Line-caught albacore tuna *Thunnus alalunga* (Bonnaterre, 1788): An observation voyage by Seafish as part of a BIM-funded study

March 2005

Julian Swarbrick
Fisheries Development Group

SR569

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Author: Julian Swarbrick
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Summary:

Seafish was invited to take part in a BIM sea trial to test two different hook-and-line methods for catching Atlantic albacore tuna in the Bay of Biscay: by surface longline and by trolling with lures. Trials were conducted during July 2004 on board a converted Irish pelagic trawler, working from the French port of Les Sables d'Olonne. The trials work was done in conjunction with several French vessels fitted with longline equipment and a Spanish trolling vessel working with lures. The trial observed by Seafish was one of a series of voyages made by BIM in this fishery during 2004.

The objectives of BIM were to establish the efficiency of using surface longlines for albacore using different baits and deployment methods. A secondary objective was to encourage active co-operation with other European fisheries bodies and to disseminate the information obtained from this study. The objective of Seafish in attending was to be able to place the methods observed in context with the UK fishing industry.

The results from the trials showed that, whilst it was possible to catch tuna with surface longlines, the catch rates were very low when compared with the trolling method, which is the dominant method used in the Bay of Biscay by a mostly Spanish fleet. The French vessels that were testing longlines had inconsistent results during the trials. It was demonstrated that, for longlining, crew experience and vessel location were important factors in the success of the operation.

The report highlights the fact that although the UK has a quota for albacore tuna, at present, this quota is not used by UK vessels. A recommendation is made to disseminate the findings of the study to fishermen in southwest England (Cornwall) where there has been a previous interest in tuna fishing. A further recommendation is made to establish the market opportunities that exist in the UK for line-caught tuna.

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1. Introduction

In July 2004, Seafish was invited by BIM (Bord Iascaigh Mhara) to take part in a 12 day Atlantic voyage on board the 14.7m Killybegs trawler MFV *Westbound* SO936 catching albacore tuna by hook and line methods. A Seafish member of staff accompanied the vessel which departed from the French port of Les Sables d'Olonne on 20th July, and docked at Castletownbeare in south-west Ireland on 31st July. The trip extended 736 km (460 nautical miles) west of France (figure 4) where the water depths are about 4500 m (2460 fathoms). The voyage comprised one of a series in this study.

Seafish has some experience in the albacore tuna fishery as a result of a MAFF (now DEFRA) commissioned study into alternative fishing methods for albacore tuna (Swarbrick 1998) (7). This was carried out in response to EU proposals to ban drift nets by the end of 2001 (UN Resolution 44/225[1]; EU Regulation 1239/98[2]). Through attending the 2004 sea trials, Seafish was able to provide some assistance and advice to BIM and further the development of co-operation between the two fishery institutes.

BIM has considerable experience in this fishery. An EC / PESCA funded study by BIM in 1998-99 (2) examined alternative fishing methods for albacore tuna in response to the EU decision to ban drift nets. In that study, a comparative assessment was made of pelagic pair trawling, trolling and surface longlining, together with a biological assessment of the fishery and an economic analysis. More recently, BIM carried out an observation voyage on board a Mediterranean longliner in 2002 (Mulligan 2002) (8) and also some limited longline sea trials for albacore in 2003 (Mulligan 2003) (9).

The primary objectives of BIM in this 2004 study were to determine the relative efficiency of using surface longlines in the capture of albacore tuna. As part of this study, three longline systems currently in use were to be evaluated in conjunction with different types of hook and bait. BIM was working closely with several French fishermen and a French fishermen's co-operative based in Les Sables d'Olonne (the Coopérative Maritime Des Marins Pêcheurs). These French fishing interests were working together to develop the tuna longline fishery with the assistance of local grant funding. Other objectives of BIM were to improve the quality and care of the catch, to develop a marketing strategy for the product, to introduce Irish skippers to their Spanish and French counterparts and to build professional relationships with other fishery organisations (See Appendix I, *Proposal and Rationale of the BIM study*).

This report describes an account from an observational point of view of one of a series of BIM sea trials in this study. It is not intended to be an exhaustive study of

[1] The General Assembly of the United Nations unanimously agreed a moratorium on large-scale pelagic drift net fishing in December 1989 (Resolution 44/225). The moratorium came into force on 30 June 1992.

[2] The EC regulation banning drift nets for tuna came into force on 1 January 2002. (Council Regulation (EC) No. 1239/98 of 8 June 1998, amending Regulation (EC) No. 894/97 laying down certain technical measures for the conservation of fishery resources.)

the fishery, nor to provide definitive experimental results. A review of some related literature was undertaken to put the observations into context. Full details of the series of sea trials, together with acquired data and other literature, is available from BIM (Mulligan 2004) (10).

2. Aims and Objectives

The main objective of Seafish in attending this BIM trial was to observe the fishing methods used to catch albacore tuna so as to be able to place them in context with the UK fishing industry.

3. Materials and methods

The 16 metre Irish vessel (14.7m registered length) used for the trials is normally based in the Irish port of Killybegs, and engages in pelagic trawling for sprats, herring and mackerel. The hull was of steel with the wheelhouse and accommodation constructed forwards of the open working deck (figure 1). Three net drums were built into an overhead gantry which straddled the deck area at the stern of the vessel. The engine developed 400kW (230hp) (nominal) and the propeller was ducted through a Kort nozzle. The vessel had a three-barrel winch *(by North Sea Winches^{TM})* and was equipped with a separate electro-hydraulic power pack driving a self-tensioning winch for deploying a net-sounder cable and transducer.

Mulligan, BIM

Figure 1: MFV *Westbound* SO936 departing from Les Sables d'Olonne

The *Westbound* had been fitted with two means of catching tuna: a Spanish longline system baited with small sardines, and trolling equipment for fishing with artificial lures.

3.1. Trolling Equipment

The trolling equipment comprised two 11m (36 feet) steel poles extended out over the port and starboard sides of the vessel from a midships position, and also lines streamed in the water directly over the stern rail. Weighted lures were attached to the ends of the lines, each lure having a barbed double hook. The trolling gear allowed the skipper to determine the presence of tuna before deploying the longline. This equipment was supplied by Dunmore Marine Supply, Ireland.

Trolling lines were deployed from the port and starboard sides and the stern of the vessel. Lines were deployed from a bank of 5 hydraulically powered line retrieval reels mounted on a common drive shaft on the port side of the vessel (further described in Anon. 1999) (2). Lines were also deployed from three hand-cranked reels mounted on the starboard side. (It is usual for the reels on a Spanish tuna trolling vessel to be hydraulically powered independently of each other, rather than hand-cranked. See figures 5 & 10.) In addition to these lines, 4 hand lines were deployed from the stern rail. In total, 12 trolling lines were deployed. The general layout of the trolling lines and their respective lengths is shown in figure 1.

The multiple reels on the port side of the vessel allowed each line to be hauled independently of the others. Figure 2 shows details of how a line is deployed using this system. The longest line of about 50 fathoms (91m) with a 1.6mm diameter was streamed from near the tip of the pole (position 5, figure 2). Each line was streamed from a length of wire or twine which was attached to a running line along the pole by a rubber shock cord (figure 5). The shock cord was intended to protect the line from the transient loads incurred by the sudden strike of a fish at the lure. When retrieved, the outboard lines were able to pass over the top of any inboard lines without tangling. The light wire allowed the nylon line to swing across the other lines and assume a position close alongside the vessel from which it was easy to bring a fish onboard.

Lines that were deployed from the stern were attached to a simple wire hook. This served to retain the monofilament close the surface of the water and act as a bite indicator. A strike by a tuna would pull the line off the wire hook (see figure 3).

Lures were weighted to about 90g and were mounted on 5 fathoms (9m) of 0.9mm diameter nylon monofilament line. It was found necessary to add extra weight to the lures, especially during poor weather, to ensure that the lure penetrated the surface film of the water. This extra weight was added in the form of a barrel lead threaded on the line at a position about 5 fathoms (9m) from the lure.

The choice of lure was important, as changing lures resulted in changes in catch rates. It is very difficult to speculate exactly how and why this occurs, but dark coloured lures were observed to be more effective at catching albacore on bright sunny days than light coloured lures.

3.2. Surface Longline Equipment

The surface longlining equipment comprised a hydraulically powered *line drum* holding about 60km of 2.5mm diameter nylon monofilament line, and a hydraulically powered *line setter* which controls the tension of the line (and therefore its depth in the water) as it is deployed over the stern while the vessel steams ahead (figures 6 & 8). The longline equipment was supplied by Talleres Hermida, SL. of Vigo, Spain, and installed on the *Westbound* in the port of St. Gilles, France.

The nylon monofilament hook snoods used on this voyage were 3.5m in length with a weighted swivel at their midpoint. The line was suspended below surface floats on 2m nylon monofilament strops. Hooks were tied directly to the nylon monofilament snood and stowed in large bins ready for deployment (figure 7). Hook sizes used were approximately size 4.0 with a point to shank distance (gape) of about 18mm.

The line was suspended from surface floats spaced approximately 160m apart. Weighting the line was achieved using 5kg weights clipped to the line adjacent to a float. Each end of the line was marked with a dhan float equipped with a radar reflector and a radio transmitter which could be located using a direction finding (D/F) radio receiver. The line was set with the vessel steaming ahead at about 8 knots. The line was baited with small sardines as it was being set, and so vigilance was required to deal with any hooks which became fouled as the line was set. Audible cues were automatically provided by the line setter through a loudspeaker to indicate to the crew when to attach a hook snood and when to attach a float. Attachment was by sprung longline clips which could be rapidly clipped onto the mainline by hand.

The longline was deployed at dawn and left until about mid-day. Once in the water, the several kilometres of line was immediately vulnerable to shipping, so a radar watch was maintained throughout the soak time of the line. (A fishing vessel would easily and safely be able to cross the longline, but this would not be the case for a bulk-carrier class of vessel.) Hauling the longline commenced after a soak time of about 3-4 hours and took about 3 hours to retrieve 800 hooks spaced approximately 20m apart. The total longline length for 800 hooks deployed was approximately 16km.

The line was hauled continuously, being stopped only to remove fish and rectify tangles (figure 9). The line passed through a stainless steel block suspended from a davit at head height. Each clip ran up to the waiting line operator who disengaged each from the line. Snoods were passed aftwards along a transport wire which ran outboard and parallel with the gunwale. The snoods were then taken off the transport wire by the crew and stowed in large bins.

3.3. Care of the catch

Albacore tuna were brought onboard using either a landing net or a gaff. They were unhooked and then placed directly into large 1m^3 bins of iced seawater to chill on deck. The fish were not stunned or bled. After about 30 minutes in the ice/water mix, each fish was lifted out and lowered by hand into the refrigerated fish room. They were then wrapped in perforated plastic sheeting before being shelved in ice. The fish room was kept at a temperature below 4ºC. The maximum shelf-age of the fish by the time it reached the market was 9 days.

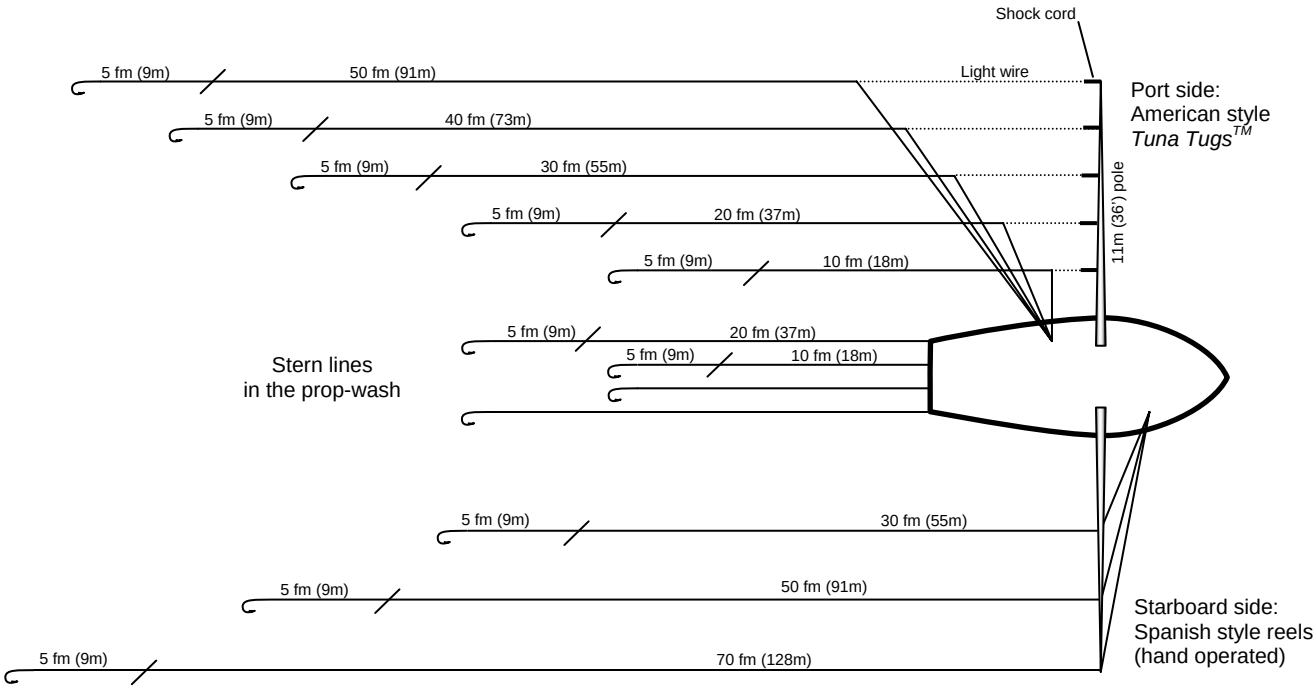

Figure 1 General layout of the trolling lines on MFV *Westbound* (not to scale)

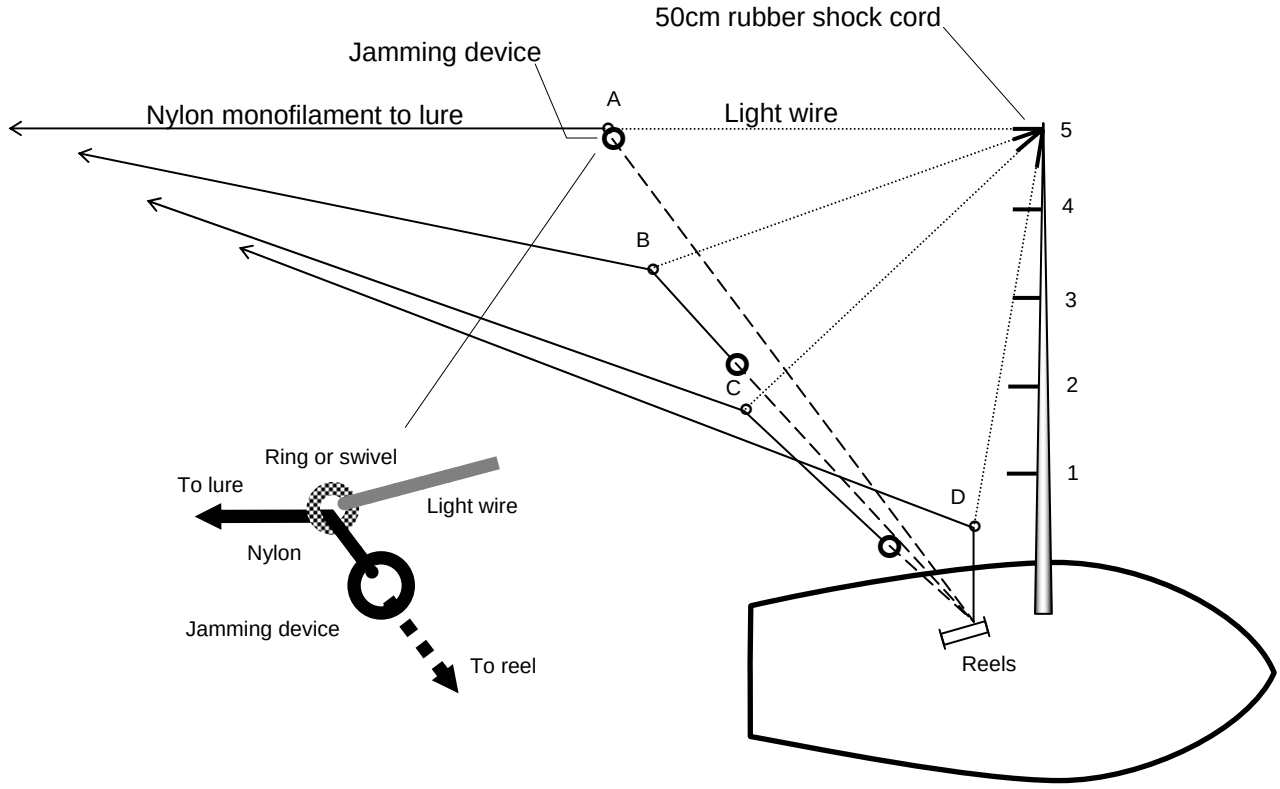

Figure 2 Showing the mechanics of line retrieval with the multi-reel trolling system. For clarity, only one line of 5 is illustrated here (not to scale)

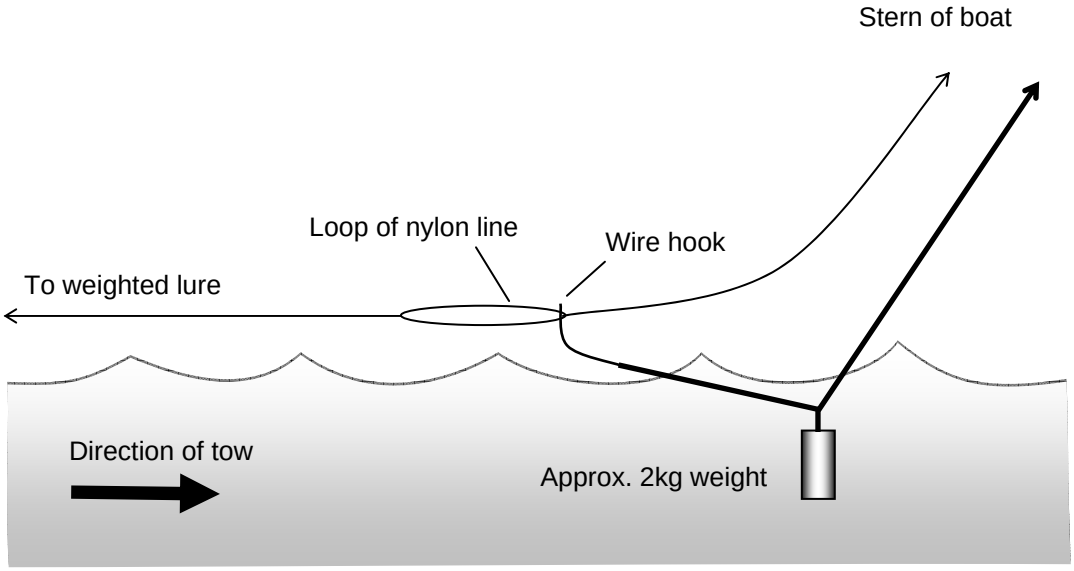

Figure 3 Detail of the trolling lines deployed from the stern of the *Westbound*

3.4. Searching for fish

The *Westbound* steamed for 3 days to reach the fishing grounds in the western Bay of Biscay region. The trolling equipment was then deployed to monitor the presence of tuna. Once tuna were being caught frequently (approximately more than 10 in an hour), the skipper was then able to decide whether to set the longline.

Once on the grounds, the radio and radar were constantly monitored to check for signs of other fishing vessels, and a watch was posted to look out for signs of fish activity at the surface. On two occasions, fish activity was observed in the form of a *fish-ball* of albacore tuna chasing shoals of small pelagic fish – usually anchovies and horse mackerel (figures 12 & 13). The surface observations could be augmented by using the vessel's sector-scanning sonar. In these cases, the sonar showed the shoals of small pelagic fish as distinct traces with clear disturbances running through them. The disturbances were caused by hunting albacore causing the shoal to rapidly change direction. On each occasion that an aggregation of tuna was observed, the vessel lost contact with it after a few minutes because there was no way of determining in which direction the shoal had travelled. This emphasises the importance of being able to fish as part of a team, which is how the Basque and Galician fishermen work.

BIM had arranged for some guidance to be given by the skipper of the Spanish vessel *Pachilan* through a pre-arranged radio code system. This system allowed covert communication without giving away the position or intentions of either vessel. Using this system to obtain information from the skipper of the *Pachilan,* the *Westbound* was able to locate the Spanish trolling fleet and work alongside.

It was observed that when the *Westbound* located tuna with the trolling equipment and turned around to pass through the shoal again, the skippers of surrounding

Spanish vessels would notice this. Despite the relatively large distances involved (about 12 miles), if fish were proving difficult to catch then, based on their radar observations, any Spanish vessels in the vicinity would head for any other vessel which appeared to be successfully targeting a shoal of tuna. This emphasises the team nature of trolling for albacore.

Fishing with a longline cannot be regarded as a team activity in the same way as for trolling, however, because of the large sea area required to deploy a longline. A surface longline for albacore may reach 20km in length and may drift several kilometres during the soak time. For these reasons it was very difficult for the *Westbound* to work in close proximity to the French longline vessels.

4. Results

Fishing began in an area approximately 460 miles west of Les Sables d'Olonne (see map, figure 4). There were 9 days of fishing from 22 July to 30 July.

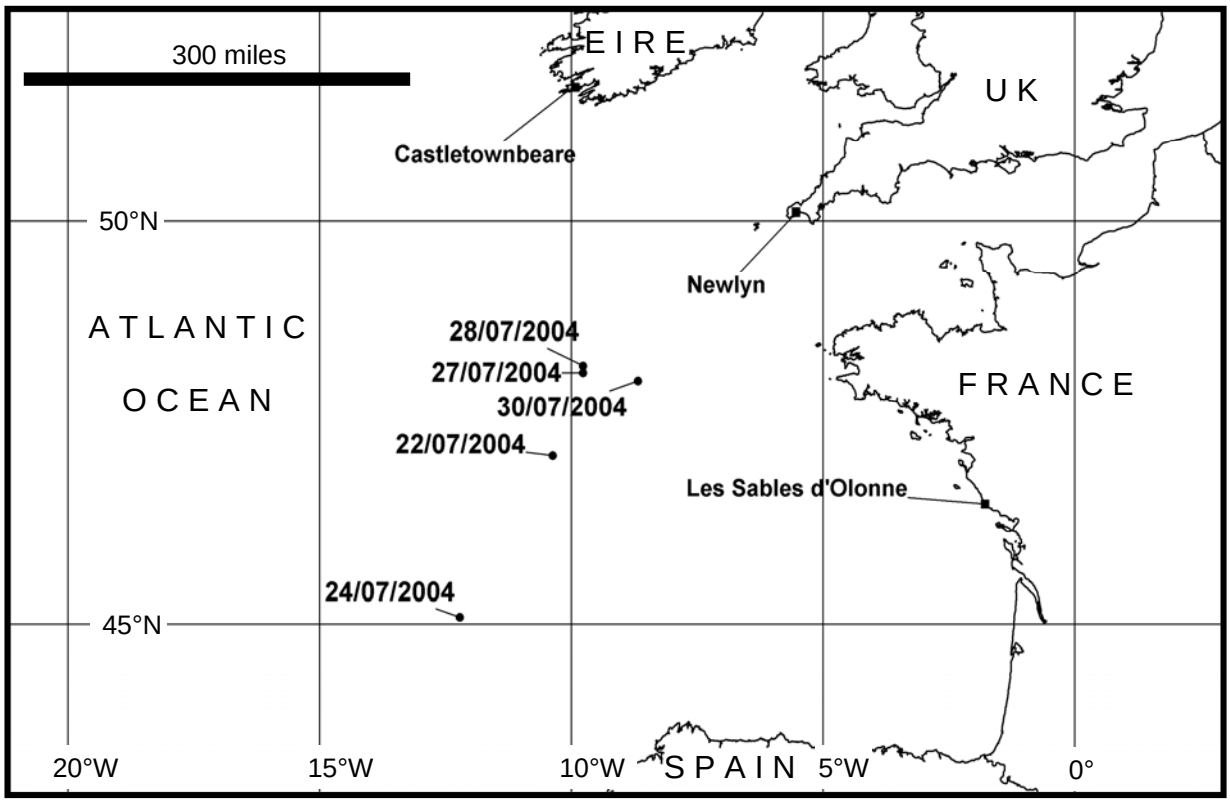

Figure 4 Map showing vessel location with dates

111 tuna were caught by trolling and 3 by longlining during the observed voyage. During a previous voyage (fishing days 7-15 July) 232 fish were caught by trolling and 53 by longlining. The catches for both voyages are shown in Table 1.

Table 1 Albacore catches from MFV *Westbound;* Voyage 1 (fishing days 7-8 July) and voyage 2 (fishing days 22-30 July were observed by Seafish)

Fishing day	Numbers of fish caught per day		Number of longline hooks	Catch per 100 hooks
	Trolling	Longline		
7 July 2004	11	0	0	0.00
8 July 2004	29	23	580	3.97
9 July 2004	40	0	0	0.00
10 July 2004	44	11	550	2.00
11 July 2004	20	2	570	0.35
12 July 2004	25	7	590	1.19
13 July 2004	40	6	585	1.03
14 July 2004	18	3	700	0.43
15 July 2004	5	1	810	0.12
22 July 2004	4	0	800	0.00
23 July 2004	22	0	800	0.00
24 July 2004	1	0	800	0.00
25 July 2004	8	0	800	0.00
26 July 2004	35	0	800	0.00
27 July 2004	11	0	800	0.00
28July 2004	10	0	800	0.00
29 July 2004	20	3	800	0.38
30 July 2004	0	0	800	0.00

Fishing days 22-30 July were observed by Seafish

Catches made with the longline were very variable. There was insufficient data to be able to make an objective assessment as to how variable, however. Noticeably fewer tuna were caught by the *Westbound* with the longline compared with the French longlining vessels. Table 2 provides some longline catch data of other vessels, for comparison.

Table 2 A comparison of longline catches from within the trials period and from other periods and studies

Fishing day 29 July: Catches reported by other longliners			
	No. of fish	**No. of hooks**	**fish/100 hooks**
MFV Les Miserables	14	2000	0.7
MFV Myosotis	17	2000	0.85
Unnamed vessel	34	2000	1.7
Fishing day 30 July : Catches reported by other longliners			
	No. of fish	**No. of hooks**	**fish/100 hooks**
MFV Les Miserables	250	2000	12.5
MFV Myosotis	22	2000	1.1
Catch reported by MFV Westbound in August 2004			
	No. of fish	**No. of hooks**	**fish/100 hooks**
MFV Westbound	16	2000	0.8
MFV Westbound	15	1200	1.25
Catch reported by Mulligan, 2003 (BIM internal report) (8)			
	No. of fish	**No. of hooks**	**fish/100 hooks**
MFV Kittiwake	13	670	1.94
MFV Kittiwake	11	500	2.20
MFV Kittiwake	15	450	3.33
MFV Kittiwake	8	300	2.67
(Morandeau 1998 reported 0.15 fish per 100 hooks) (3)			

4.1. Bycatch

By-catch taken during observation of the BIM trials with the longline included several blue sharks, *Prionace glauca* Linnaeus 1758, 2 pelagic stingrays *Pteroplatytrygon violacea* Bonaparte 1832, a porbeagle shark *Lamna nasus* Bonnaterre 1788, and one opah (also called moonfish or kingfish) *Lampris guttatus* Brünnich 1788. All these species were landed to market. The opah makes particularly good eating (Hatfield, 2004; pers. comm.)[3]. In terms of numbers of sharks caught per hook, 10 sharks were caught using a total of 2400 hooks over a three day period in one area. This equates to 1 shark in 240 hooks, or 0.04%.

[3] Dr Emma Hatfield, FRS Marine Laboratory, Aberdeen.

Figure 5
American style Tuna Tugs™ mounted on the port rail

Figure 6
Longline equipment: Line setter mounted on the stern

Figure 7
Hooks, snoods and swivels, stowed in a large bin, ready for deployment

Figure 8
Shooting the longline; the line drum is at the bottom of the picture

Figure 9
Hauling the longline, showing the path of the nylon monofilament

Figure 10
Pole on port side, showing 5 lines being streamed from rubber shock-cords

Figure 11
Example of a hand-operated reel (lower centre) alongside hydraulic-powered reels

Figure 12
Albacore tuna in a feeding frenzy, hunting anchovies (Swarbrick 1998) (7)

Figure 13
Albacore tuna chasing small horse mackerel

5. Discussion

Catches were poor in this trial and would not be economically viable. It would be interesting to make an assessment of the variability of catches among the Spanish trolling fleet - approx. 600 vessels according to Ortiz de Zárate *et al.* 2004 (4) - to be able to relate the catches made with the trolling method during this trial with an average catch.

5.1. Fish behaviour

Two distinct size classes of tuna were encountered: 4-6 kg and 6-10 kg. Albacore of this size tend to be juveniles aged between 1 and 4 years, depending on sex. The onset of maturation is different for males and females. Female albacore tend to mature at about 85cm FL (> 4 years), while males can become mature at much smaller sizes (Shomura *et al.* 1991) (5). Table 3 presents albacore age, length and weight relationships.

Table 3 Albacore age, length and weight relationships (combined sexes)

Age (years)	TL[1]	FL[2]	Whole weight[3]
1	53cm	48cm	2.3kg
2	66cm	60cm	4.4kg
3	77cm	70cm	6.7kg
4	86cm	78cm	9.0kg

TL = Total Length
FL=Fork Length

[1] From Ortiz de Zárate *et al.* 2004 (4)
[2] TL x 0.913622 = FL (Fishbase)
[3] ln(weight) = 2.76 x ln(FL) - 9.83 (Pacific data, Griggs) (11)

The albacore fishery is targeted by about 600 Spanish vessels working with two types of gear: baits (20%) and artificial lures (80%) (Ortiz de Zárate *et al.* 2004) (4). Bait boats are mostly Spanish and are worked by relatively large numbers of crew using live baits and hand poles. Longlining is a recent activity in this fishery, but it fits into the category of bait fishing. The trolling vessels use artificial lures (see section 4.1). It is known that albacore tuna being caught by trolling with lures exhibit different behaviour compared with those fish being caught with baits (pers. comm.); (Swarbrick 1998) (7). Fish caught by Spanish bait boats are actively feeding – indeed, they are further encouraged into a localised *feeding frenzy* through the use of hull-mounted water jets which spray on the water surface. However, those fish caught by trolling are probably migrating and are not in such a localised feeding frenzy. They may strike at fast moving artificial lures through a predatory instinct in a manner not unlike an Atlantic salmon attacking an angler's lure during a freshwater river migration, when it is known that they do not feed. Because of these behavioural differences, the *Westbound's* practice of using trolling equipment as 'feelers', to detect the presence of tuna prior to setting a longline might be flawed.

Shomura *et al,* 1991 (5) reported that albacore tend to accumulate near coastal upwelling fronts, and that albacore movements are related to sea surface temperatures. This was also discussed in BIM, anon. (1999) (2) in which the Celtic shelf-break front and the Porcupine Bank front were described as being oceanographic features likely to influence the catches of albacore tuna. For a longline vessel, it might be advantageous to concentrate on these areas when locating suitable aggregations of tuna to target.

It was noticed that lures being trolled from the stern in the prop-wash of the vessel tended to catch more frequently than the lures that were trolled from the poles. It may be possible that albacore find that the motion of the bubbles in the prop-wash resembles the schooling behaviour of small fish, or that they are hunting for possible prey species obscured from view within the prop-wash. Both of these suggestions are speculation, however. The propeller of the *Westbound* was fitted with a Kort nozzle. It is interesting to note that Swarbrick, 1998 (7) and BIM, 1999 (2) both suggested that, when fitted to a trolling vessel, Kort nozzles can lead to a reduction in the catch rates of albacore tuna.

5.2. Differences in longline performance

The *Westbound* was using similar longline gear compared with the French longliners, but tended to work much shorter lengths of line (about 800 hooks compared with 2000 hooks, see Tables 1 and 2; see also Appendix II). For the most part, catch rates were similarly low for both the *Westbound* and for the French vessels (see Table 1) but the French longliners caught more fish with longer lines.

There were several possible reasons as to why poor catches were taken with the longlines. The skipper suggested that the 2.5mm diameter, white coloured main line was visible to albacore tuna and prevented efficient fishing because of this. The line exhibited a strong tendency to become very twisted during the soak time in the water, which would prevent deployment of the bait at the correct depth. The crew was relatively inexperienced at searching for tuna and handling longline equipment.

Because of these low catch rates and associated line deployment problems, BIM decided to change the line for one of lower diameter during the following month. Data from other longline vessels fishing in other areas at the same time (July 2004) indicated that a good catch for a longline in the Bay of Biscay would be about 200 albacore tuna with 2000 hooks (a catch rate of 10%).

5.3. Care of the catch

Price *et al.* (1994) (1) recommends that best practice is to stun each albacore tuna immediately after it is brought on deck, prior to the fish being bled. The crew of the *Westbound* was not observed to follow this process. There is extensive information in Price *et al.* (1994) (1) on handling albacore on board a fishing vessel, post capture.

5.4. Commercial viability

About 2 tonnes of tuna was caught by trolling with poles and lures during the sea trials, with no by-catch. The skipper of the *Westbound* estimated that, under commercial fishing conditions, about 150-200 tuna per day (equating to about 5 tonnes per trip) were needed to make the fishery viable for an Irish vessel. This is also suggested in the EU study no. 98/010 (BIM, anon. 1999) (2).

Landing prices (per kg) varied, depending on the market. At the time of the trials, line-caught albacore was realising 4-5 euros/kg in France, 2.5 euros/kg in Spain, and 1.8 euros/kg in Ireland (the Irish market is proportional to the Spanish market, with the disadvantage of incurring additional transport costs).

The trials demonstrated that it is possible to catch albacore tuna with hooks and lines, both with a longline and by trolling with poles and lures. Of the two methods, trolling is less expensive in terms of gear required (about 15,000 euros, with hydraulic haulers, or about 1000 euros without hydraulic haulers). However, the method necessitates 18-hour periods on deck. The longline is a more expensive option (about 75,000 euros) but has the potential to catch more fish per day, and 2000 hooks can be retrieved in 8 hours. However, it requires skill in deployment because line lengths can reach 20km, and this needs careful watch-keeping when set.

The trials also demonstrated that the vessel fuel consumption operating in the trolling fishery is significantly less than in a trawl fishery. The skipper of the *Westbound* estimated that, during the 13-day sea trip, the fuel consumption of the vessel was reduced by about 75% when compared with a trawling trip of a similar duration. For a vessel engaged principally in longlining (where it is not necessary to be continually in motion in order to catch fish) it is likely that fuel consumption would be further reduced when compared with a vessel whose principal catching method is trolling.

5.5. Licences and quotas for albacore tuna in the UK

The total allowable catch (TAC) allocated by the EU to the UK for 2004 was 402.1 tonnes, and, at present (Nov 2004) none of it has been taken up by directed tuna fishing. For the year 2004, 181.1 tonnes was allocated each to England and to Scotland, with 39.9 tonnes allocated as a UK-wide bycatch provision for other fisheries. No albacore tuna have been recorded as being landed under any of these allowances in 2004.

There are 12 UK tuna licences in total; 6 are allocated to England and administered by DEFRA[4], and 6 are allocated to Scotland and administered by SEERAD[5]. None of the 12 licences are currently allocated to a vessel (November 2004). In Spring 2005 both of these agencies plan to re-advertise the availability of albacore tuna licences

[4] Department for Environment, Food and Rural Affairs; Roger Mason, Fish IV

[5] Scottish Executive: Environment and Rural Affairs Department; Ian Fowler, Sea Fisheries Management Division

to their respective fishing industries. No fee will be levied for obtaining an albacore licence.

5.6. Implications for Cornish fishing vessels

There are several reasons why it might be beneficial for the skippers of appropriate Cornish vessels to consider operating in a hook-and-line fishery for albacore tuna.

Cornwall is the best-placed region in the UK for access to the fishery, which is based in the Bay of Biscay northwards to the coastal regions of southern Ireland.

The albacore tuna is an under-exploited resource in the UK. There are 6 tuna licences available from DEFRA (section 6.5). There is the possibility of financial incentives available for Cornish fishermen to diversify away from pressure stock species.

Efforts required to diversify into catching line caught tuna could be eligible for funding under PESCA[6]. Preliminary investigations have suggested that applications could be positively received by the PESCA administration.

From the observations made during this BIM voyage, there is no evidence that there is a significant bycatch in the tuna trolling fishery in Biscay.

The Cornish fleet is composed mainly of small, inshore vessels. Vessels for working in the tuna trolling fishery must be capable of working at long range for periods of at least 15 days in ocean conditions (Swarbrick 1998) (7). For both safety and efficiency, prospective skippers must consider operating as a team.

Providing that market conditions allow, and providing that vessels of an appropriate specification are willing to participate, then line-caught tuna landed into Cornwall could be associated with a fishery that offers a premium quality product with a low environmental impact. Having a low environmental impact could be a significant marketing attribute in itself.

[6] South West PESCA Ltd. is publicly funded by FIFG, Cornwall County Council, Cornwall's District Councils and the South West of England Regional Development Agency

6. Conclusions

1. Whilst it is possible to catch tuna using a baited surface longline, the catch rates achieved by the *Westbound* with the longline were low when compared with the trolling method using lures.

2. The catch rates achieved by the *Westbound* were much less than those of the French longlining vessels. This suggests that crew experience and vessel location are both important factors in the success of a longline fishing operation for albacore.

3. Trolling for albacore tuna is a team effort, requiring several vessels to be able to locate and to follow shoals of migrating tuna.

4. Surface longlining is an extensive operation. It requires good watch-keeping skills and requires a large area of ocean to be clear of large, deep-drafted vessels (for example, bulk carriers).

5. Both longlining and trolling offer considerable reductions in fuel consumption compared with trawling operations.

6. To be economically viable it is necessary to catch about 150-200 tuna per day (2004) (equating to about 5 tonnes per trip).

7. There was no bycatch taken with the trolling method on this sea trial, whereas there was a certain amount of bycatch taken with the longline (see section 5.1).

8. There are 12 licences available for UK vessels to fish for albacore tuna (in 2004), and there is an unused quota (in 2004) of albacore tuna allocated to the UK. It is therefore possible for UK vessels of appropriate specification to diversify into the albacore fishery.

7. Recommendations

1. It is recommended that the findings of this study be disseminated to fishermen in southwest England to gauge their interest in the possibility of catching albacore tuna. As part of this, it would be necessary to ensure that any candidate vessels are capable of working in the fishery.

2. It is also recommended that a thorough market study be completed before embarking on any sea trials in the albacore fishery. Without having the reassurance of a market for albacore and an in-depth knowledge of its dynamics, the fishery would not be particularly attractive.

8. References

(1) Price, J. *et al.* 1994, Recommendations for on board handling of albacore tuna; University of California; 8pp. Published online at Seafood Network Information Center, *www-seafood.ucdavis.edu/Pubs/albacore.htm*

(2) BIM, anon. 1999, Diversification trials with alternative tuna fishing techniques including the use of remote sensing technology; final report to the European Commission; EU contract no. 98/010 and PESCA contract no. 98.IR.PA.29, BIM, Ireland. 78pp.

(3) Morandeau, F. and George Jean-Paul, 1998, Essais de palangre dérivante: Campaign Germon efféctuée à bord du «Teddy», navire de l'Ile d'Yeu, du 23.09 au 15.10.1998; IFREMER, DITI/GO/TP Lorient. In French.

(4) Ortiz de Zárate, V. *et al.* 2004, Statistics of the Spanish Albacore *(Thunnus alalunga)* surface fishery in the North-Eastern Atlantic in 2002; in: Col. Vol. Sci. Pap. ICAAT, 56(4): 1442-1449 (2004).

(5) Shomura, R. *et al.* 1991, A review of the biology and fisheries for Albacore, *Thunnus alalunga,* in the South Pacific Ocean; in: Proceedings of the first FAO expert consultation on interactions of Pacific tuna fisheries, 3-11 Dec. 1991, Nouméa, New Caledonia, FAO fish. tech. pap. 336/2, Interactions of Pacific tuna fisheries, vol.2.

(6) Crone, P.R. 2001, Albacore; in: California's Living Marine Resources: A Status Report, p317-321

(7) Swarbrick, J. 1998, Drift netting for Tuna: The feasibility and costs of alternative fishing methods; a MAFF commission; consultancy report no. CR153, Sea Fish Industry Authority.

(8) Mulligan, M. 2002, A study of tuna and billfish surface longline fisheries in the Mediterranean Sea area; BIM report. 42pp.

(9) Mulligan, M. 2003, Surface longline trials for Albacore Tuna, August-September 2003; BIM internal report. 4pp.

(10) Mulligan, M. 2004 (in prep.), Final report: Surface longline trials for albacore tuna July-October 2004.

(11) Griggs, L. (2002), Monitoring the length structure of commercial landings of albacore tuna during the 2001-2002 fishing year; 15th meeting of the Standing Committee on Tuna and Billfish, Honolulu 2002, Working Paper ALB5, National Institute of Water and Atmospheric Research Ltd. (NIWA), Wellington, New Zealand.

APPENDICES

APPENDIX I

Proposal and rationale of the BIM study

The following is an outline of the proposal by Myles Mulligan, Resource Development Technologist, BIM, to the relevant parties concerned, regarding a possible team project in the development of a surface longline fishery for albacore tuna (*Thunnus alalunga*) in the North-east Atlantic sea-area.

The trial area proposed takes in the sea-area from 40ºN to 53º 30”N (latitude) and from the coast of France to 22ºW (longitude).

The proposed trial period for this project would be from the beginning of June through to September 2004.

It is proposed to use the Spanish vessel *Pachilan* to assist in this trial. This vessel is a dedicated pole and line vessel, based in the port of Burela, and has actively assisted BIM in a previous trial of this nature in 2003.

A French organisation or co-operative has also expressed interest in participating in this project with up to 5 vessels interested in using this method.

A suitable vessel from the Irish fleet has yet to be chosen.

The objectives of this project are to determine:

1. The efficiency of using surface longlines in the capture of albacore tuna.
2. Which of 3 systems currently in use are most efficient regarding vessel size/ type, crew and sea-area.
3. The efficiency of bait types caught in occidental waters in comparison to the typical bait *Sardina pilchardus* from the Mediterranean Sea area.

Secondary objectives would be:

1. In the case of Irish vessels, to improve the quality and care of the catch
2. As a team effort to develop a marketing strategy for the product.
3. For Irish skippers to learn first-hand from both their Spanish and French counter-parts, who in general have more experience in the Atlantic tuna fishery.
4. The opportunity for two semi-state or state organisations along with a prominent French organisation to work together as a team, developing professional relationships and the possible shared development of new technology or fishing methods both now and in the future.

It could be looked upon as being an excellent exercise at EC level to observe 3 national fishing bodies/ organisations working together in the present political climate with all its problems.

Each country could subsidise their respective vessels for the first 30 days at sea or the first month.

After this subsidised period and relative success and sustainability being achieved, the vessels would continue fishing effort till the end of the season without any more direct financial assistance.

The 3 systems presently in use would or could be tested on the participating vessels.

One of these systems, “ABLE”, is relatively new and French patented. There is not much information available regarding the system at this present time apart from the fact that one of the French vessels has the system on-board. The actual company that sells this system has no interest in taking part in this or any project.

The Spanish vessel *Pachilan* has the Lindgren-Pitman (USA) system while we have the modified one supplied by Talleres Hermida (Spain). One of the French vessels is installing the Spanish modified reel; one other has the Lindgren-Pitman reel while the third has the ABLE system. Both Talleres Hermida and Hi-Liner have expressed an interest in providing technical assistance throughout the project

The cost of the bait is to be provided for the initial 30 days by all project partners for all participating vessels. Included in this supply would be other bait types to use for comparison with the sardine.

The protocol for the trials would be standard to all parties with facilities provided for instructor/ observer aboard for the duration of the trials. The possibility of crew-exchange or other means of hands-on training would need to be discussed and concise technical reports be drawn up by all partners at the culmination.

All matters relating to finance, bait supply and trial protocol are open to discussion

APPENDIX II

Trials update released by BIM, August 2004

BIM article extracted from 'The Irish Skipper' *www.irishskipper.net*

Following previous contact with Betrand Fortineau, manager of the Co-operative Maritime des Marins Pecheurs, and the Spanish vessel *Pachilan,* a joint effort/ co-operation was agreed for the duration of these trials. Thus the *Westbound* has been fishing alongside 5 French vessels from Ile D'Yeu (*Myosotis, Mamouth, Vendetta, Marial* and *Calebarian*) and *Les Miserables* from Noirmoutier, some of which have been testing surface longlining gear in the tuna fishery for the last two years.

Three different longline systems installed on the vessels are being assessed along with the rigging of gear, including snood lengths, hook sizes, baits and baiting techniques. Again, through co-operation with the French, the *Westbound* has also been allowed to land directly into the same French market in Les Sables as the other vessels and thus allowing a direct comparison of landings, with an average price of €5.50 The vessel has completed two trips to date and catches have been poor compared to the French vessels.

For the first trip the *Westbound* landed around 1.5 tonnes compared to 8 tonnes landed by the best French boat. However, aside from the difference in experience with the longline gear, significant problems were also found with the mainline, restricting the effective number of hooks the vessel can fish to (a maximum of) 1,200 per day compared to 2,200-2,600 being worked by the French vessels.

It was also felt that there were other subtle differences between the *Westbound's* gear and the French gear and taking this on board it was decided, that Myles Mulligan would join the French vessel *Myosotis* for a trip and see at first hand. This proved very useful and a number of differences in rigging were indeed found. The biggest fundamental difference was that the *Myosotis* is using soft 1.6mm branch line as mainline compared to hard 2.5mm mainline being used on the *Westbound.* Other differences noted included the addition of weights onto the float lines and 14 hooks between floats with a weight placed at every 7th hook.

The baiting technique is also considered important as is a reduction in soak time. During this trip good catch rates were observed with the best return being 370 fish for 2,500 hooks, averaging 6kg giving an approximate catch of just over 2 tonnes, representing a CPUE of 15%.

Currently (August 2004) the *Westbound* is on her third trip, rigged with new 1.6mm branchline as the mainline and the other adjustments taken into account. It remains to be seen whether the technique will be viable, but indications from the French boats would suggest a positive outcome to the trials is possible.

BIM would like to acknowledge the assistance and co-operation received from the French and Spanish skippers and in particular Monsieur Betrand Fortineau of the Co-operative Maritime des Marins Pecheurs during these trials.

APPENDIX III

Catching Albacore – Spanish style

Myles Mulligan, Gear Technologist, BIM

BIM article published in 'The Irish Skipper' *www.irishskipper.net*

"Trolling is not quite as simple as rigging up a couple of poles and haulers and subsequently 'chucking a couple of hooks over the side'. As with trawling or longlining, trolling is an art of its own. Care and attention must be taken both in rigging the vessel out and then continually whilst fishing. This method has been practised by fishermen from both the Cantabria region and Galicia over the last three centuries."

This season alone, a fleet of up to 300 dedicated vessels between 14-30m with up to four support ships participated in the fishery off the western seaboard.

Lagun Bi is a 19m/280hp wooden vessel from Bermeo in the Basque Country, and has a hull design typical of the majority of the Spanish fishing fleet. Out of the tuna season, her fishing effort consists mainly of potting for *Nephrops* and lining for mackerel. This vessel is one of a group of Spanish boats including *Izurria Berria*, *Maria Digne Dos* and *Nuveo Maria Reyes,* which has worked together over the last couple of years with the Irish trollers *Annandale* and *Warren Lock,* sharing information on catch rates and areas being worked.

Getting ready

In Spain, preparations for the tuna season begin in April. Vessels are slipped, hulls cleaned and painted with a dark matt shade of anti-fouling. To reduce noise levels and vibrations and to prevent unwanted reflections and flashes of light under the water, the propeller is removed and the blades are etched to create a matt effect. The rudder bearing, cutlass bearing and all seals are then inspected and replaced if necessary. A steel cover with a dark matt finish usually masks any anodes, while inside the hull, seals and mountings that dampen vibrations from pumps and alternators are inspected or replaced.

Once this process is completed, the poles, mechanised haulers and the lines are rigged, while refrigeration and other systems are inspected and repaired if necessary. Only then is the vessel prepared to go trolling commercially for tuna. Traditionally the fleet departs around the end of May, after the *Fiestas del Carmen* in Galicia, and the *Andra Mari* in the Basque region (blessing of the boats).

Layout

It is important to note that, no matter what system used, the gear actually contributes only 40% towards the viable success of trolling. The Spanish mechanised system comprises up to 15 independent hydraulic haulers depending on the vessel size and crew experience.

Usually 4-5 haulers are deployed per side with 2-5 haulers worked off the stern and quarters. Two 18m *barras* or poles are mounted aft of midships consisting originally of eucalyptus trunks, but now they are of specially made steel or fibreglass construction.
These poles are set at an angle of between 23°-35° from the horizontal whilst fishing.

Each hauler spool holds between 40 fathoms (73m) and 90 fathoms (165m) as a combination of:

30-40 fathoms (55m-92m) of 4.0mm nylon, plus
3-33 fathoms (5m-60m) of 1.20mm monofilament line, plus
3-9 fathoms (5m-16m) of 1.20mm monofilament, plus
4.5 -7.5 fathoms (8m-14m) of 0.90mm monofilament, plus a weighted lure.

There is no set combination of line lengths or sizes as this depends greatly on personal experience over various seasons, and generally, all the vessels work similar gear. The typical Spanish type lures and small plastic squid are used both on their own or combined. These are all mounted above a double barbed hook, with strips of coloured ribbon sometimes tied on the hook bend.

Every day, gear performance has to be observed as the colour combinations used for each lure vary according to its position, time of day and both light and ambient weather conditions.

Upkeep
Maintenance of the gear, replacement of dull or frayed lines and weights is essential. The lines are deployed during daylight hours and towed at a speed of between 6.5 to 7.2 knots. Dawn and dusk are generally the best times of the day with the preferred water temperature range of between 15-22°C.

Once the fish are taken on board they are stunned (a practice not observed to be carried out on the MFV *Westbound*) and then handled with great care. They are not bled[7], and they are allowed to cool down before being stored in the fishroom - in some cases by immersion in iced water for a short while. The fish are shelved and laid belly up on ice, sometimes with a plastic sheath. At no given time are there more than two layers one on top of the other, as this would compress the fish resulting in a loss of value.

Manpower
An impression exists that the Spanish system requires large numbers of crew. Generally the large vessels have a crew of between 10 and 12, with some members dedicated to only one task on board. In contrast, many of the smaller vessels keep numbers to a safe minimum with up to five crew including the skipper. It obviously means more responsibilities and workload but also more financial gain per person as there are less shares. It also reflects the current crew scarcity being experienced in Spain.

[7] Price (1994) (1) recommends that bleeding the fish after stunning them is best practice.

Spanish tuna vessels work a share system with crew members also receiving added incentives, achieving ‘win-win’ situation for both crew and vessels. A typical example for a crew of five persons would be that from the gross earnings, the expenses (not including diesel) are deducted. The resulting net earnings are divided 50:50 between owner(s) and crew. The diesel is then deducted from the owners half while the crews half is divided into eight shares. Each person receives 1.5 shares except the skipper (only when the vessel is skipper/owned), with the engineer and cook getting an extra .25 share. The person in charge of the fish room and the person responsible for the general maintenance, cleaning and painting of the vessel would both receive an extra 8 per cent of the gross for the season.

APPENDIX IV

Background to the Irish albacore tuna fishery

Information published by BIM in 'The Irish Skipper' *www.irishskipper.net*

The albacore tuna fishery

Fishing for Albacore Tuna, *Thunnus alalunga* Bonnaterre 1788, is carried out in the Atlantic Ocean and the Mediterranean Sea, mainly by Spain, France and Ireland. The Irish fishery for albacore developed in the early 1990s and is now a valuable fishery, centred on the south and southwest coasts where Castletownbere and Dingle are the main landing ports.

The Irish season starts in July and continues until the end of September, and the bulk of the catch is landed fresh and exported to Spain and France. A TAC and quota system introduced this year (2001) saw Ireland achieve a quota of 3,158 tonnes, or 11% of the EU allowance of almost 29,000 tonnes.

Background

Tuna are among the most biologically advanced fishes in the ocean. They travel long distances on migratory routes - capable of travelling up to 100 miles a day or 10,000 miles a year - moving from tropical to temperate waters. They are prolific breeders, with the females producing millions of eggs[8]; only a few of these will ever reach maturity. Tuna are rare among fish because they can retain heat in their bodies, which is generated by their muscles, keeping their bodies warmer than the surrounding water. Tuna must swim constantly to get the oxygen they require. With their hydrodynamic design, warm muscles and the ability to swim at incredible speeds for short bursts, this makes them very efficient predators. Their diet consists of fish, crustaceans and squids. Albacore can be found in mixed schools with skipjack tuna (*Katsuwonus pelamis* Linnaeus 1758), yellowfin tuna (*Thunnus albacares* Bonnaterre, 1788) and small northern bluefin tuna (*Thunnus thynnus* Linnaeus, 1758). These schools can often be found around objects or weed floating on the surface of the water.

Studies

Limited studies have shown there are three separate stocks of Albacore tuna: the Mediterranean stock and the northern and southern Atlantic stocks. The northern stock covers the whole of the Atlantic, north of 5 degrees. The International Commission for the Conservation of Atlantic Tuna (ICCAT) regulates the fishing of tuna species and relies on scientific advice from its Standing Committee on Research and Statistics (SCRS).
In 2000, the SCRS said that the spawning stock of northern albacore was approximately 30% below the level at which the maximum sustainable yield (MSY) could be attained, but that current catches could be sustained in the short term. Biological information has increased in recent years due to studies carried out by BIM and the Marine Institute, who have collected data since the fishery started in Ireland. These studies are undertaken in an effort to develop alternative methods of catching albacore, away from drift nets and gill nets.

[8] FishBase records a fecundity of 2 million eggs for albacore; www.fishbase .org

The use of drift nets [was] prohibited from January 1, 2002, due to the controversy over the possible high levels and nature of by-catches.

The drift-net ban announcement in 1998 received an angry response from both the British and Irish fleets as no studies or trials on alternative methods had at been investigated at that time.

Results from the Marine Institute's sampling programme - part of the 1999 BIM project at dockside and on board commercial fishing vessels - have shown that the majority of Irish catches of albacore tuna are between 60cm and 80cm. Albacore have a maximum weight of 45kgs and a maximum length of 140cm; sexual maturity may be attained when fish are about 90cm or around five years old. However, information on age and maturity is very limited and based on poor sampling data. Samples indicate that mature albacore are taken in deeper waters towards the end of the season.

Fishing methods

The northern stock of albacore tuna are caught over a large area, stretching from approximately 100 miles west of Kerry to the south of the Bay of Biscay. They can be caught by four different methods: bait boats, trolling, drift nets and long lines. Valuable by-catches of bluefin tuna and swordfish (*Xiphias gladius* Linnaeus 1758) are also taken with the albacore. The two fishing methods of relevance to the Irish fishery once the drift-net ban in place will be pair-trawling and trolling.

Some success has been achieved in pair mid-water trawling, which is a familiar method of fishing for Irish vessels catching mackerel, horse mackerel and herring. The second method, more relevant to smaller Irish vessels, is trolling. This involves towing several lures across the surface of the sea using automatic trolling machines and outriggers. Albacore caught by trolling will fetch a higher price when sold fresh compared to trawled tuna. (Trawled fish are often bruised and damaged by being towed for long periods in a net, and are only suitable for the canned market). Maybe a higher price could be achieved for trawled tuna if they were canned in Ireland instead of being sold to French and Spanish canneries at low prices.

Tuna catching methods

Mechanised trolling

The American mechanised trolling systems used during trials have the advantage over Spanish trolling gear in that only four crew are required, compared with eight to ten on Spanish vessels. These systems comprise two 5-spool hydraulic tuna reels, mounted port and starboard and one single hydraulic tuna puller mounted on the stern. Vessels are rigged with two 10-12 metre outrigger tapered booms, consisting of 6m steel pipes with 5-6m fibreglass or aluminium tapered tips. These poles are set at an angle of about 30° to the horizontal whilst fishing. From a combination of the lines mounted on the poles and the lines worked across the transom, anything from 11 to 14 lines can be deployed. The main lines are constructed in 3-4mm diameter round blue braided nylon line ranging from 10-75m in length, to which is fixed a 10m monofilament trace terminating in a single weighted lure.

A variety of lure designs consisting of feathers, plastic squid and Spanish style lures with strips of coloured bunting on the hook bend can be used all mounted above a double barbless or barbed hook. The colours used are varied according to ambient weather conditions. Rubber shock absorbers are attached to the main line to absorb the momentum of a striking tuna.

The lines are deployed during daylight hours and towed at a speed in excess of 5 knots. Dawn and dusk are generally the best times of the day. Very bright, calm days or heavy swell conditions generally yield poor catches.

Pair Pelagic Trawling for Albacore Tuna
During trials, both the French system and the Irish system of pair pelagic fishing were tried.

For the French system, each vessel uses only one single warp into which is connected twin bridles of 150-180m in length. The vertical mouth opening of the trawl is maintained by using large polyform^{TM} floats (100kgf or greater) mounted at the centre of the headline and on the wing-ends, and foot-rope weights rigged on a basis of 1kg per HP per side, in addition to 7.5m chain extensions on the footrope. This rig gives vertical openings of between 36-50m depending on net design, with the headline kept at a distance of between 2-5m below the surface.

The Irish rig, as used in the herring and mackerel fisheries, differs insofar as each vessel uses 12-30m of double bridles followed by the wingend weights and 150-300m of warp. The same floats and weights are used, but depending on the amount of warp shot, the headline and footrope are staggered, allowing the vertical opening to be easily controlled.
This method was favoured by most of the vessels as it was more familiar to the skippers and crews, and when fish concentrations were encountered, seemed to work as well as the French system.

Both French and Irish style trawls were used during the tuna project, with both fishing equally well.

French pelagic trawls are manufactured with their foreparts in 18m or larger mesh in 10mm polyester (terylene), tapering to 4m mesh in 8mm polyester. The headline is made of stainless steel wire, whilst the sidepanel ropes are constructed in braided nylon. The main body of these nets is manufactured in braided nylon twine and terminates with a nylon or polyethylene codend of between 80-120mm.

The Irish tuna trawls are of a much more conventional pelagic trawl design in that the front sections are constructed in nylon, with the headline and footropes mounted on braided polyester rope rather than wire. Fishing is restricted to night-time with the vessels towing close together at between 0.1-0.15 nautical miles. In order for the method to be effective, towing speeds must be in excess of 3.5 knots and vessels must have enough horsepower in reserve to be able to increase towing speed if tuna are detected in the mouth of the net. Low frequency sounders and sonar would

appear to best for detecting tuna, and a good net sounder is an essential piece of equipment.