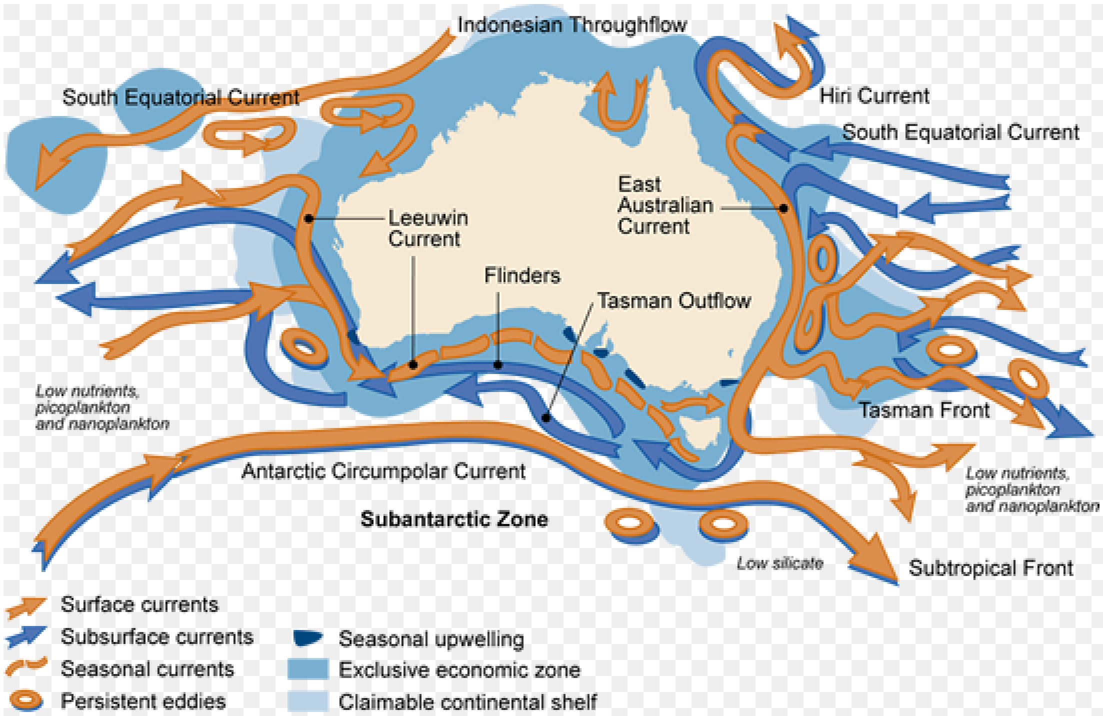



**Figure 2. Ocean currents off Australia**
*Source: Wikipedia*

## 1.4 Objectives

- Investigate the occurrence and type of CLS found and used within the target geography
- Investigate contemporary use of CLS within the Australian wild-catch fishing industry with a focus on State and Commonwealth fishing off Queensland
- Document findings and formulate solution proposals, trials and analysis

## 1.5 Overview of chemical light sticks

CLS or glow sticks are a self-contained, short-term light source. They consist of a translucent plastic tube containing isolated substances that, when combined, make light through chemiluminescence, so there is no requirement of an external energy source. The light cannot be turned off and the CLS can be used only once. Glow sticks are often used for recreation, but may also be relied upon for light during military, police, fire, or emergency medical services operations.

The chemicals used in CLS are generally a mixture of hydrogen peroxide ($H_2O_2$), oxylates ($C_2O_2$) and coloured dyes (Santos 2009). The concentration and the exact mix of chemicals in the sticks vary depending on the manufacturer. Some types of sticks are believed to contain potentially carcinogenic chemicals (Holbrook 2014). Cyalume is a common term associated with chemical light sticks and is a trademarked product. Cyalume products are produced by Cyalume, a guarantee concerning the quality of the substances used and the performance of the products. Many suppliers use this trademark illegally and try to imitate the formulations, so for this report OceanWatch will refer to the generic term chemical light stick (CLS). Given that CLS are used heavily in the longline fishing industry around the world and have been found in the marine environment (Ivar do Sul 2009), it raises the question of what the situation in Australia is in 2020.

**Data on recovery**

Several Australian Marine Debris Initiative Database variables were interrogated to assess features such as hotspots for recovery, how CLS observations on the GBR varied with other states, how numbers recorded varied with the years, which states recorded the most debris in general, cleanup effort applied in each state, and how CLS rated as a percentage of all marine debris recorded over the 11 years.

The top three states with the most clean ups effort were Queensland, WA and NSW (Figure 3). It is worth noting that Victoria has an increased effort percentage but a lower proportion of debris count over the period (Figure 4).

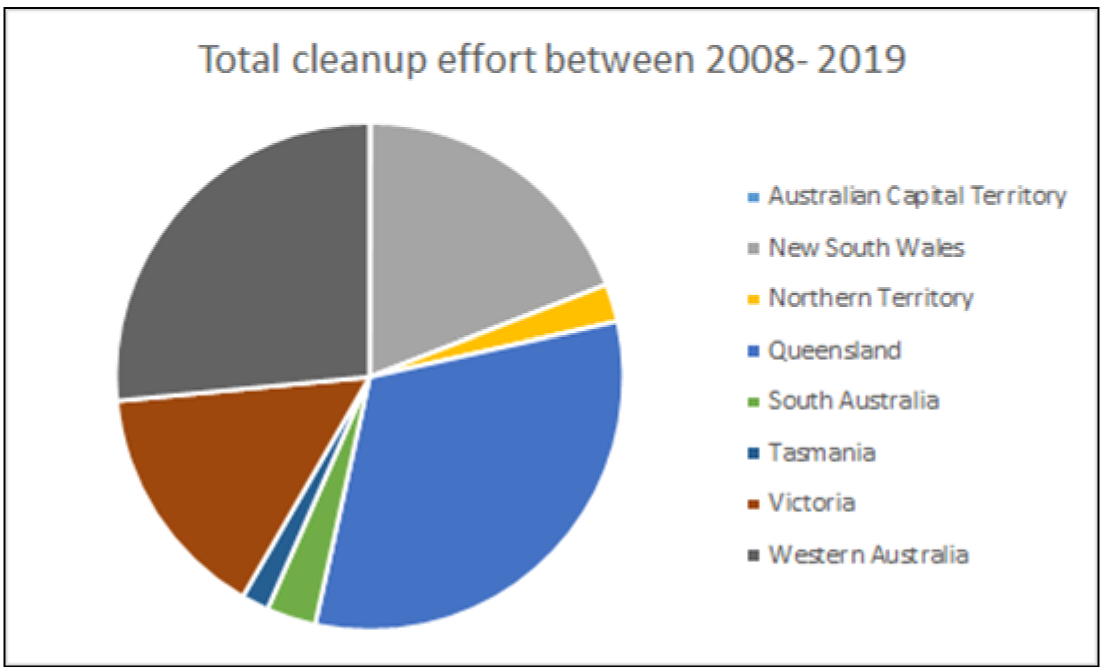



**Figure 3. Total cleanup effort between 2008-2019**
*Source: AMDI Database*

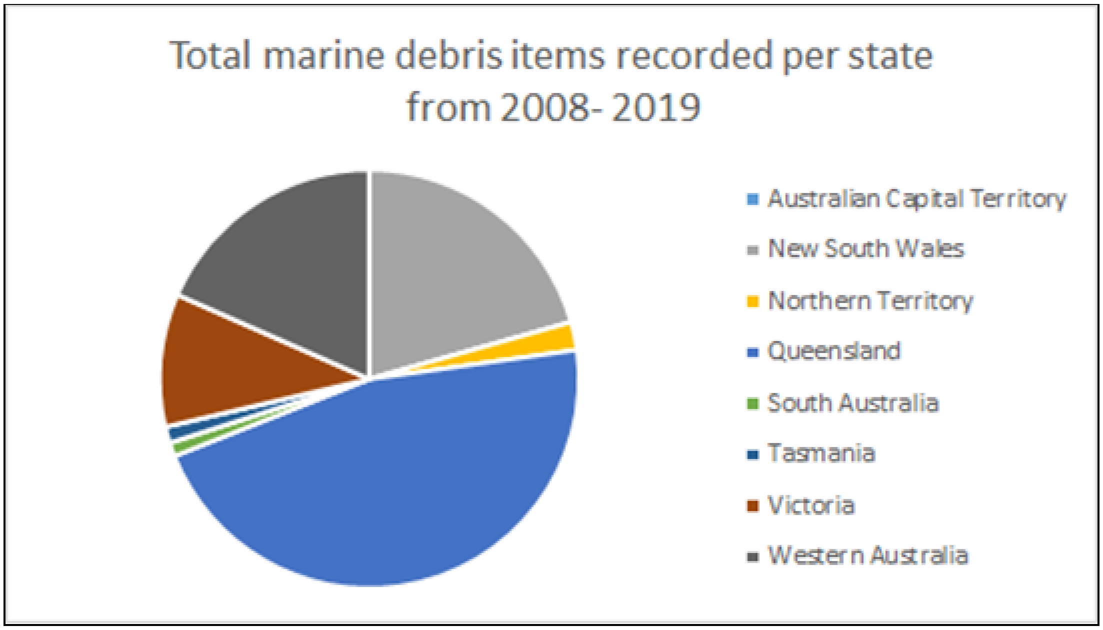



**Figure 4. Total marine debris items recorded per state from 2008-2019**
*Source: AMDI Database*

A significantly higher number of CLS was recovered in QLD followed by WA (Table 1). It should be noted that this includes all CLS types. OceanWatch did not have enough data to identify CLS types that are predominantly used by professional fishers, e.g., A1, A5 types (Figure 5).

**Table 1. Total numbers of all chemical light sticks recorded on Australian coastlines per state for the period 2008 - 2019**
*Source: AMDI Database*

| Location | NT | ACT | NSW | QLD | SA | TAS | VIC | WA |
|---|---|---|---|---|---|---|---|---|
| CLS | 27 | 44 | 3723 | **18,681** | 229 | 44 | 715 | 8,997 |

Cylume sticks - type A

**Figure 5. CLS categorised as type A in the Australian Marine Debris Initiative**
*Source: Tangaroa Blue Foundation*

There was a significant fluctuation in the numbers of CLS recovered each year (Table 2). While 2015 was double that of 2014, some other years the overall numbers are still quite low - keeping in mind the numbers here are for all CLS types, not just those recorded as being used by professional fishing. Also, it is important to note that the numbers presented here are those that were recorded following cleanups, and some groups are known to have stored focus items (Coolum & North Shore Coast Care). These items are yet to be analyzed and inputted in the Australian Marine Debris Initiative. There are many locations that have not been surveyed which could potentially add to the totals presented in Table 2. Some CLS would also wash back out with tides into currents, and therefore would not be collected during beach cleanups. Not all models of CLS float, and even those that do once punctured may lose buoyancy and sink to the seafloor.

**Table 2. Chemical light sticks recorded on coastline within the study area of the GBR per year for the period 2008 - 2019**
*Source: AMDI Database*

| **Year** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | **2015** | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total** | 15 | 72 | 145 | 47 | 291 | 433 | 690 | **1227** | 983 | 504 | 557 | 785 |

When plotting visually how the recovery number of light sticks compare across Australia, we get the below map (Figure 6). Mid- and Southern Queensland cleanup locations appear to have higher numbers than other locations around the country.

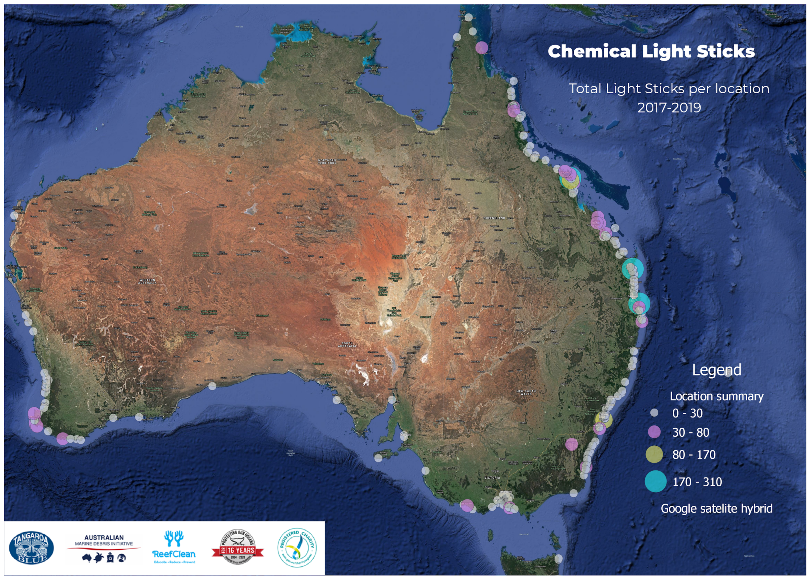



**Figure 6. Map of all chemical light sticks recorded by Tangaroa Blue Foundation for the period 2017 - 2019**
*Source: Tangaroa Blue Foundation*

When focusing on the GBR study area, local sites of cleanups indicate hotspots (Figure 7). However, as previously mentioned, with large areas of the coastline unmonitored or irregularly cleaned, it is difficult to draw conclusive results from such mapping.

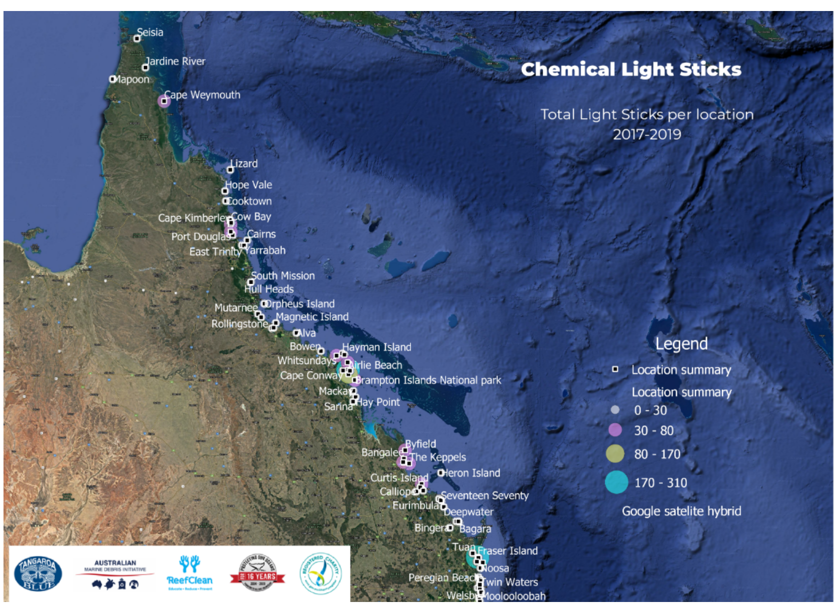



**Figure 7. Map of all chemical light sticks recorded by Tangaroa Blue Foundation on coastline within the study area of the GBR for the period 2017 - 2019**
*Source: Tangaroa Blue Foundation*

## 1.6 Why are chemical light sticks an issue

Although substantial literature exists on the behaviour of marine organisms in response to artificial light sources, the impacts of plastic accumulation in marine environments, and the toxicity of chemical CLS compounds to marine fauna and humans, are unknown. Comparatively, little knowledge exists on the feasibility/impacts of employing alternative fish attractants and/or light sources (i.e. LED vs chemiluminescent light), and waste-stream management regarding CLS disposal. The primary polluting effects of chemical CLS can be categorized in three ways: plastic, chemical and light.

### 1.6.1 Plastic Pollution - Research on North and South American fisheries

The bioaccumulation of plastic and microplastics in marine species is well documented and results in higher mortality rates and degradation of ecosystems. CLS contribution to marine debris has also been looked at as contributing to entanglement rates and aesthetics. Chemical light stick-specific plastic contribution to oceans is however unknown. No statistics exist for the global production of marine plastics associated with fishing lights, regardless of the light source. Nguyen and Winger's (2019) research showed that even if every trap in the snow crab fishery off the Atlantic coast of Canada (1.2 m) were equipped with a low-powered LED light (57.6 g plastic), it would equate to placing 69.1 tons of plastic into the ocean annually. This research further highlights a significant flaw in the alternative light source literature regarding source reduction: even though LEDs are reusable and have a relatively long lifespan, it is impossible to control the number of lights lost once placed into the ocean. Assuming just 8% of traps are lost annually in this scenario, it still equates to 5.5 tons of plastic debris in the north Atlantic per year.

Litter from chemical light sticks is considered the largest source of plastic waste from underwater fishing lights that could affect the environment and human health (Nguyen & Winger, 2019). Light sticks have a short lifespan, i.e. they work for 12 hours and are non-reusable (Ito et al., 1998; Stone and Dixon, 2001; Poisson et al., 2010). After a single day of operation, thousands of spent light sticks may be discarded at sea and constitute a potential toxicant to marine flora and fauna (Poisson et al., 2010). For instance, 7000 discarded light sticks were collected within 90 km of the northern coast of Bahia State, Brazil (Oliveira et al., 2014). This highlights the fact that fishing operations using light sticks contribute to the risk of plastic waste (Oliveira et al., 2014). Although there have been international agreements banning the disposal of waste at sea since the 1970s, it is hard to control and enforce in reality (Detloff and Istel, 2016; Morris et al., 2016).

### 1.6.2 Chemical Pollution and Toxicity

The chemical solution in CLS poses a significant risk to marine fauna and human health. The chemicals used in CLS are generally a mixture of hydrogen peroxide, oxylate, and coloured dyes (Santos 2009). These compounds were found to have adverse effects on the survival and hatchability of marine species. For example, after just 48 hours of exposure to the chemical solution the hatchability in *Artemia salina*, a species of aquatic crustaceans, decreased by 100% (Pinho, 2009). Chemiluminescent compounds have more recently been indicated as potentially toxic at every concentration in human exposures with chemical light sticks after disposal on shores (Cesar-iberio, 2017). A study in *Nature* found complementary evidence of high cyto- and genotoxicity in light stick solutions in exposure with humans (Oliveira, T., da Silva, A., de Moura, R, 2014).

#### 1.6.3 Light Pollution and indirect effects of light-inducted behaviour responses

The light produced by CLS during their lifespan contributes to ambient light pollution, which may have adverse effects on marine fauna and is considered a threat to biodiversity (Nguyen, 2018).

Light-induced behavioural responses are the reason that CLS are used. Some target species are attracted by light sources such as CLS, stimulating feeding behaviour (as CLS may emulate luminescence of injured prey species). This stimulus may influence behavioural response in certain non-target (including TEP) species. However, data are conflicting on the direct correlation of CLS on increased catch rates of TEP species and further research is required.

CLS have been found to impact fish foraging behaviour, spatial distribution, migration, and predation (Nguyen, 2018). The increase in light stick use has been associated with an increase in catch rates of some target species (Nguyen, 2018). That said, it is unclear whether or not the use of CLS has a direct impact on increased yields and improved fishing performance in general. Further research needs to be done to assess any correlation between CLS use and catch rate.

#### 1.6.4 Cost-Benefit Analysis

Despite the increasingly well-known negative impacts of chemical light sticks use, their potential to increase catch rate, and their energy effectiveness compared to other GHG-emitting commercial light sources, make chemical light sticks appealing to fishermen from a cost-benefit perspective. Because luminous attractors represent such a large proportion of overall costs, especially for small-scale operations, more research on the relative effectiveness of different types of attractors should be conducted to maximize return per lights deployed.

## 1.7 Background on fishing industry use of chemical light sticks

Chemical light sticks are used internationally in pelagic longline fisheries as fish attractants. The chemical solutions mimic light that bait species usually produce in addition to improving the fisherman's view of the bait. These CLS have short lifespans (~12 hours) and are non-reusable. In addition to being a primary source of plastic pollution, CLS also contributes to light pollution that may threaten marine fauna. Queensland is impacted by marine debris (greater than 5 mm) and light stick pollution more than any other Australian State. Tangaroa Blue estimates that

Queensland has recorded the highest number of discarded CLS over the last decade (18,681), which is over 9,600 more than any other state during the same timeframe (Tangaroa Blue, n.d.). The disproportionate accumulation of chemical light sticks in Queensland is of particular concern given the potential impact on the Great Barrier Reef.

### 1.7.1 Summary of Eastern Tuna and Billfish Fishery

In Australian waters two Commonwealth fisheries target pelagic species, the Eastern Tuna and the Billfish Fishery (ETBF), and the Western Tuna and Billfish Fishery (WTBF). The ETBF is managed by output controls such as limiting the catch of tuna and billfish species (total allowable catch, or TAC), and input controls such as restricting the number of boats that can fish and regulating the configuration of gear they can use. The five main species targeted by the ETBF include albacore tuna, bigeye tuna, broadbill swordfish, striped marlin and yellowfin tuna (Table 3).

**Table 3. Eastern Tuna and Billfish Fishery total allowable catch per year for the period 2017 - 2019**

*Source: FRDC*

| Species | 2017 TAC | 2018 TAC | 2019 TAC |
|---|---|---|---|
| **Albacore tuna** | 2,500 | 2,351 | 2,500 |
| **Bigeye tuna** | 1,056 | 957 | 1,056 |
| **Yellowfin tuna** | 2,400 | 2,054 | 2,400 |
| **Broadbill swordfish** | 1,285 | 960 | 1,250 |
| **Striped marlin** | 351 | 311 | 351 |

The total fishery value of the ETBF was $AUD 35 million in 2015.

Two types of fishing gears are used in this fishery:

- Longline: baited hooks attached to the mainline by short lines called snoods that hang off the line. The longline can be many kilometres long and can carry thousands of hooks (Figure 8);
- Minor line: short lines and only have a small number of hooks, often even just one. The main forms of minor line fishing are; trolling, poling, rod and reel.

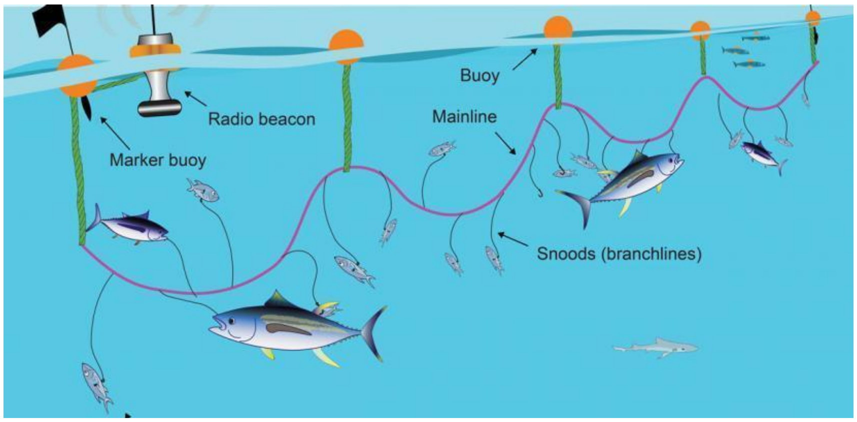
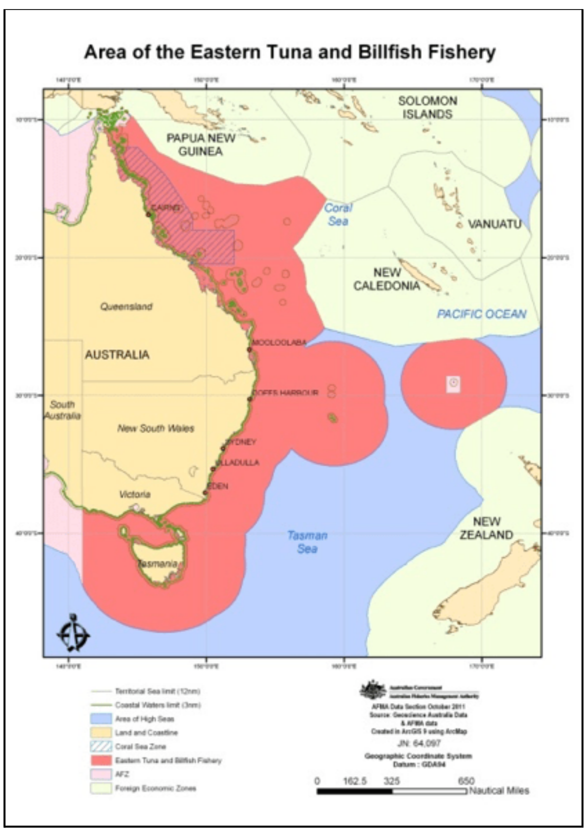
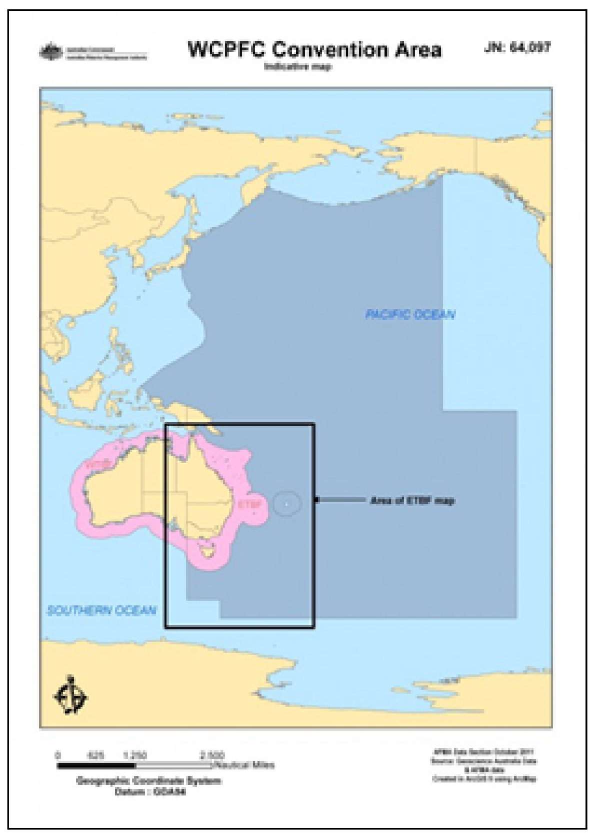



**Figure 8. Longlining fishing method diagram**
*Source: Australian Fishery Management Authority*

The Eastern Tuna and Billfish Fishery extends from Cape York in Queensland to the South Australian/Victorian border. Fishing occurs in both the Australian Fishing Zone and adjacent high seas (Figures 9-10).




**Left image**
**Figure 9. The area of the Eastern Tuna and Billfish Fishery**
*Source: Australian Fisheries Management Authority*

**Right image**

**Figure 10. The Australian fishery in relation to the Western and Central Pacific Fisheries Commission Area of Competence. The ETBF is also part of the Western and Central Pacific Fisheries Commission**.

*Source: Australian Fisheries Management Authority*

Between May and October, the waters off NSW and Victoria are cooler and species, like southern bluefin tuna, migrate through these areas.

The major landing ports are:

- Cairns
- Mooloolaba
- Gold Coast
- Coffs Harbour
- Nelson Bay
- Sydney
- Ulladulla
- Bermagui

The ETBF's fishing season is 12 months, beginning on the 1st of January. Since 1997, the Eastern Tuna and Billfish Fishery (ETBF) logbooks have collected information on the use of light-sticks in the fishery for each fishing operation.

A CSIRO report 2014/021 "Developing innovative approaches to improve CPUE standardisation for Australia's multispecies longline fisheries" provides information relating to the use of light sticks in the ETBF, for the period 1997-2015. One of the criteria analysed in this study was the percentage of hooks with CLS observed (Table 4).

**Table 4. Number of observations of the percentage of hooks with CLS in the Eastern and Tuna Billfish Fishery during the period 1997 - 2015**

*Source: CSIRO*

| Percentage of hooks with chemical light sticks | Number of observations |
|---|---|
| 0% | 34,931 |
| 1 to 19 % | 10,640 |
| 20 to 39 % | 17,327 |
| 40 to 59 % | 37,997 |

| | |
|---|---|
| 60 to 79 % | 6,275 |
| 80 to 99 % | 7,898 |
| 100% | 22,301 |

Light stick usage is influenced by individual fisher practices in response to the target species behavioural preferences. For example, the catch of broadbill swordfish increases with the use of CLS in afternoon sets while albacore tuna show preference for pilchard baits, with fewer CLS used in morning sets.

Examination of the following map indicates effort for the fishery in 2018 (Figure 11).

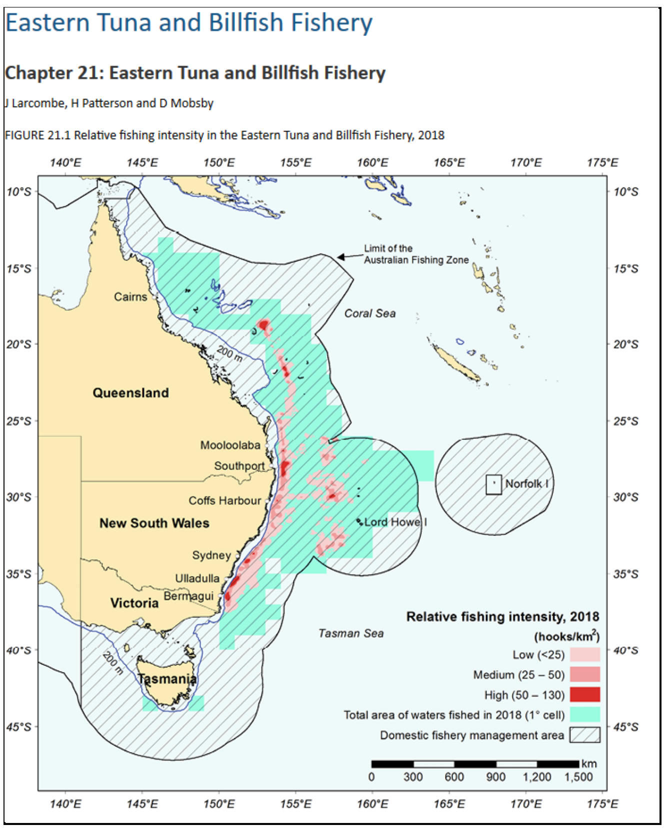



**Figure 11. Relative fishing intensity in the Eastern Tuna and Billfish Fishery**
*Source: Australian Government - Department of Agriculture, Water and the Environment*

### 1.7.2 Summary of Western Tuna and Billfish Fishery

The Western Tuna and Billfish Fishery covers the sea area west from the tip of Cape York in Queensland, around Western Australia, to the border between Victoria and South Australia (Figure 12).

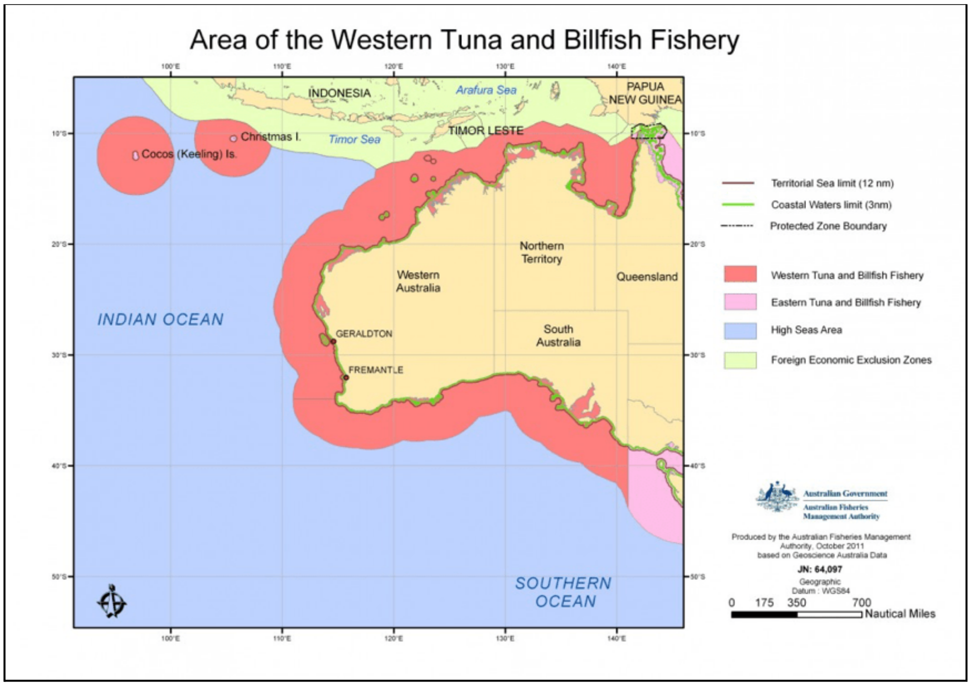



**Figure 12. The area of Western Tuna Billfish Fishery**
*Source: Australian Fisheries Management Authority*

Fishing occurs in both the Australian Fishing Zone and adjacent high seas, and the major landing ports are Fremantle and Geraldton. The WTBF's fishing season is 12 months, beginning on the 1st of February.

Both the above fisheries are multi-species and use gear according to fish movements, water temperatures and climatic conditions. Light stick use thus varies from night to night, day to day and depending on the target species.

Examination of the following map indicates effort for the fishery for 2018 (Figure 13).

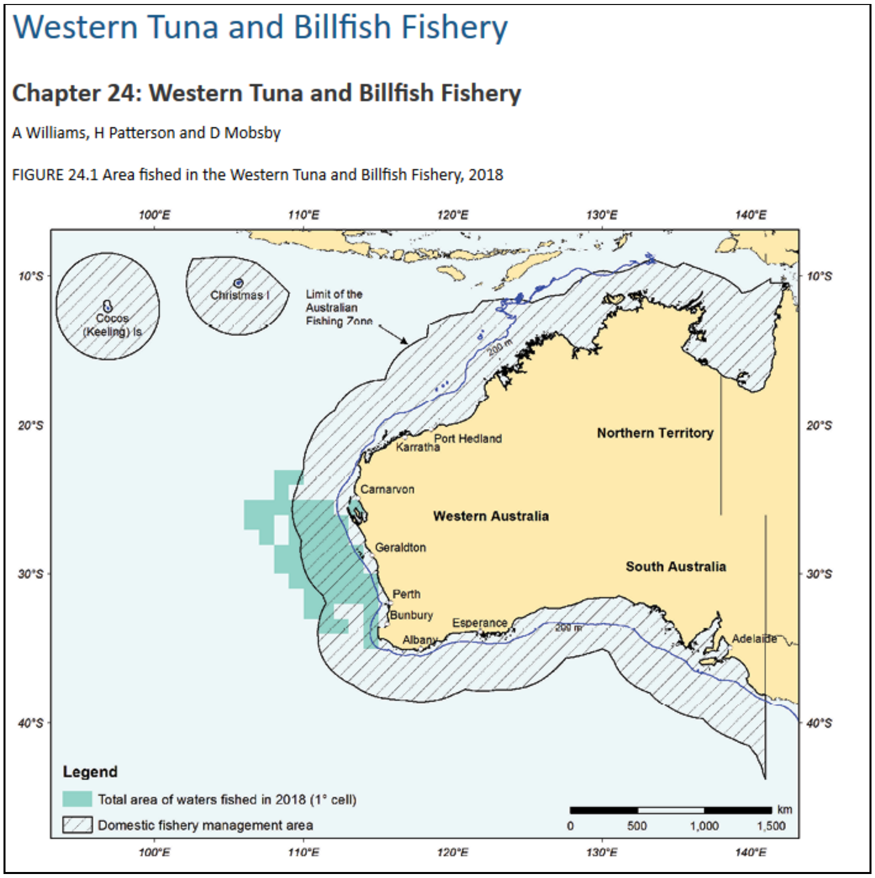



**Figure 13. Fishing intensity in the Western Tuna and Billfish Fishery**
*Source: Australian Government - Department of Agriculture, Water and the Environment*

It is logical in a smaller scale source reduction plan that by examining effort, or use of the target product by the fishery, one can conclude the likely sources of CLS loss. In this instance, it is unlikely, based on its fishing distribution, that the western tuna billfish fishery contributes to the light stick occurrence on beaches on the eastern side of Australia. However, the widespread effort within the eastern tuna and billfish fishery does not assist in linking effort to a source of CLS loss. In making such a comparison it might be more relevant to look at set gear by species targeted, as identified above. OceanWatch does not know whether these data exist.

As a part of the study, OceanWatch developed a survey to gather an understanding of light stick usage within the professional fishing industry. OceanWatch opened the survey to wild-catch fishers in some state waters. While the feedback indicated minimal use. It is useful to consider the types of fishing effort in each area of interest, as location may align with debris distribution also.

The below maps are generated from the Queensland Government's website Q-fis (Figures 14 to 16). Also in this instance the granularity does not point to specific locations of potential loss, and is even less valuable given that the Queensland fishing industry suggested CLS are used minimally in the state, and that sometimes light sticks are used only in one-off trials during crab pot fishing.

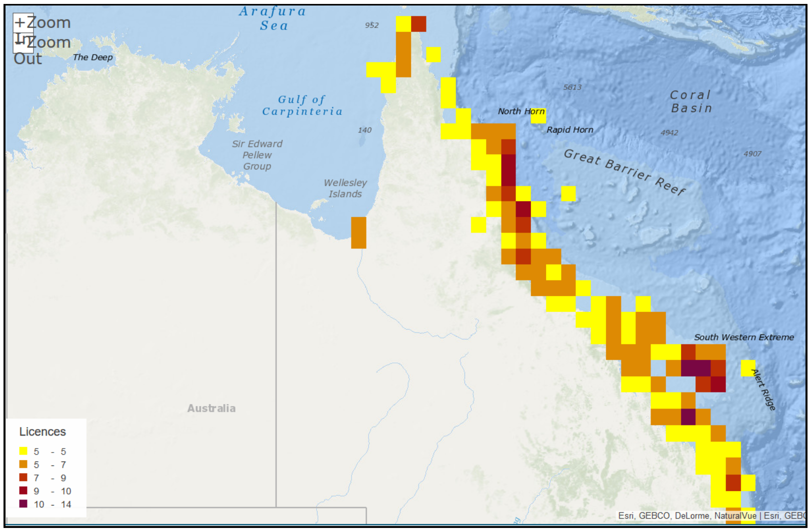



**Figure 14. The commercial catch and effort data by method for the Charter fishery for all years from 1990**

*Source: Queensland Government's website Q-fis*

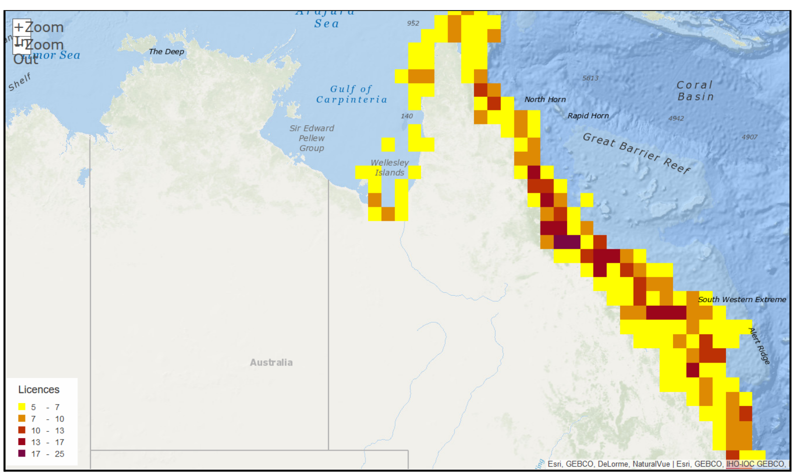



**Figure 15. The commercial catch and effort data for the Line fishery for all years from 1990**

*Source: Queensland Government's website Q-fis*

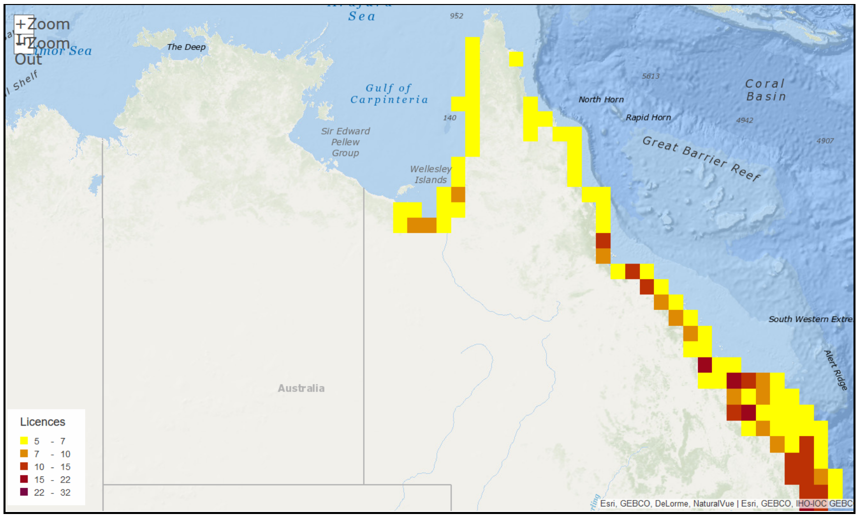


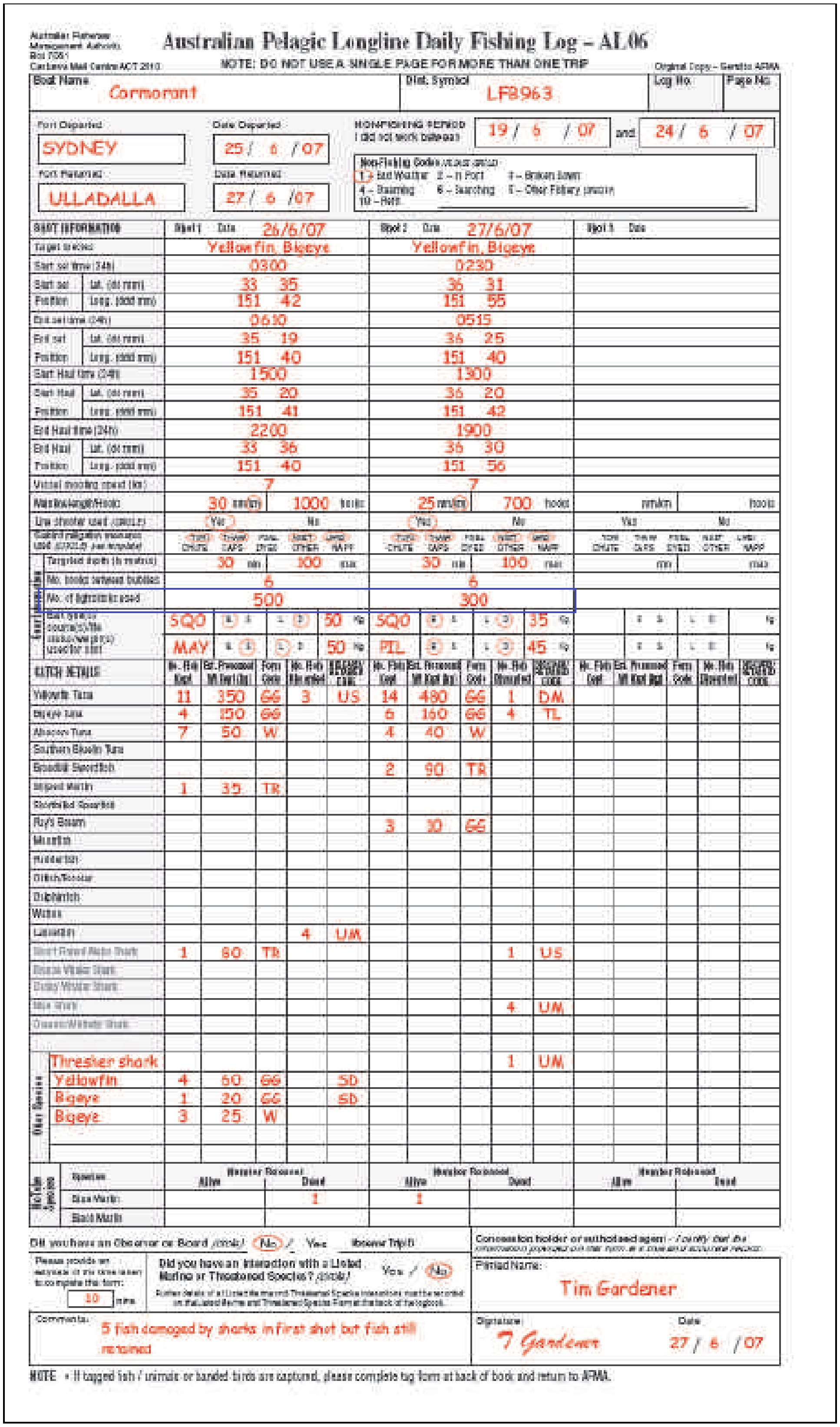

**Figure 16: The commercial catch and effort data for the Pot fishery for all years from 1990.**
*Source: Queensland Government's website Q-fis*

### 1.7.3 Australian Fisheries Management Authority - Data on CLS losses

#### Australian Fisheries Management Authority

The Australian Fisheries Management Authority (AFMA) is the Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources on behalf of the Australian Community.

AFMA Daily Fishing Logbooks are a record of daily catch information (Figures 17). They are in place and compulsory in the Eastern and Tuna Billfish Fishery. Any holder of a fishing concession is responsible for ensuring that the Daily Fishing Logbook is completed and submitted to AFMA. Those logbooks are used to collect information about fishing location, gear type used, catch composition and interactions with threatened, endangered or protected species.



Australian Fisheries Management Authority
Box 7051
Canberra Mail Centre ACT 2610

# Australian Pelagic Longline Daily Fishing Log - AL06

NOTE: DO NOT USE A SINGLE PAGE FOR MORE THAN ONE TRIP

Original Copy – Send to AFMA

| Boat Name | Dist. Symbol | Log No. | Page No. |
|---|---|---|---|
| Cormorant | LFB963 | | |

Port Departed: SYDNEY — Date Departed: 25 / 6 / 07

Port Returned: ULLADALLA — Date Returned: 27 / 6 / 07

NON-FISHING PERIOD: I did not work between 19 / 6 / 07 and 24 / 6 / 07

Non-Fishing Codes: 1 – Bad Weather, 2 – In Port, 3 – Broken Down, 4 – Steaming, 6 – Searching, 7 – Other Fishery, 10 – Rest

| SHOT INFORMATION | Shot 1 Date 26/6/07 | Shot 2 Date 27/6/07 | Shot 3 Date |
|---|---|---|---|
| Target species | Yellowfin, Bigeye | Yellowfin, Bigeye | |
| Start set time (24h) | 0300 | 0230 | |
| Start set Position Lat. (dd mm) | 33 35 | 36 31 | |
| Start set Position Long. (ddd mm) | 151 42 | 151 55 | |
| End set time (24h) | 0610 | 0515 | |
| End set Position Lat. (dd mm) | 35 19 | 36 25 | |
| End set Position Long. (ddd mm) | 151 40 | 151 40 | |
| Start Haul time (24h) | 1500 | 1300 | |
| Start Haul Position Lat. (dd mm) | 35 20 | 36 20 | |
| Start Haul Position Long. (ddd mm) | 151 41 | 151 42 | |
| End Haul time (24h) | 2200 | 1900 | |
| End Haul Position Lat. (dd mm) | 33 36 | 36 30 | |
| End Haul Position Long. (ddd mm) | 151 40 | 151 56 | |
| Vessel shooting speed (kn) | 7 | 7 | |
| Mainline length/Hooks | 30 nm/km, 1000 hooks | 25 nm/km, 700 hooks | nm/km, hooks |
| Line shooter used (circle) | Yes / No | Yes / No | Yes / No |
| Seabird mitigation measures used (circle) | TORI CHUTE, THAW CAPS, FOOD DYED, NIGHT OTHER, LINE NAPP | TORI CHUTE, THAW CAPS, FOOD DYED, NIGHT OTHER, LINE NAPP | TORI CHUTE, THAW CAPS, FOOD DYED, NIGHT OTHER, LINE NAPP |
| Targeted depth (in metres) | 30 min, 100 max | 30 min, 100 max | min, max |
| No. hooks between buoys | 6 | 6 | |
| No. of lightsticks used | 500 | 300 | |
| Bait species source(s)/life status/weight(s) used for shot | SQO, 50 kg; MAY, 50 kg | SQO, 35 kg; PIL, 45 kg | kg |

| CATCH DETAILS | Shot 1 No. Fish Kept | Est. Processed Wt Kept (kg) | Form Code | No. Fish Discarded | Discard/Released Code | Shot 2 No. Fish Kept | Est. Processed Wt Kept (kg) | Form Code | No. Fish Discarded | Discard/Released Code | Shot 3 No. Fish Kept | Est. Processed Wt Kept (kg) | Form Code | No. Fish Discarded | Discard/Released Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellowfin Tuna | 11 | 350 | GG | 3 | US | 14 | 480 | GG | 1 | DM | | | | | |
| Bigeye Tuna | 4 | 150 | GG | | | 6 | 160 | GG | 4 | TL | | | | | |
| Albacore Tuna | 7 | 50 | W | | | 4 | 40 | W | | | | | | | |
| Southern Bluefin Tuna | | | | | | | | | | | | | | | |
| Broadbill Swordfish | | | | | | 2 | 90 | TR | | | | | | | |
| Striped Marlin | 1 | 35 | TR | | | | | | | | | | | | |
| Shortbill Spearfish | | | | | | | | | | | | | | | |
| Ray's Bream | | | | | | 3 | 30 | GG | | | | | | | |
| Moonfish | | | | | | | | | | | | | | | |
| Rudderfish | | | | | | | | | | | | | | | |
| Oilfish/Escolar | | | | | | | | | | | | | | | |
| Dolphinfish | | | | | | | | | | | | | | | |
| Wahoo | | | | | | | | | | | | | | | |
| Lancetfish | | | | 4 | UM | | | | | | | | | | |
| Short Finned Mako Shark | 1 | 80 | TR | | | | | | 1 | US | | | | | |
| Bronze Whaler Shark | | | | | | | | | | | | | | | |
| Dusky Whaler Shark | | | | | | | | | | | | | | | |
| Blue Shark | | | | | | | | | 4 | UM | | | | | |
| Oceanic Whitetip Shark | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Thresher shark | | | | | | | | | 1 | UM | | | | | |
| Yellowfin | 4 | 60 | GG | | SD | | | | | | | | | | |
| Bigeye | 1 | 20 | GG | | SD | | | | | | | | | | |
| Bigeye | 3 | 25 | W | | | | | | | | | | | | |

| No Take Species | Shot 1 Number Released Alive | Dead | Shot 2 Number Released Alive | Dead | Shot 3 Number Released Alive | Dead |
|---|---|---|---|---|---|---|
| Blue Marlin | | 1 | 1 | | | |
| Black Marlin | | | | | | |

Did you have an Observer on Board (circle) No / Yes Observer Trip ID

Please provide an estimate of the time taken to complete this form: 10 mins

Did you have an interaction with a Listed Marine or Threatened Species? (circle) Yes / No

Further details of all Listed Marine and Threatened Species interactions must be recorded on the Listed Marine and Threatened Species Form at the back of the logbook.

Concession holder or authorised agent - I certify that the information provided on this form is a true and accurate record.

Printed Name: Tim Gardener

Signature: T Gardener — Date: 27 / 6 / 07

Comments: 5 fish damaged by sharks in first shot but fish still retained

NOTE • If tagged fish / animals or banded birds are captured, please complete tag form at back of book and return to AFMA.

**Figure 17. Australian Pelagic Longline Daily Fishing Log - AL06 (in use since early 2008)**

*Source: Australian Government - Bureau of Rural Sciences*

In addition to Daily Fishing Logbooks, AFMA employed fisheries observers until July 2015 to collect data on board Eastern Tuna and Billfish Fishery vessels. Observers are AFMA employees trained in specialised sampling techniques including biological traits such as the sex and length of a fish and environmental observations such as whether birds presence and other wildlife that could be seen during a fishing trip. For each boat from the Eastern and Tuna Billfish Fishery observed, AFMA employees fill a datasheet collecting various pieces of information including vessel name, start fishing latitude and longitude, number of light sticks deployed and retrieved.

From 2015, AFMA set up an electronic monitoring system. The e-monitoring is a system of video cameras and sensors capable of monitoring and recording fishing activities, which can be reviewed later to verify what fishers report on their fishing logbooks. This system is now compulsory for commercial fishing boats in the Eastern Tuna Billfish Fishery (Figure 18).

**Figure 18. AFMA Electronic Monitoring System installed on a boat**
*Source: Australian Government - Australian Fisheries Management Authority*

The AFMA provided OceanWatch with access to commercially sensitive data collected on Eastern Tuna and Billfish Fishery boats from 2005 to 2020. For this project, OceanWatch had access to two sets of data:

- AFMA Fisheries Observers dataset (OBS): AFMA Fishery Observers collected these data on boats from 2005 to 2015.
- AFMA Daily Fishing Logbook dataset (DFL): Fishing Concessions collecting data for each fishing trip from 2005 to 2020

The types of data collected in those two data sets are similar (vessel identification number, date and time, start fishing longitude and latitude, number of light sticks deployed), however there are some differences. For example, the OBS dataset includes the number of CLS deployed and retrieved, the DFL dataset only includes the number of CLS deployed. This means that the comparison or collation of both datasets means that the extrapolation of light stick loss is non uniform for the period in question.

No raw data are disclosed in this report to meet data licensing requirements.

**Data Analysis**

AFMA estimated observing an average of 5% of the Eastern and Tuna Billfish Fishery's boats per year. OceanWatch multiplied the light sticks data from the Fishery Observers Dataset (OBS) by 20 to have estimated numbers for 100% of the whole fishery. This kind of analysis has limitations, however with the data provided this was the best estimate OceanWatch could calculate. This gives an overall idea of the use of light sticks in the ETBF. Because Fishery Observers stopped onboard observations in July 2015, OceanWatch decided not to take into account the data collected during the first 6 months of 2015 (from January 2015 to July 2015) in the below figures to only compare whole years.

a. *LS used*

Both datasets suggest the Eastern and Tuna Billfish Fishery deployed light sticks.

According to the DFL dataset, light sticks are deployed in 73% of gear deployment shots (Figure 19). Instead, according to the OBS dataset, light sticks are deployed in 68% of gear deployment shots (Figure 20).

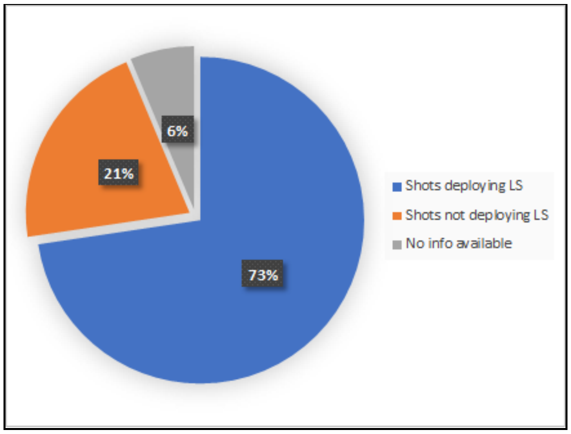



**Figure 19. Percentage of shots using light sticks based on AFMA's Daily Fishing Logbooks dataset collected from 2005 to 2020**

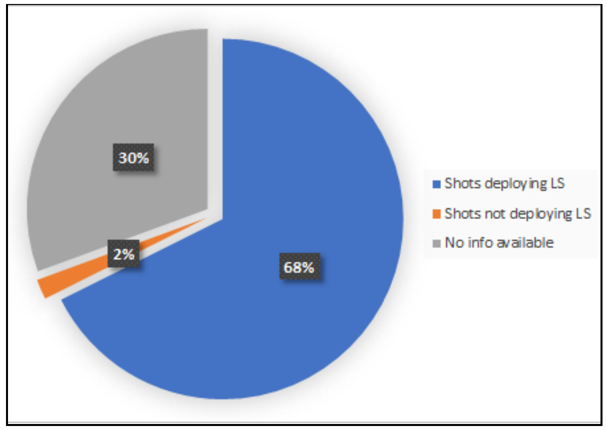



**Figure 20. Percentage of shots using light sticks based on the AFMA's Fishery Observers dataset collected from 2005 to 2015**

When combining the DFL and OBS datasets from 2005 to 2014 (as shown in Figure 21), the OBS estimates on CLS deployed are generally higher than the ones in the DFL dataset on CLS deployed for 7 years out of 10. Two hypotheses could explain this difference:

- AFMA Fishery Observers have been observing boats using more CLS than the rest of the fishery;
- The 5% observation rate is only an estimate. Extrapolating the trend allows a large margin of error. However, numbers of CLS deployed in OBS and DFL datasets in 2005 and 2006 are really close.

The DFL dataset shows an increase of CLS deployed from 2011 to 2017 and a decrease from 2017 to 2020. From 2011 to 2017, the number of CLS deployed has increased 132% according to the DFL dataset. From 2017 to 2020, the number of CLS deployed has decreased 38% according to the DFL dataset (Figure 21). According to Phil Ravanello, Program Manager at Tuna Australia, there are a couple of drivers for the decrease in CLS use:

- Squid bait use has decreased because of the high price of bait and associated light stick use.
- COVID-19 has negatively impacted export of swordfish. Therefore, fishermen are reducing their catch of swordfish while increasing their catch of albacore. When targeting albacore, longliners usually don't use CLS.

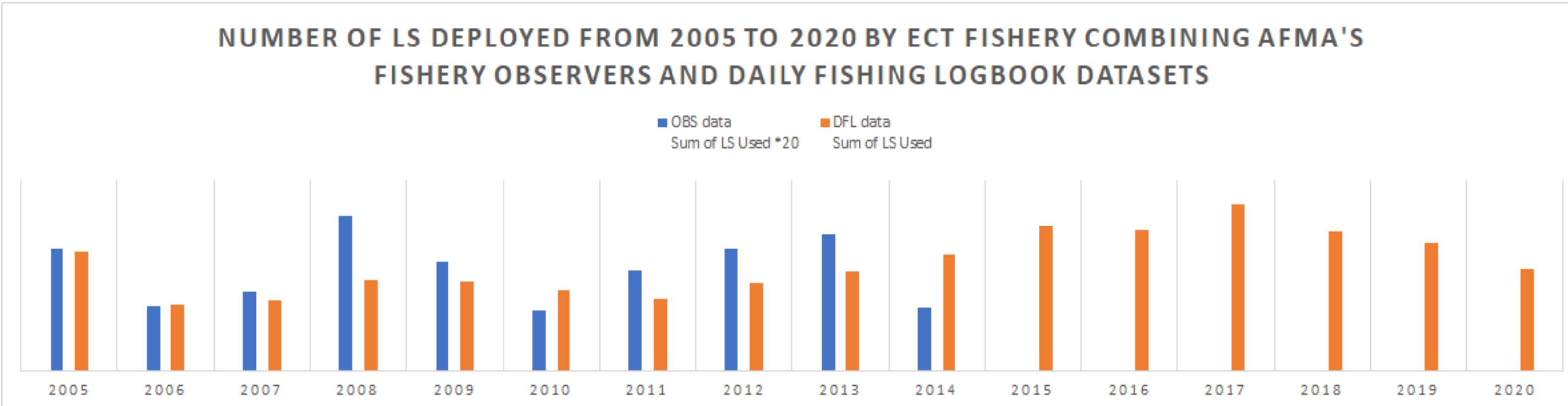



**Figure 21. Number of CLS deployed from 2005 to 2020 by ECT fishery combining AFMA's Fishery Observers and Daily Fishing Logbook datasets**

*b. LS lost*

According to the AFMA's Observers Dataset, boats of the ETBF lose on average 6.2% of light sticks deployed per year (Figure 22).

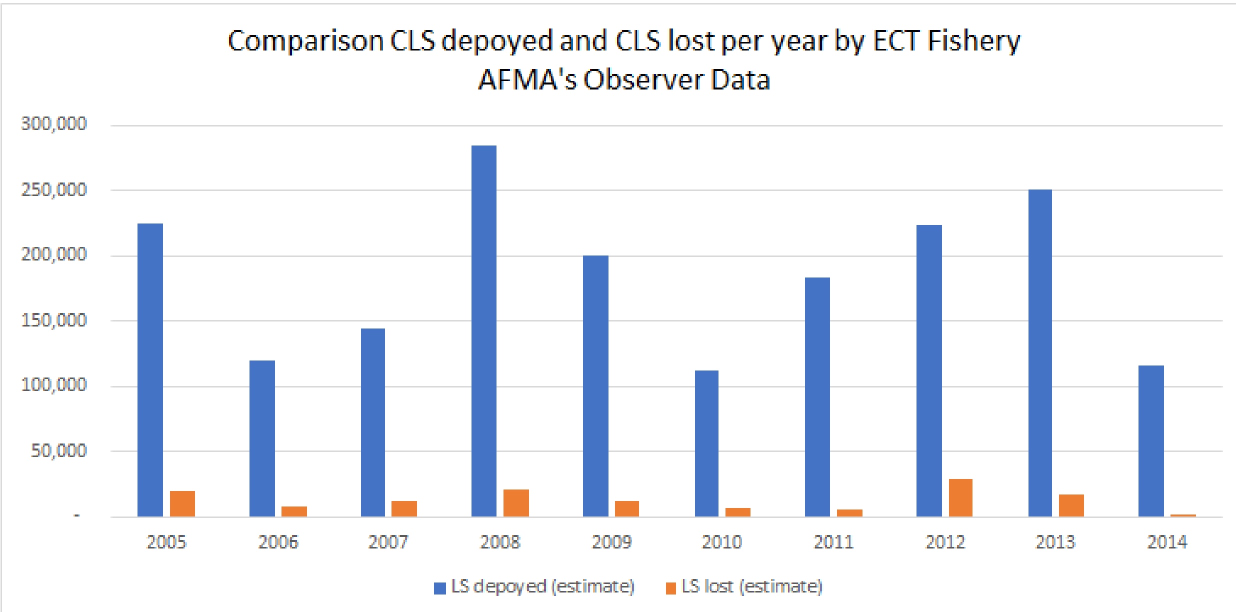



**Figure 22. Comparison of CLS deployed and CLS lost per year by ECT Fishery**
*Source: AFMA's Observer Dataset*

A fluctuation in the numbers deployed each year was noticeable (Figure 23). It is important to keep in mind the most recent data OceanWatch had access to are from 2015 and are based on AFMA officers' observations on board of around only 5% of the ETBF fleet. These are therefore not recent data.

When comparing Figure 22 with Table 2 (Chemical light sticks recorded on coastline within the study area of the GBR per year for the period 2008-2019), the number of CLS loss per year does not coincide with the numbers of CLS found on beaches with a given year or series of years. As an example, Tangaroa Blue Foundation found 690 light sticks during cleanups in 2014, which represents the highest number of CLS found during the period 2008 - 2014. However, according to OBS dataset, the ETBF lost the smallest amount during the same period, only 1% (1,205) of light sticks. It is a hard exercise to evaluate how long it would take for a light stick to wash up on the beach. However, according to the Esri software Message in a bottle, a floating marine debris located on the Australian East coast in the Australian Fishing Zone, takes up to 150 days to reach the coast (see Figure 24).

### c. *Fishing effort and CLS lost map*

Figure 24 indicates classes of CLS loss over a 10 year period per spatial location. Fishing effort is also displayed in the background. CLS loss tends to overlap with effort, although this is not always the case. Reasons for loss are not regularly recorded other than occasional reference to bite off or cut off. Bite off is a term related to loss of line due to sharks or larger animals while cut off relates to expected loss due to shipping or weather stress. One event can result in the loss of a large number of CLS commiserates with km of line/gear loss.

To create Figure 23, OceanWatch considered an arbitrary margin error of 20 CLS. This is the reason why OceanWatch didn't include shots where less than 20 CLS were lost. OceanWatch also decided to exclude all shots reporting a number of CLS deployed but didn't report any number on CLS retrieved. Indeed, OceanWatch can't evaluate the number of CLS lost without data on retrieval.

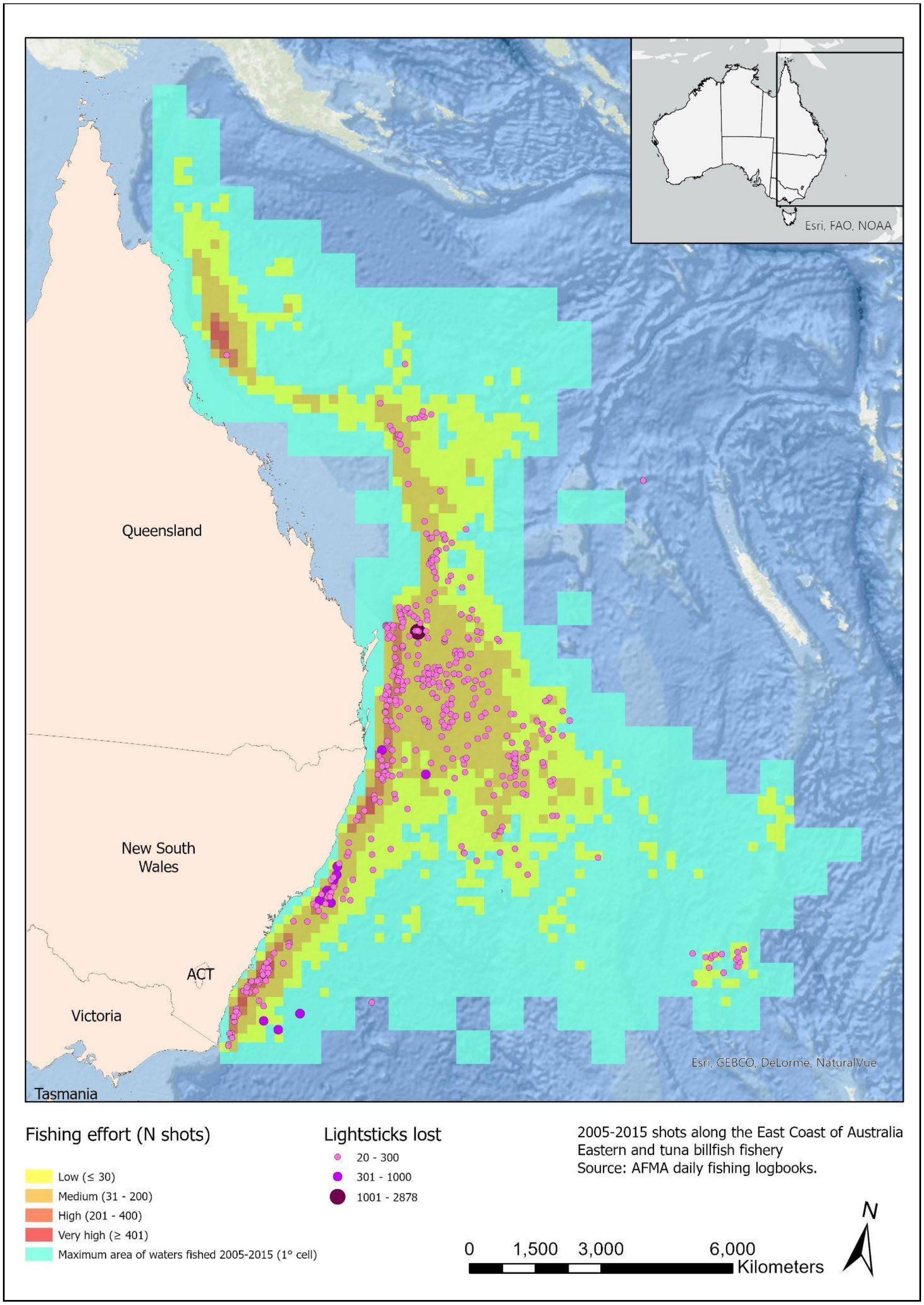



**Figure 23. Fishing Effort (in number of shots) and Chemical Light Sticks lost by the ETBF from 2005 to 2015**

Sum of fishing shots occurring in each grid cell, 30 x 30 km grid

*Source: AFMA ETBF Observers and Daily Fishing Logbooks Datasets* *d. Australian East Coast currents*

Esri developed a tool to follow and predict the migration of a message in a bottle, or an oil spill. OceanWatch used Esri software to understand where a CLS becoming marine debris could migrate. Results vary depending on the dropped pin location, currents, starting day, etc. However, it looks like whenever lost on the Australian coast, debris (if floating) tend to run along the East coast (Figure 24). Red dots represent potential origin of loss (on the 24/06/2020) and brown dots represent potential location of debris after 264 days.

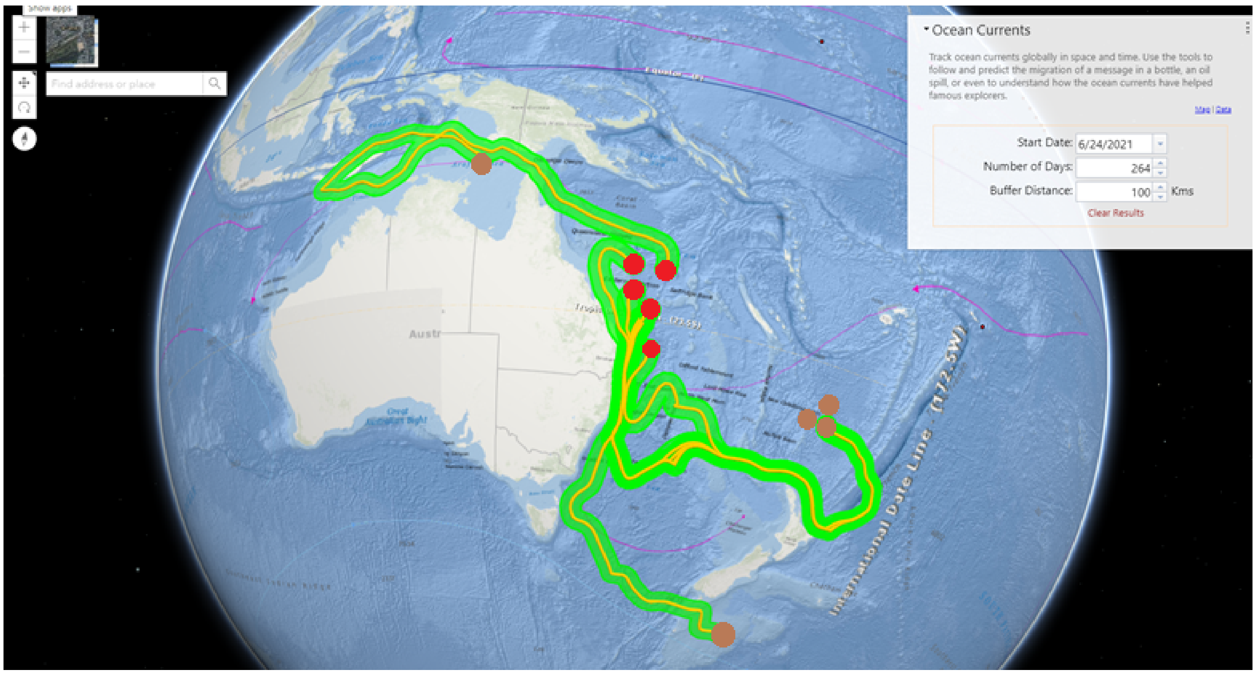



**Figure 24. Ocean currents - Message in a bottle**

*Source: Esri - Ocean Currents*

It is a difficult exercise to evaluate the behaviour of a light stick when becoming marine debris. Indeed, if light sticks get lost because of a cut off on the fishing line, the weight of this new marine debris may make it sink into the seabed.

## 1.8 Identifying Stakeholders

For the purposes of this project, “Stakeholder” has been defined as people who can be directly affected by or are users of CLS.

The following CLS user groups can be determined as CLS stakeholders;

- the fishing industry
- recreational fishers

- Indigenous customary fishers
- commercial divers
- recreational divers
- land based users of CLS (for parties, festivals and concerts)
- military
- oil and gas industry
- broad communities

The majority of the above CLS stakeholders are beyond the scope of this study. That should not be interpreted as abrogating the importance of further research to understand the impact of CLS on these groups. Given that there is broad community access to CLS, everyone has a role to play in minimising marine debris impacts, including CLS.

The focus of this study is the fishing industry, based on the knowledge, use and loss of CLS connected to fishing operations, and focuses on NSW, WA and Commonwealth fisheries. The fishing industry is defined as people involved in activities conducted in or from Australia concerned with the commercial taking of fish or seafood products. Australia's fisheries span across a large area of the Pacific Ocean. The Australian Fishing Zone, which straddles both the territorial sea and the EEZ, has an area of over 8 million $km^2$ and is larger than the area of mainland Australia. This zone contains mainly Commonwealth managed fisheries. State jurisdictions operate predominantly in coastal waters up to the 3 nautical mile limit.

## 1.9 Engagement Methodology

The following terms are defined as such for the scope of this report.

**Engagement -** a generic, inclusive term to explain a number of approaches, including one way communication or information delivery, consultation, involvement and collaboration in decision-making, and empowered action in informal groups or formal partnerships.

**Stakeholder engagement** - a planned process with identified groups of people, whether they are connected by geographic location, special interest or affiliation, to address issues affecting the marine environment.

OceanWatch follows five key principles when engaging with the fishing industry:

1. Stakeholder engagement is embedded in all that OceanWatch does as the national Marine NRM;

2. Staff are actively supported to engage stakeholders, and empowered to build partnerships;

3. Stakeholder engagement is well planned, tailored, targeted, and evaluated;

4. Provide meaningful opportunities for stakeholders to contribute to marine NRM strategies and activities;

5. Work transparently and respectfully with our stakeholders and establish clear roles and expectations.

One of the most critical aspects of conducting good extension work is choosing the right model and related tools for the job. Importantly, it is recognised that industry engagement is critical for adoption of best practice, and should be undertaken at the earliest possible stage of the project, and also throughout the delivery of the project activities. OceanWatch has identified that effective engagement with the fishing industry should mostly utilise face-to-face communication. However, in the absence of face-to-face engagement due to Covid-19 restrictions, OceanWatch has utilised secondary engagement methods such as surveys, e-mails, newsletters and phone calls.

# PART 2 Solution proposals, trials and analysis

In seeking possible solutions to mitigating CLS presence on our coastline, OceanWatch first reviewed previous literature and ideas on the topic. It was observed that a key area of response that needed more attention was in developing and implementing less harmful alternatives to CLS, with an emphasis on reusability and biodegradability. These alternatives are light sources, bio-plastics and alternate prey-mimicking methods.

## 2.1 Stakeholders

Various types of stakeholders within the fishing industry were engaged throughout this project (Table 6).

**Table 6. List of stakeholders and their engagement type contacted during the study**

| Category | Organisation | Contacted by | Date | Engagement type (consult or involve) |
|---|---|---|---|---|
| **Australian Stockers of CLS** | Chandlery at the Sydney Fish market | OceanWatch | April 2020 | Consulted as to range and sale of sticks |
| **Individuals** | Australian Southern Bluefin Tuna Industry Association | OceanWatch | May 2020 | Consulted on study direction |
| | Queensland Trawl Boat fishermen | OceanWatch | May 2020 | Consulted as a QSIA board member with insight into state fisheries |
| | Members - Professional Fishers Association | OceanWatch | May 2020 | Consulted through the first CLS survey to provide insight into NSW state fisheries |
| | Master Fishermen of NSW- OceanWatch Master Fisherman Program | OceanWatch | June 2020 | Consulted through the first CLS survey |
| | MSC Manager | TBF | June 2020 | Consulted on experiences of |

| | | | | |
|---|---|---|---|---|
| | | | | pelagic fishing |
| | MSC Manager | TBF | June 2020 | Consulted re experiences on light stick use |
| | MSC Manager | TBF | June 2020 | Consulted - Waiting for an answer |
| | Members - Tuna Australia | OceanWatch | June 2020 | Consulted through the second CLS survey |
| | Members - Queensland Seafood Industry Association | OceanWatch | May 2020 | Consulted through the first CLS survey |
| | Members - Western Australia Fishing Industry Council | OceanWatch | June 2020 | Consulted through the second CLS survey (not yet released at time of this publication) |
| | Global Ghost Gear Initiative | OceanWatch | June 2020 | Consulted regarding the world situation |
| **Peak bodies** | AFMA | TBF | May 2020 | Requested to be involved in data understanding Involved in the Working Group |
| | Tuna Australia | OceanWatch | June 2020 | Involved in the Working Group Involved as a partner in the trial |

**Feedback comments**

Individuals (names in some cases removed to protect anonymity).

- Queensland trawl boat skipper: "CLS are not used within the trawl sector. Light (mostly battery operated) has been discussed as a method of bycatch reduction but I wasn't aware of any uptake."
- SA tuna deckhand: "It's not uncommon to lose between 5-15% of CLS used per night overboard. It's a sensitive issue that a few years back was of widespread concern. Most

losses occur as a result of cut lines, off the lines due to weak attachment points, or simply a missed throw at the bin."

- MSC Representative: "Longline fishermen mostly in the swordfish fisheries use CLS but I'm not sure how many use renewable lights vs. single use. In the Pacific Ocean a decade ago everyone was using single use sticks and I used to import from wherever I could get the best price. The things a skipper looks for is price and brightness/burn time. Regarding disposal I would hope most skippers instruct their crews to collect the sticks during haul back to take ashore as there might be 500+ attached each night. To be honest I don't know how conscientious crews are these days. Even with crews that collect the sticks there will always be some loss, maybe up to 10% depending on the attachment method."
- MSC Australia representative: "I have not done much work with longline operators in Australia but I'm with you that glowstick use in the commercial fishing industry is definitely something that is popular amongst this fishing method. The only other sector that use glowsticks as prevalently as the longline fleets could be the recreational fishing sector – I often see them washed up on beaches after big storms. MSC WA Octopus use a flashing lure in their traps to catch octopus but this is a bit different to the use of glowsticks in a longline fishery (they are less likely to be lost as the equipment is higher value and reusable)."
- AFMA observer: "Light stick use is variable on each vessel. Some use one per hook, others one per 5 or 10 hooks. Use doesn't always result in a higher catch. The method of attachment was suggested as a possible improvement."
- AFMA observer: "I don't recall use of light sticks based on a month on a Japanese boat."
- Anecdotal estimate: "A previous estimate by Renee Belanger in 2013 suggested from her interviews with Stockists of CLS, 1500 CLS were lost of between the 6-8 million sold. If they were all Professional fishing related that equates to a recovery rate of 0.021% of those sold. 1500 sticks could theoretically be lost from 1 bin of rubbish lost overboard."

Peak bodies

- Queensland Seafood Industry Association (QSIA) is the peak industry body representing the Queensland seafood industry. The members include professional fishers, seafood processors, marketers, retailers and other businesses associated with the seafood industry. Their representation to members and the community at large is to promote the consumption of wild caught Queensland seafood. The EO suggested only a few members fished the Eastern Tuna and Billfish fishery and wasn't aware of other Qld state based fisheries that used CLS but would ask around. He suggested OceanWatch contact a QSIA board member based in Bundaberg.
- Formed in 2016, Tuna Australia represents statutory fishing right owners, holders, fish processors and sellers, and associate members of the Eastern and Western tuna and billfish fisheries of Australia. The goal of Tuna Australia is to plan, invest and manage

the association to improve representation of the fishery. The CEO of Tuna Australia and manager has assisted in the generation and dispersal of survey questions after looking into the topic internally. While the recovery of survey results during this time was expected to be low due to Covid-19 trading conditions they will continue to work together over the coming months to further delve into the topic.

## 2.2 Outline of the loss process

**Chemical light stick use within industry surveys**

Two surveys were deployed to better understand light stick usage within the professional fishing industry.

Survey 1 was distributed via Survey Monkey to NSW wildcatch professional fishermen, to identify individual fisher endorsements, frequency of CLS use, importance of CLS use on catch rates, potential CLS loss and measures to minimise loss, preferred CLS types and origin of purchase and CLS alternatives (Appendix 5.1). Survey 2 targeted members of Tuna Australia and was designed to capture more specific information from both the Eastern and Western Tuna and Billfish fisheries in Commonwealth waters (Appendix 5.2).

### 2.2.1 Survey 1: results to date - 30/06/2020

20 people answered the survey including 17 professional fishermen. As this study is focusing on the use of CLS by professional fishermen, only professional fishermen's answers are provided below.

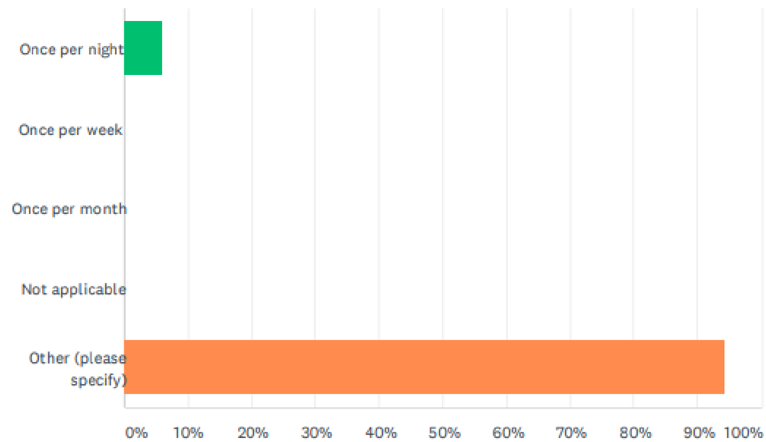
Q2 Which fishery do you work within?

Answered: 18 Skipped: 14

| Fishery | Responses |
|---|---|
| Queensland Commercial Pot | 1 |
| NSW Estuary General | 8 |
| NSW Ocean Trap and Line | 5 |
| NSW Estuary Prawn Trawl | 3 |

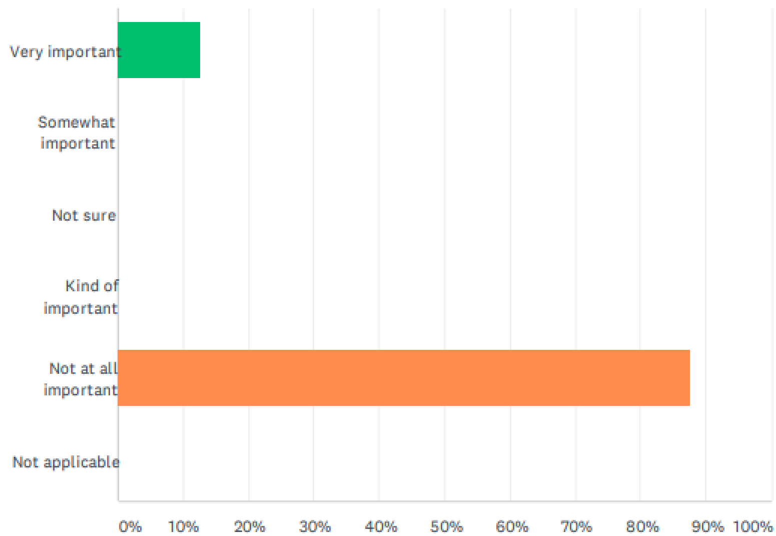
## Q3 It's understood light sticks are lost while on line on occasion due to cuts/breaks from shipping, the release of bycatch or bad weather. Please estimate frequency:

Answered: 17 Skipped: 0




## Q4 How important are the use of light sticks to the success of your fishing operation/catch rates?

Answered: 16 Skipped: 1



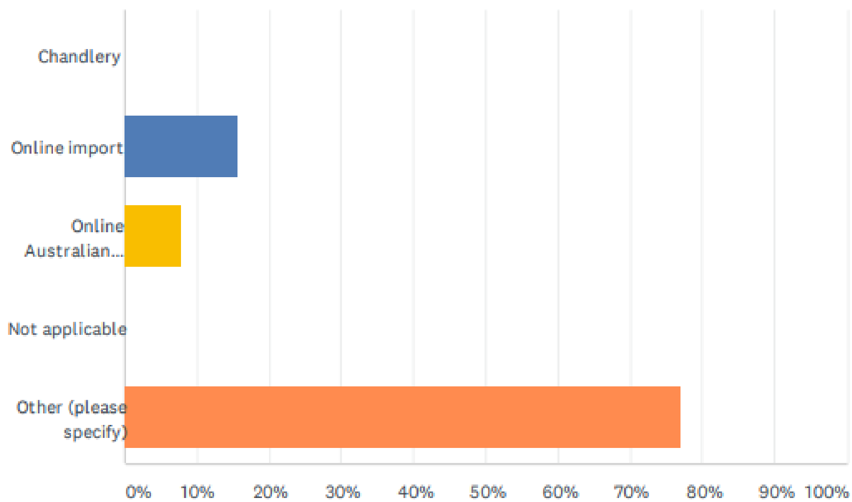
## Q5 What type of light stick specifically do you use?

Answered: 11    Skipped: 6

| Light sticks used | Responses |
|---|---|
| A7 | 1 |
| A | 1 |
| N/A | 9 |

## Q6 Where are they purchased?

Answered: 13    Skipped: 4




## Q7 Do you use something else as an attractant?

Answered: 12    Skipped: 5

| Comments | Responses |
|---|---|
| "Water activated flashing light" | 1 |
| "I tried a few battery operated types but battery costs and seal failures make them uneconomical to use. I also tried some solar types which fail as well." | 1 |
| N/A | 10 |

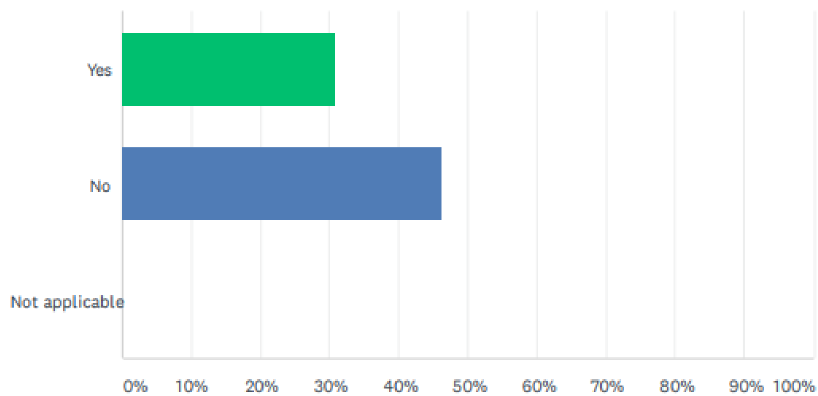
## Q8 How many light sticks would you use typically in a year?

Answered: 12 Skipped: 5

| Number of chemical light sticks used typically in a year | Responses |
|---|---|
| 50 | 1 |
| 1 000 | 1 |
| N/A | 10 |

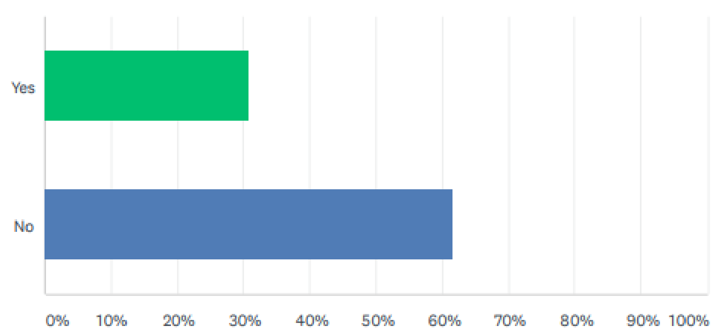
## Q9 Are you aware of losing light sticks?

Answered: 13 Skipped: 4




## Q10 Do you have any ideas on how that loss could be minimized or reduced?

Answered: 13 Skipped: 4



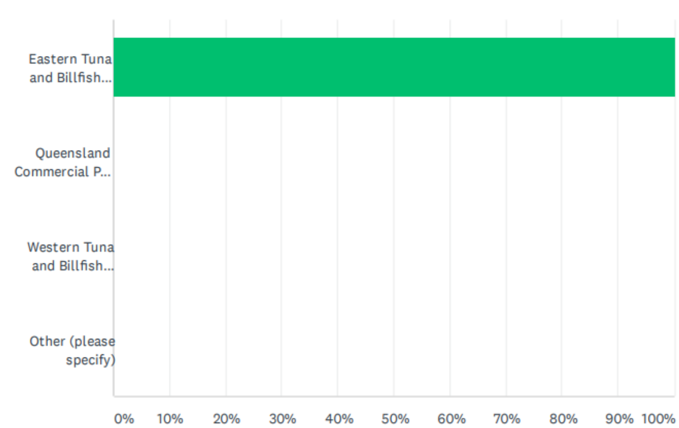

| Comments |
|---|

| |
|---|
| “Better clips” |
| “A better way to attach the light stick to the gear” |

Only 6% of the people surveyed reported using CLS. The results of this survey indicate that the use of CLS is not common among NSW-based fishermen.

### 2.2.2 Survey 2: results to date - 30/06/2020

Survey 2 was distributed via Survey Monkey to members of Tuna Australia to identify individual fisher endorsements, frequency of CLS use, importance of CLS use on catch rates, potential CLS loss and measures to minimise loss such as attachment points, satisfaction of attachment security, preferred CLS types and origin of purchase, CLS and other marine debris management and documentation, and potential/current CLS alternatives. Despite incentives, only 3 people have answered the survey to date.




Q2 From the categories of light sticks depicted below, identify which light sticks most closely resemble the one’s used in your fishing operations: *requires answer*

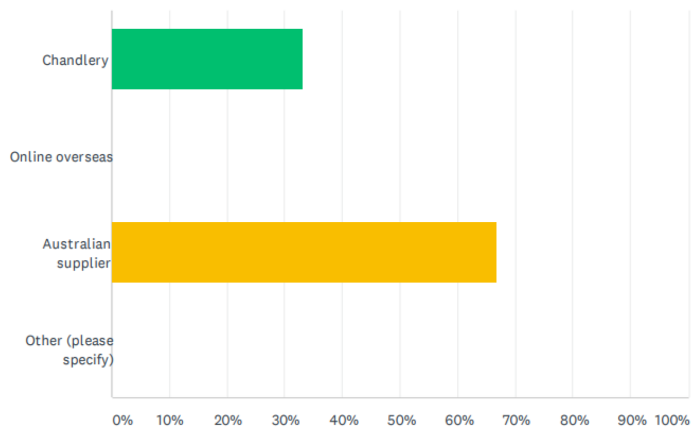
Answered: 3 Skipped: 0

| Light sticks used | Responses |
|---|---|

| | |
|---|---|
| A5 | 2 |
| C2 | 1 |

## Q3 Where are they purchased?*requires answer*

Answered: 3 Skipped: 0




## Q4 Do you use other light emitting sources as an attractant?*requires answer*

Answered: 3 Skipped: 0

| # | RESPONSES | DATE |
|---|---|---|
| 1 | No | 6/18/2020 5:32 PM |
| 2 | Tuna lights. Take AA batteries, clip on mainline | 6/15/2020 3:06 PM |
| 3 | No | 6/15/2020 1:29 PM |

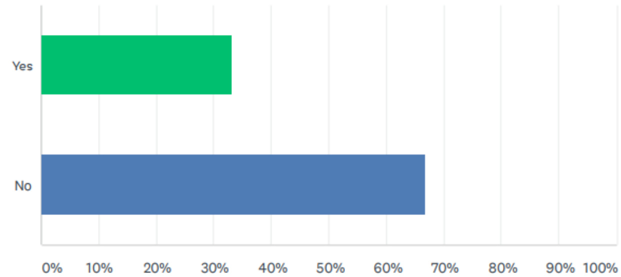
## Q5 How many light sticks would you use typically in a year?*requires answer*

Answered: 3 Skipped: 0

| # | RESPONSES | DATE |
|---|---|---|
| 1 | 200000 | 6/18/2020 5:32 PM |
| 2 | 50000 | 6/15/2020 3:06 PM |
| 3 | 1 million | 6/15/2020 1:29 PM |

## Q6 Are you aware of losing light sticks?*requires answer*

Answered: 3 Skipped: 0



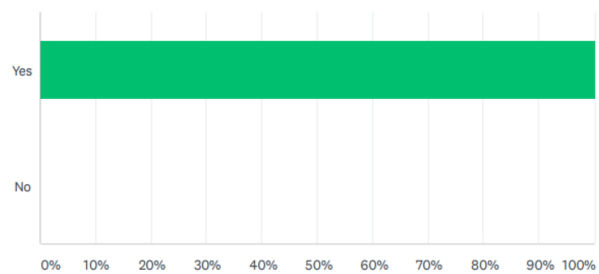

## Q7 What method do you use to secure your light sticks to your fishing gear?*requires answer*

Answered: 3 Skipped: 0

| # | RESPONSES | DATE |
|---|---|---|
| 1 | The eye in the top of the light stick | 6/18/2020 5:32 PM |
| 2 | Loop line through lightstick. | 6/15/2020 3:06 PM |
| 3 | the attachment | 6/15/2020 1:29 PM |

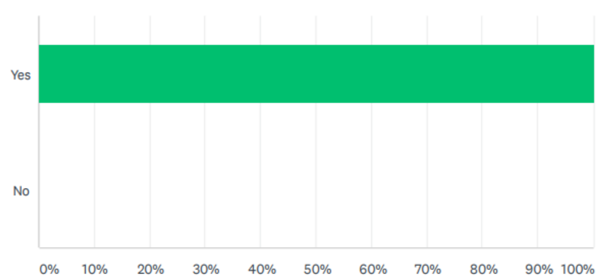
## Q8 Are you satisfied that the connection of your light sticks to fishing gear is secure?*requires answer*

Answered: 3 Skipped: 0




## Q9 Do you have a company policy or boat level policy on the retention of light sticks and other potential sources of marine pollution?*requires answer*

Answered: 3 Skipped: 0



Q10 If light sticks are lost to the environment, how does this occur? *requires answer*

Answered: 3 Skipped: 0

| # | RESPONSES | DATE |
|---|---|---|
| 1 | They don't get lost | 6/18/2020 5:32 PM |
| 2 | Lightsticks r put in swivel, instead of looped on line. Boats do this to not damage line, and to increase shoot away speed. Lightsticks come off when some fish r caught, or not put in swivel properly | 6/15/2020 3:06 PM |
| 3 | lost fishing gear | 6/15/2020 1:29 PM |

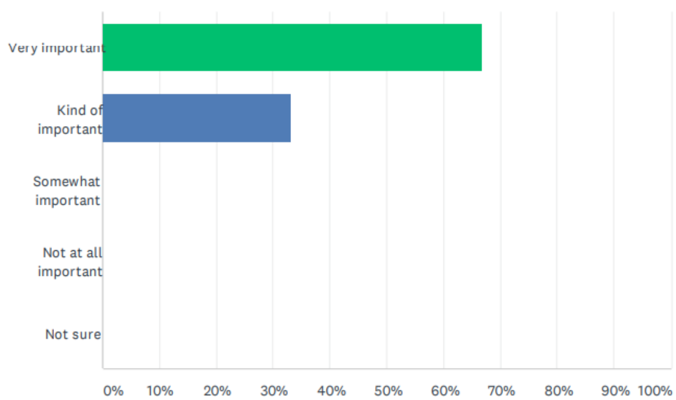
Q11 Do you have any ideas on how that loss could be minimised or reduced?*requires answer*

Answered: 3 Skipped: 0

| # | RESPONSES | DATE |
|---|---|---|
| 1 | No because they don't get lost | 6/18/2020 5:32 PM |
| 2 | See previous response | 6/15/2020 3:06 PM |
| 3 | change lightstick attachment | 6/15/2020 1:29 PM |

Q12 How important are the use of light sticks to the success of your fishing operation/catch rates?*requires answer*

Answered: 3 Skipped: 0



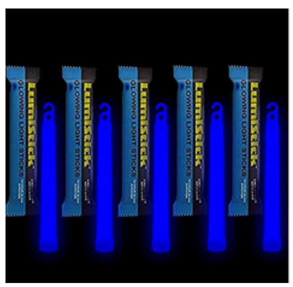

Use by vessels chasing tuna and other pelagics tends to vary from vessel to vessel. Question one and two of the survey indicates that the use of CLS is common in the Eastern and Tuna Billfish Fishery (between 50 000 to 1 million CLS used typically in a year). According to two of the interviewed fishermen, the loss of CLS could be reduced with an improvement of the CLS attachment to the fishing line.

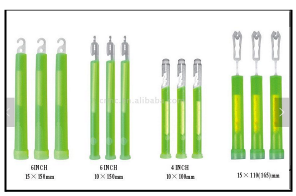
It is important to note that trends are only derived from the 3 responses received. The conclusions might change if OceanWatch receives more responses.

## 2.3 Data on sales

CLS are principally purchased from 3 main sources. Chandleries (including local tackle shops, commercial supply shops and larger retailers such as BCF, Anaconda, Kmart), online (Ebay, Amazon and Alibaba) and directly from an overseas supplier. A review of CLS availability looking at cost, type and composition shedded light on companies to approach to ask about product sales and customer insights. A few companies from an online search were selected (Table 7).

**Table 7. Review of purchase retailers**

| Source | Description | Cost per unit | Type as classified by the AMDI Database |
|---|---|---|---|
| Amazon |  | $2.50 | D4/ D5 |
| Ebay |   | $6.35 | red and green recreational, type unknown |
| Ebay |  | $0.43 | Red A5 |

| | | | |
|---|---|---|---|
| Ebay |  | $0.67 | Yellow |
| Alibaba |  | $0.89 | Yellow D4 |
| Alibaba |   | $0.06 (min order 10,000) | Various |
| Qld Chandler- |  | $ unlisted | 4 inch blue- A5 |

This search primarily focused on the style of typical professional use sticks classed as A5 and A1 in the AMDI Database ID guide. Within a search of Ebay, Alibaba and Amazon limited incidences of typical A1 or A5 designs could be located for sale online, with a great variety of designs available.

On Ebay Australia, a search returned 838 results, however most CLS available were a smaller type more suitable to recreational fishing. Price varied by quantity, with those targeting recreational use being more expensive and packaged in smaller numbers. A few independent online retailers were found to supply the A5 design.

A previous search of tackle stores, K-mart, BCF and Anaconda failed to find the A1 or A5 CLS types which may help to pinpoint a more specialised user group.

A study conducted by Nash in QLD and WA in 2016 tracked the sources of CLS found on the beach in eight locations in QLD and eight locations in WA. This study found that the most frequent type of sticks found was the A5 stick, identified as belonging to the longline fishing industry and available widely on the internet (Figure 25). Results at the time showed that neither of the two major manufacturers that sold CLS in Australia produced A5 sticks. This suggests that it is highly plausible for CLS that became marine debris to travel from neighbouring countries and end up in Australian waters (Nash 2016). In contradiction, a 2020 website search by OceanWatch of both the above retailers found an A5 type was for sale and readily available. Such information was used to inform the surveys.


**Figure 25. A5 CLS available on Gloweez website**

## 2.4 Alternatives

There are a number of alternative products to CLS. However, there are no alternatives that are as cost-effective, widely available and reliable in the marketplace.

### 2.4.1 Alternative light sources

Of the alternative options, substitute light sources have received the most attention in the literature. The aim in exploring light sources other than chemiluminescent ones is to achieve higher efficiency with reduced environmental impact. Battery-operated light sticks are most commonly discussed as one such solution as their greenhouse gas footprint is lower than CLS, their lifespan is longer, and there is potential for using them alongside currently used fishing equipment as they are not too dissimilar to CLS (Figures 26 and 27). For example, Fishtek Marine makes a low cost, tough and long-lasting LED light stick called the GloPro, which is designed to replace chemical light sticks. Changing the light source, however, does not address the issue of marine debris completely. During use, battery-operated light sticks that are lost would sink into the water, and contain both batteries and plastic. That said, there is no literature on the relationship between light source and the relative required plastic casing. In addition to changing light sources, more attention needs to be given to alternative energy sources such as reusable batteries and solar powered LEDs to improve lifespan and reduce marine waste.

**Figure 26. Alternative LED battery operated light for tuna longline retailing at 3.50-5 USD on Amazon**

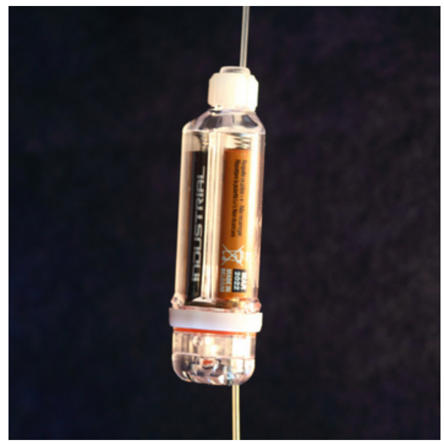


**Figure 27. GloPro, the Fishtek Marine's long-lasting LED**

Zarubin *et al*. (2011) studied a promising bio-alternative to CLS, although no follow-up research seems to have been conducted. They found that the nocturnal ringtail cardinalfish was more attracted to zooplankton which had fed on luminescent bacteria and subsequently started to glow (Zarubin *et al.* 2011). This study raises questions about the feasibility of harvesting such bioluminescent bacteria for use in commercial fishing operations. Bioluminescence occurs through a chemical reaction in the same way that the compounds in the chemical light sticks interact, although in this case the chemicals at play are not foreign to the marine environment. For a bioluminescent reaction to occur, species must contain the molecule luciferin that reacts with oxygen to produce light. The synthetic production of a contained bioluminescent reaction system might also be considered here in developing alternative sources of light in fishing operations.

### 2.4.2 Plastic alternatives

New endeavours have focused on the feasibility of employing bioplastics in CLS, to drastically reduce marine debris from disposed sticks. Research on the use of bioplastics in fishing equipment is well underway, with companies like MarinaTex looking into bioplastic made from organic fish waste. Thus, the ideal solution remains phasing out chemical light sources altogether, opting for other sources of light mentioned or attractants altogether, and lastly, focusing on mitigating efforts for what is already in the ocean.

#### 2.4.3 Attractant alternatives

Non-cased luminescent methods of fish attraction have great potential for plastic and chemical reduction, are feasible, and easy to test. These methods may take the form of luminescent tubes, beads, dips, or other prey mimics. Prey dipping should be of particular interest in source reduction efforts as it requires little to no use of plastic. A 1980 field study found that catch rates were 1.2 times as high in tuna when a bait dipped in luminescent solution was used (Makiguchi *et al*., 1980). Research is still needed, however, to assess how such a solution might impact the surrounding environment when dispersed in water.

Looking beyond luminescent methods altogether, scent-based prey mimics are being explored as additional alternatives to CLS. An U.S.A.-based company, *Berkley Fishing*, developed a 100% biodegradable and 100% natural ingredient soft-bait called "*Gulp*". The water-based bait is said to disintegrate in two years in marine environments and within 8-10 months in landfills. The bait comes in a variety of prey-mimicking shapes and is pre-soaked in a scent solution, supposed to have a 400 times higher scent dispersal than traditional scented bait.

### 2.5 Solution trialed

#### 2.5.1 Working Group

In order to identify fit for purpose solutions, OceanWatch convened a working group. Members include:

- Phil Ravanello - Program Manager Tuna Australia
- Tamre Sarhan - Observer Coordinator AFMA
- Simon Rowe - Program Manager Environment OceanWatch
- Claire Denamur - Project Officer OceanWatch

**Scope**

The scope of the working group has been defined as documenting the use of light sticks within the Australian Tuna longline industry, record handling and loss processes, and look to trial alternative practices or products that may reduce the likelihood of CLS becoming debris.

**Terms of reference**

As a group, members were invited to:

- Look at the evidence to date around the use and loss of chemical light sticks (AFMA ETBF Daily Fishing Logbook and Observers datasets)

- Identify CLS alternatives
- Trial CLS alternatives in Australian Waters
- Monitor effectiveness
- Report with recommendations to Tuna Industry- CC Tangaroa Blue, the Australian Government

**Timeframe**

OceanWatch organised seven meetings with the Working Group. The objectives of each meeting were the following (Table 8)

**Table 8. Objectives of Working Group meetings**

| Meeting objectives | Participants | Meeting date |
|---|---|---|
| Introduction<br>Defining the Working Group objectives and scope<br>Discussing potential solutions | Tuna Australia<br>OceanWatch | September 2020 |
| Ascertain ABARES capacity and direction to link fish catch data with CLS use experimental design.<br>Was methods envisaged going to be statistically adequate within budget and timeframe. | OceanWatch<br>ABARES<br>(Stephanie Black;<br>James Larcombe;<br>Robert Curtotti;<br>David Mosby) | October 2020 |
| Identifying fit for purpose alternatives to CLS | ETBF Fisherman | October 2020 |
| Present the first draft of the Trial Experimental design | Tuna Australia<br>OceanWatch | November 2020 |
| Interpreting AFMA's data | Tuna Australia<br>AFMA<br>OceanWatch | December 2020 |
| Discussing the first draft of AFMA's data analysis | Tuna Australia AFMA<br>OceanWatch | January 2021 |
| Discussing the final version of the experimental design | Tuna Australia<br>AFMA<br>OceanWatch | February 2021 |
| Gear Trial Library - Round 1 | OceanWatch | March 2021<br>June 2021 |
| Review of the results and comments | Tuna Australia<br>AFMA | June 2021 |

### 2.5.2 Battery operated light stick gear trial library - Design

Organising a gear trial of CLS alternatives was one of the objectives of the Working Group. With the help of an ETBF Fisherman who trialed a large number of battery-operated light sticks in the past, OceanWatch identified two light stick models that are fit for purpose (Table 9).

**Table 9. Products identified as adapted alternatives to CLS**

| **Product name** | ProGlow | Tuna Light |
| --- | --- | --- |
| **Product shape** |  |  |
| **Colours available** | Green, blue, white, disco | Green, blue, white, red |

In order to reach a large number of fishermen, OceanWatch decided to design the light sticks trial as a library. This lending service is an opportunity for fishermen to test and trial new gear. Tuna Australia identified potential interested fishermen among their members, who OceanWatch collated in a library register. A set of light sticks that included 2 battery-operated light stick types (Table 9), instructions (Figure 28) and feedback questionnaires (Figure 29) were sent to the participants. At the end of the lending service, participants were invited to give feedback on the use and return the battery-operated light sticks.

OceanWatch loaned fishers a set of two alternative light sticks for 5 weeks (or a minimum of 20 shots). During this period, fishers/skippers were asked to attach both models of battery-operated light sticks to the line (branchline or mainline as long as it replaces or reduces the number of chemical light sticks deployed). However, to have consistency, OceanWatch asked them to follow the same set up throughout the trial. After they retrieved the line, OceanWatch asked fishers/skippers to fill in an evaluation sheet. This document includes questions on the attachment method, attachment efficiency, durability, catch rate evolution, and viability.

## Battery operated light stick gear trial library

OceanWatch is working with Tuna Australia to identify efficient and easy-to-use alternatives to single-use chemical light sticks. If lost in the ocean, chemical light sticks undeniably become marine debris and pose a risk to marine fauna and can significantly impact the perception of the fishing industry within the community when washing up on the beach.

Thank you for helping us trial the alternatives identified.

This gear trial is organised like a **library**. Our aim is to ensure many skippers get a loan as opposed to obtaining statistically significant data (which would require significantly more resources). We will loan you a set of two different alternative light sticks for **5 weeks** or, ideally, a **minimum of 20 shots**. Feel free to use these within your fleet.
During this period, we would like you to:

- **Attach both models of battery-operated light sticks** to your line (branchline or mainline as long as it replaces or reduces the number of chemical light sticks deployed). It is up to you as skipper, how you deployed the two colors (blue and green). From an operational perspective as skipper, you might decide to set the light sticks on a segment of your line (rather than separated among the entire mainline). To have consistency, we ask you to follow the same setup throughout the trial.
- **Fill in an evaluation sheet after you retrieve your line**: Regardless of the combination of alternatives, we need you to fill in an evaluation sheet per light stick design.
  We need you to fill 2 evaluation sheets per shot: one per light stick design per shot.
- **Take pictures of evaluation sheets**: Whenever possible, take a picture of the evaluation sheet(s) and text it to Claire - 0427 883 018.
- **Keep all the evaluation sheets**: Please keep all the evaluation sheets and send them back to us at the end of the trial in the pre-paid envelope attached as a backup.

To allow us to loan the battery-operated light sticks to other skippers, we will contact you to organise the return after 5 weeks. Ideally,

If you have any question, comment, or concern, please feel free to contact:
Claire Denamur - 0427 883 018 / claire@oceanwatch.org.au

### Contents of this parcel

- **120** ProGlow light sticks (65 blue, 65 green)
- **118** Fishing International tuna lights (65 blue, 65 green)
- 50 evaluation sheets
- A pre-paid envelope to send us back the collate evaluation sheets

**LED alternatives are more fragile than chemical ones. We recommend being mindful when retrieving your line.**

### Product Description

In order to reduce single-use chemical light sticks, the two alternatives are presented below.

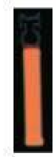
| **Product name** | ProGlow | Tuna Light | Chemical Light Sticks |
|---|---|---|---|
| **Product shape** |  |  |  |
| **Colors available** | Green, blue, white, disco | Green, blue, white, red | Green, blue, white, red, yellow, pink... |
| **Brightness** | 0,7 lumen | Estimated 2 times brighter than ProGlow | 0,07 lumen |
| **Battery type** | 2* AA (included) | 2* AA (purchased separately) | NA |
| **Battery changing process** | Open the bottom with a screwdriver | Unscrew top | NA |
| **Expected battery life** | 500 hours | 400 hours (with JayCars Eclipse Battery) | 8 - 12 hours |
| **Turn on method** | Water sensitive | Screw top | Apply pressure to the center of the stick |
| **Attachment point** | Shark clip (purchased separately) | Shark clip (included) | Plastic hook |
| **Price range** (not including GST) | $4 - $6 | $9.90 - $20 | $0.14 - $0.50 |

**Figure 28. Introductory document sent to fishermen in relation to the battery-operated light sticks gear trial library**

**Battery operated light stick gear trial library**
**Evaluation sheet**

OCEANWATCH AUSTRALIA

GENERAL INFORMATION

| | | | |
|---|---|---|---|
| Vessel | | | |
| Skipper | | | |
| Date / Hour | | | |
| Sea condition when retrieving the line *(circle right answer)* | Calm | Moderate | Rough |
| Targeted species | | | |
| Alternatives light sticks trialed *(circle right answer)* | Option A  | Option B  | |
| How many of the circled option above were deployed? Please draw your configuration (incl branchline, hooks, swivel, battery operated light sticks, chemical light sticks). |   | | |
| Percentage of hooks with light deployed | | | |
| Any tangled while deploying/retrieving the mainline? | YES | | NO |
| | If **YES**, Estimate number of **chemical** light sticks lost | | |
| | If **YES**, Estimate number of **alternative** light sticks lost | | |
| Alternatives light sticks stuck in the tori line? | YES | | NO |

**LIGHT STICKS ALTERNATIVES EVALUATION** (circle right answer)

How would you rate the **attachment method** compared to chemical light sticks?

| | | | |
|---|---|---|---|
| Very easy | Fairly easy | Not very easy | Not easy |

How would you rate the **attachment efficiency** compared to chemical light sticks?

| | | | |
|---|---|---|---|
| Very good | Fairly good | Not very good | Not good |

How would you rate the **durability** compared to chemical light sticks?

| | | | |
|---|---|---|---|
| Very good | Fairly good | Not very good | Not good |

How would you rate your **catch rate** compared to chemical light sticks?

| | | |
|---|---|---|
| Increase | Stable | Decrease |

Would you consider these as **viable** alternatives?

| | | |
|---|---|---|
| Yes | Maybe | No |

Any comments

**Figure 29. Evaluation sheet sent to fishermen as part of the battery-operated light sticks gear trial library**

**Battery operated light-sticks gear trial library - First round**

The battery-operated light sticks were sent to 3 fishers for the first round. The products were distributed according to the needs and will of the fishermen (Table 10).

It is important to note that the gear trial was optional for fishermen and being part of a trial takes time. All fishermen contacted were really interested in the subject and the one who accepted to be part of the trial took time to organise the delivery of the material, train skippers and crew, fill in evaluation documents at the end of each shot, etc. All fishermen and skippers were very available when OceanWatch contacted them. OceanWatch is very grateful and thankful for their involvement.

**Table 10. Distribution of battery-operated light sticks for the first round of the Battery-operated light stick gear trial library**

| Operator | Battery-operated light sticks set | Gear trial start date | Gear trial end date |
|---|---|---|---|
| Operator 1 | 250 Fishing International<br>250 ProGlow | 25/05/21 | 29/06/21 |
| Operator 2 | 130 Fishing International<br>130 ProGlow | 27/05/21 | 01/07/21 |
| Operator 3 | 120 Fishing International<br>120 ProGlow | 09/06/21 | 14/07/21 |

Although the end date of the project is 30/06/2021, OceanWatch decided to continue the gear library with additional long line skippers. Therefore, OceanWatch should receive additional data from other fishermen in the future.

### 2.5.3 Trial conclusions

While fishermen have been trying battery-operated light sticks in the past, the process of documenting their use and efficiency is valuable.

By the end of June 2021, three longline fishermen had completed trialing the two types of battery-operated light sticks identified, and OceanWatch was about to commence the second rotation of the library with another three boats. A number of other fishermen did not choose to be part of the trial based on the reasons listed below.

**Impact on catch**

None of the alternatives identified offer a similar brightness to the chemical light sticks generally used (~0.07 lumen). The battery-operated light sticks identified are up to 20 times brighter. This level of brightness attracts unwanted species, especially sharks, which can lead to bite-offs (i.e. missing hooks).

**Species targeted**

Some skippers only use light sticks when targeting swordfish. Broadbill swordfish are highly migratory and are found throughout the Atlantic, Indian and Pacific Oceans. They are primarily a warm-water species that moves into cooler, temperate waters for feeding during the Australian summer months and returns to warmer tropical waters for spawning and over-wintering. Being the peak swordfish fishing season in Australia July-August, the timing of the trial was not suitable. Moreover, COVID-19 has negatively impacted export of swordfish. Therefore, fishermen are reducing their catch of swordfish while increasing their catch of albacore.

**Maintenance work**

Battery-operated light sticks need more maintenance work than chemical light sticks (i.e. opening and changing the batteries). The battery changing process is long, it impacts crew operations and puts extra pressure on staff.

**Financial hurdle**

The price of battery-operated light sticks is between 25 to 100 times higher than that of chemical light sticks. A mainline can consist of up to 2,500 hooks with a CLS on each hook. The upfront cost to switch to 100% battery-operated light sticks is a large financial hurdle.

Below are comments recorded by participants to the trial:

**Line set-up and cost benefit**

As indicated above, the brightness of the battery-operated light stick is higher than CLS.

When deep-setting (around 300 m deep), battery-operated light sticks are sometimes used as bait attractants on the mainline, reducing the use of chemical light sticks on the branchlines (Figure 30).

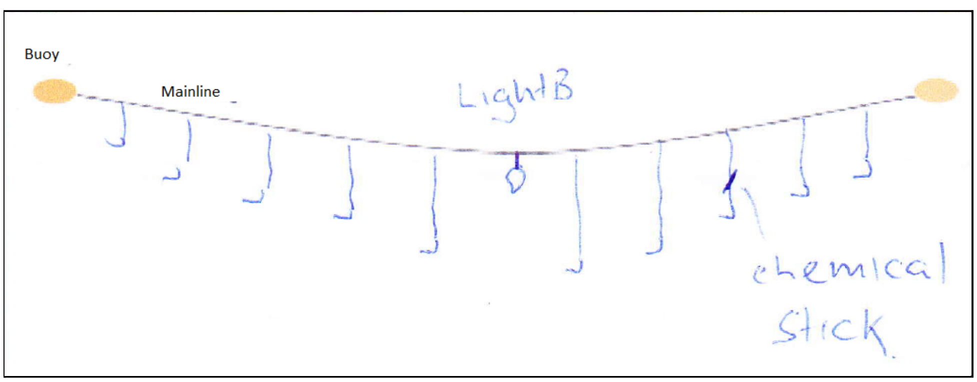



**Figure 30. Diagram of the line set-up of one of a fisherman during the trial. Light B is battery operated light stick Option B**

According to one of the fisherman, battery-operated light sticks and CLS have complementary roles:

- Battery-operated light stick attracts bait to the hookset which in turn, attract tuna
- Chemical light sticks attract fish to actual baited hooks

Even if the upfront cost is high, a lot of fishermen considered the alternatives as commercially viable. Being battery-operated light sticks much brighter than CLS (around 10 times), some fishermen attach battery-operated lights to the mainline and not to hooks (e.g. Operator 1 and Operator 3). Instead of having CLS attached to all 7 hooks between two bubbles, they would set up one single Option B battery-operated light stick to the mainline (Figure 31) and eliminate the use of CLS on the branchlines. This technique reduces considerably the number of light needed and eliminates the need for  CLS.

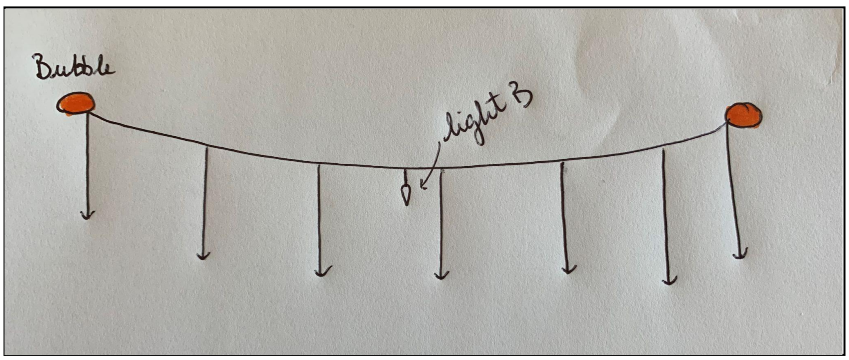



**Figure 31. Diagram of the line set-up of light B of Operator 3 during the trial. Light B is battery operated light stick Option B**

Because light A (or Option A - Figure 30) is less bright than Light B (or Option B), on the boat of the Operator 3 the line setup with this alternative was slightly different (Figure 32). While the setup was different, the number of light sticks used is still lower than having a CLS per hook.

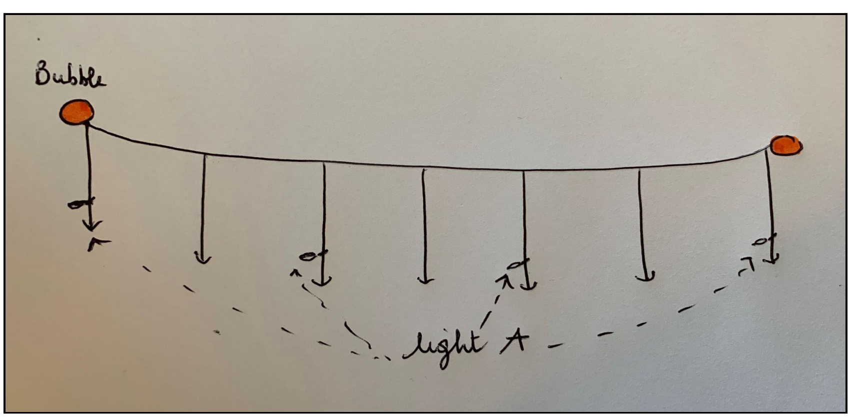


**Figure 32. Diagram of the line set-up of light A of Operator 3 during the trial. Light A is battery operated light stick Option A**

The line set up of the Operator 2 was slightly different again (Figure 33). However, the number of CLS deployed was reduced by the use of battery-operated light sticks. Three battery-operated light sticks type A were deployed alternating with three CLS. Reducing the number of CLS deployed in between two bubbles by 2.

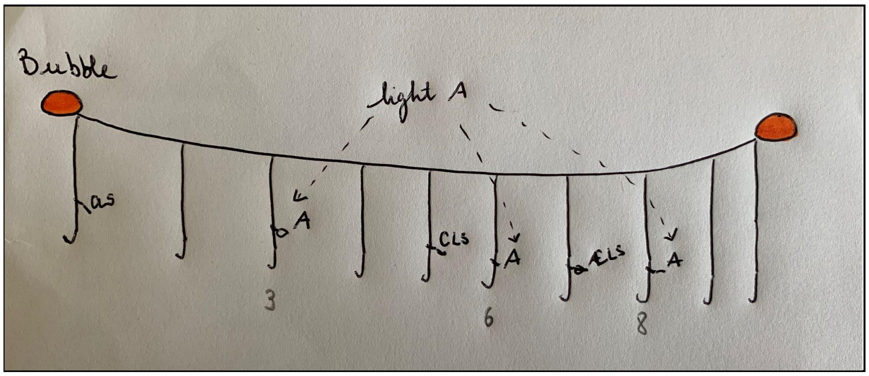



**Figure 33. Diagram of the line set-up of light A of Operator 2 during the trial. Light A is battery operated light stick Option A.**

Moreover, the lifespan of battery-operated light sticks is much higher than CLS. Those sticks lasted 5 weeks before batteries were changed.

**Attachment method**

As part of the evaluation document, fishermen had to rate the attachment method efficiency compared to CLS. Attachment method has been rated as “fairly easy” or “very easy” by all the fishermen. Indeed, both battery-operated alternatives trialled are attached to the line with a shark clip, which is an easier technique than having to tie a knot to the fragile attachment point of a CLS.

**Catch rate**

According to all fishermen, catch rate with the battery-operated light sticks has been similar to the catch rate reached when using CLS.

**Viable alternative**

All fishermen who took part in the trial considered the alternatives identified as viable.

**Engaging with the community**

The skipper of the Operator 1 is a social media influencer. To date, TK Offshore Fishing has a community of 81,975 followers. Through a video he published on his Facebook account on June

21st, he communicated about the battery-operated light sticks trial. The video has more than 17,000 views, 525 likes, 39 comments (Figure 34).

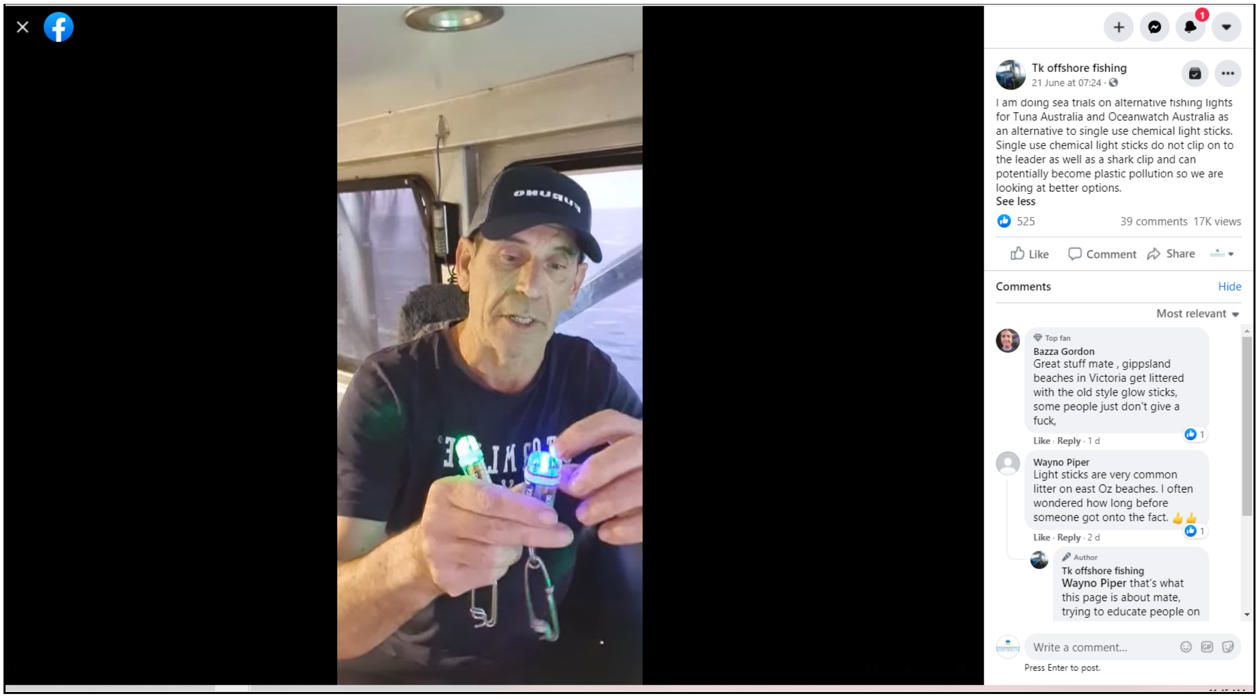



**Figure 34. Screenshot of TK Offshore Fishing video on Facebook promoting the battery-operated light stick trial**
*Source: Facebook*
https://www.facebook.com/tkoffshorefish/videos/492269688727787

100% of the comments received on this video were positive. Some people asked for more information on when and how to use the battery-operated light sticks, as well as sharing their experiences. TK Offshore Fishing has answered most of them giving advice and tips (Figures 35 and 36). Best practices promoted by industry champions seem to be a very efficient way to reach a large number of people in a trustworthy manner.


**Figure 35. TK Offshore Fishing answering questions of fishermen on battery-operated light sticks specifications**
*Source: Facebook*

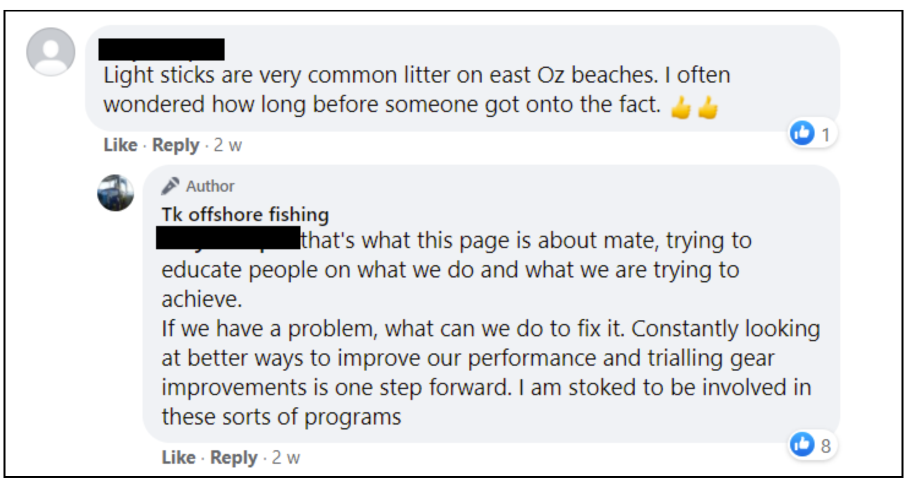



**Figure 36. TK Offshore Fishing answering to comments from community members**
*Source: Facebook*

As a conclusion, both alternatives identified have merits. However, because of their brightness level, their use is different. OceanWatch recommends that fishermen and skippers identify the alternative that best fits their needs.

# PART 3 Discussion and recommendations

## 3.1 AFMA reviewing the Daily Fishing Logbook

Observers used to record a set of data when observing longliners, which include the number of deployed and retrieved light sticks. Since 2015 however, the ETBF has introduced electronic monitoring so none of those data are transcribed in a datalog. Furthermore, the current Daily Fishing Logbooks compiled by fishermen are not recording the number of light sticks retrieved.

OceanWatch suggests including light stick retrieved data in AFMA Daily Fishing Logbook as well as the reason for their loss. This would be a good way to keep track of the number of light sticks lost by the ETBF and to identify innovative solutions if required. This data would also be a good indicator to follow over time to evaluate the uptake of alternatives to single-use CLS. The comparison of CLS found on beaches to those deployed in professional fishing would portray the tuna industry as a responsible industry if the two figures could be accurately compared.

## 3.2 Extension on best practice CLS / battery operated light stick use

It has been identified that fishing gear varies and each vessel targets different species at different times. Fishermen hold very valuable knowledge on gear set-up, which is passed from generation to generation but often not to peers.

Sharing professional industry information internally around what methods are best suited to various fishing scenarios and species (ie. battery-operated light sticks attached on mainline reducing the use of chemical light sticks on branchline when targeting southern bluefin tuna) could help fishermen to adopt an environmentally sustainable fishing method viable quickly.

This could take the form of a CLS vessel management plan reflecting a supplementary CLS code of practice.

## 3.3 A voluntary supplementary code of practice around fishing industry use of light sticks

The proposed supplementary code may include the following as a starting point for discussion:

- Highlight potential loss from fishing practice, or inadvertent CLS loss through gear loss.
- Include actions that identify such measures as minimising use when targeting species that require less artificial light stimulus, examining the attachment points of CLS and measures such as attaching CLS to swivels to minimise loss, best practice attachment of CLS, best practice collection and disposal of CLS and potentially ensuring CLS purchased meet specific guidelines.

- Handling and care and attention to use and responsible disposal (e.g. deckhands with bum bags).

Further extension using the T*Angler* Bin education approach to improve stewardship (e.g. visible signage on the on-deck receptacle).

### 3.4 Promotion of the above

OceanWatch suggests the development of a stewardship style of sticker, for boats that voluntarily adopt the supplementary Code of Practice.

A similar approach has been used to improve industry response in relation to whale entanglement. This has been achieved through stickers developed for industry to highlight responsibility and inclusivity. To minimise potential loss through carelessness or other factors, a sticker could contain key messages, as highlighted in the proposed supplementary code.

### 3.5 Inclusion of light use in the Marine Stewardship Council (MSC) certification process

The ETBF achieved MSC certification in August 2020. This means that the fishery meets the world's most recognised benchmark for sustainability: the MSC Fisheries Standard. The Standard is developed in consultation with a range of people and organisations around the world, including government academics, researchers, the fishing industry and NGOs. The MSC Fisheries Standard is based on the United Nations Food and Agriculture Organisation's (FAO) code of conduct for responsible fisheries. There could be an opportunity to include light use as part of the certification process. The MSC is holding online workshops on Endangered, Threatened and Protected (ETP) species and ghost gear. MSC is in the process of consultation with stakeholders on incorporating this into fishery certification. The public consultation survey is open between Tuesday 29 June and Thursday 29 July 2021.

### 3.6 Regulatory control measures

Control measures to reduce the number of CLS found in the marine environment may include actions such as:

- Closer monitoring of longline vessels and recreational fishermen by AFMA as there are no limits on how many CLS vessels can use (Nash 2016);
- Educating fishermen on the impacts that derelict fishing gear has on marine life (Jones 1995);
- Prohibiting the import of light sticks that are not environmentally safe into Australia (Nash 2016).

Because what happens in one ocean has the ability to affect neighbouring oceans (Thompson 2009, Sebille 2012), international measures need to be implemented as well (Nash 2016). Australian regulatory phasing out of single use CLS, whilst an option, may have consequent impacts including inefficient setting, less catch, less profitability and the need for more hooks to catch the same amount of fish. It could also be seen as a market access impediment.

Mandating a standard in CLS design hand in hand with Industry might be another option to ensure optimum design and functionality are achieved.

## 3.7 Reducing the price barrier to adoption

A few retailers contacted by OceanWatch are maintaining high prices on battery-operated light sticks. The reason is that CLS are very profitable products. Bought in very high numbers regularly, those cheap single use alternatives represent a high percentage of sales. Price point manipulation (charging a large percentage markup) is reducing the ease of adoption to less retail profitable multiple-use battery-operated units. OceanWatch encourages the development of a marketplace where consumer choices are not dictated on price alone. The production cost for battery operated light sticks, while high, could be reduced with an economy of scale and wider adoption.

## 3.8 Fishermen as change ambassadors

As seen during the gear trial, the endorsement of best practices by industry champions is a very efficient way to encourage peers to consider these practices. OceanWatch encourages industry champions to consider and trial alternatives to single-use.

## 3.9 Overseas sources of light stick

With the data available, OceanWatch cannot categorically conclude that with all the above measures implemented, CLS pollution on waterways will not cease in time but industry is committed to reduction. The pool of CLS in the ocean is unknown. A number of comments indicate other domestic user groups and specifically international fisheries could be significant contributors. Efforts should be applied on this topic as part of the Western and Central Pacific Fisheries Commission (WCPFC) Conservation and Management Measure on Marine Pollution (CMM2017-04). Similar to that suggested domestically, each could be implemented at a country level or through regional agreement.

## 4. Closing Statement

This source reduction plan was designed as a source analysis approach rather than working from a behavioural littering reduction perspective. Indeed, OceanWatch felt this approach would be more beneficial with the current level of Australia industry professionalism and boat level codes of practice in place.

This source reduction plan has been designed to investigate the claim that professional fishing sectors in Australia use and lose chemical light sticks which are consequently found and recorded in Australian waterways. While interrogating the Australian Marine Debris Initiative Database, no clear correlations were found which linked chemical light sticks (CLS) hotspots to potential regions of CLS losses by Austra lian fisheries. However, the type of CLS found on waterway hotspots did correlate to the one used as fish attractant by one of the Australian longline fisheries: the Eastern Tuna and Billfish fishery (ETBF). Interrogating AFMA's data on the ETBF usage and loss of CLS for a period of 15 years provided an indication that losses occur, and that they have declined over recent years. According to ETBF fishermen in the trial, CLS are economical, and their use is beneficial.

Examining light stick losses, OceanWatch identified cut and bite offs as the main source of CLS loss (bite offs being losses due to predators, cut offs to currents and shipping). While these are unanticipated and somewhat unavoidable causes, CLS losses are more predictable than the above due to the fragile attachment point of the average CLS. The battery-operated light sticks used in the trial presented some significant advantages to the participants, while also highlighting some practical and economic hurdles. Use of fewer battery-operated light sticks can result in a reduction in the number of CLS required for the same level of catch.

The fact that Australian longline fishers record and openly discuss CLS use shows their willingness to advance both industry practice and the public understanding of solutions. This places this user group in a proactive position to reduce marine debris while maintaining their catch and social license. Social licence -which is defined as the ongoing acceptance of a company or industry's standard business practices and operating procedures by its employees, stakeholders, and the general public- is an important attribute to maintain. With the ETBF preserving transparency, further source reduction efforts can focus on other CLS user groups identified including recreational fishers, divers and international fisheries.

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# 6. Appendixes

## 5.1 Blank Survey 1 - Distributed to NSW wild-catch fishermen and OceanWatch Master Fishermen of NSW

Questions:

1. I am…
   - ❏ A professional fisherman
   - ❏ Not a professional fisherman

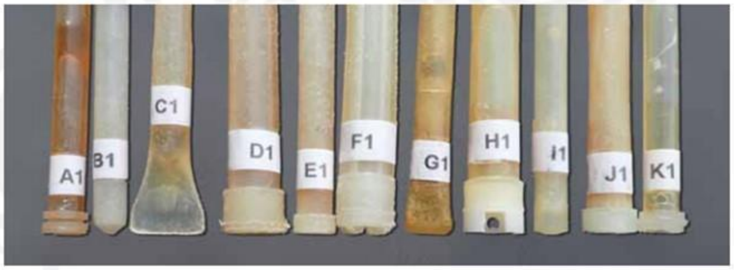
If you are a professional fisherman, go to question 2.
If you are not a professional fisherman, go straight to question 5.

2. Which fishery do you work within?
   - ❏ Eastern Tuna and Billfish Fishery
   - ❏ Queensland Commercial Pot Fishery
   - ❏ Western Tuna and Billfish Fishery
   - ❏ Other (please specify)

3. It's understood light sticks are lost while on line on occasion due to cuts/breaks from shipping, the release of bycatch or bad weather. Please estimate frequency:
   - ❏ Once per night
   - ❏ Once per week
   - ❏ Once per month
   - ❏ Not applicable
   - ❏ Other (please specify)

4. How important are the use of light sticks to the success of your fishing operation/catch rates?
   - ❏ Very important
   - ❏ Somewhat important
   - ❏ Not sure
   - ❏ Kind of important
   - ❏ Not at all important
   - ❏ Not applicable

5. What type of light stick specifically do you use?




Cylume sticks - type A

6. Where are they purchased?
- ❏ Chandlery
- ❏ Online import
- ❏ Online Australian supplier
- ❏ Not applicable
- ❏ Other (please specify)

7. Do you use something else as an attractant?

8. How many light sticks would you use typically in a year?

9. Are you aware of losing light sticks?
- ❏ Yes
- ❏ No
- ❏ Not applicable

10. Do you have any ideas on how that loss could be minimized or reduced?
- ❏ Yes
- ❏ No

11. Any other comments?

## 5.2 Blank Survey 2 - Distributed to Members of Tuna Australia

**Questions**

1. Which fishery do you work within?
   - ❏ Eastern Tuna and Billfish Fishery
   - ❏ QUeensland Commercial Pot Fishery
   - ❏ Western Tuna and Billfish Fishery

2. From the categories of light sticks depicted below, identify which light sticks most closely resemble the one's used in your fishing operations:


3. Where are they purchased?
   - ❏ Chandlery
   - ❏ Online overseas
   - ❏ Australian supplier
   - ❏ Other (please specify)

4. Do you use other light emitting sources as an attractant?

5. How many light sticks would you use typically in a year?

6. Are you aware of losing light sticks?

7. What method do you use to secure your light sticks to your fishing gear?

8. Are you satisfied that the connection of your light sticks to fishing gear is secure?
- ❏ Yes
- ❏ No

Comment field

9. Do you have a company policy or boat level policy on the retention of light sticks and other potential sources of marine pollution?
- ❏ Yes
- ❏ No

Comment field

10. If light sticks are lost to the environment, how does this occur?

11. Do you have any ideas on how that loss could be minimised or reduced?

12. How important are the use of light sticks to the success of your fishing operation/catch rates?

13. Any other comments?