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1 A comparison of catch rates of artificial lures from an automated handline
2 fishery at Shetland, UK.

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7 Abstract

8 Automated handlining (jig fishing) has recently been trialled in waters around
9 Shetland, UK. Although different types and colours of artificial lures are
10 commercially available there is a paucity of information available on the
11 effects of either lure design or lure colour on resulting catches. We compared
12 the catch rates of (1) five colours of rubber eel tube lures; and (2) five different
13 designs of artificial lure commonly used in handline fisheries. Lure colour did
14 not significantly affect catches of pollack (*Pollachius pollachius*), saithe
15 (*Pollachius virens*), cod (*Gadus morhua*), ling (*Molva molva*) or tusk (*Brosme*
16 *brosme*). Cod showed a preference for lower hooks on the six hooks per reel
17 set-up when lures were black and pollack showed a preference for lower
18 hooks when the lures were blue. There were no significant differences in
19 catches of saithe, cod, ling or tusk between the five lure types. However,
20 catches of pollack on a novel 'sonic' lure were lower than on other lures. No
21 evidence of a preference for any hook position on the reels was found with
22 any of the lure types.

23

24 Key words: Jig fishing; Artificial lure; Handline; Pollack; Saithe; Shetland

25

1 1. Introduction

2 Automated handlining, or jig fishing, is an established method for targeting a
3 number of commercially important whitefish species. Jig fishing became
4 mechanized in the 1970s when electric machines were developed
5 (Valdemarsen, 2001). Many modern jigging reels are equipped with a
6 programmable computerized motor which allows the fishermen to store
7 programmes tailored to specific fish species or seabed types.

8 A number of northern European countries including Iceland and Faroe have
9 well developed commercial automated handline fisheries (Anon., 2006). In
10 2006 more than 8,800 tonnes of fish, predominantly cod and saithe, were
11 landed from the Icelandic handline fishery (Anon., 2007). However, despite its
12 success in these areas the method has never become widely established by
13 vessels fishing in Scottish waters.

14 At Shetland only a small number of inshore vessels currently utilize automated
15 jigging machines, principally as a seasonal supplement to the more traditional
16 shellfish fishery. The main target species are pollack (*Pollachius pollachius*)
17 (locally known as lythe), cod (*Gadus morhua*), saithe (*Pollachius virens*) and
18 ling (*Molva molva*).

19 Automated handlining is generally regarded as an ecosystem friendly fishing
20 method (Bjordal, 2002) and in today's climate of consumer awareness this is a
21 factor of increasing importance. Environmental benefits include reduced fuel
22 consumption in comparison to trawl fisheries (Macdonald *et al.*, 2007). This
23 also has direct economic benefits to the fisher. Hook and line fisheries are
24 also known to select for larger individuals (Huse *et al.*, 2000), resulting in
25 reduced discards. In recent years, a number of handline fisheries have

1 voluntarily entered certification schemes designed to reassure consumers that
2 fish are caught responsibly and from sustainable fisheries (Jaffry *et al.*, 2004).

3 The perceived benefits of automated handlining have resulted in a renewed
4 interest in it as an alternative fishing method, particularly for smaller inshore
5 vessels. Although there is some information on the effects of hook size on
6 catch rates (Johannessen, 1983; Skeide *et al.*, 1986; Huse and Fernö, 1990)
7 and on bait type and size on catch rates (Bjordal, 1983; Fernö and Huse,
8 1983; Løkkeborg and Bjordal, 1995) there is very little published information
9 on the effectiveness of different artificial lures.

10 Jig fishing operates by attracting fish to artificial lures that are 'jigged' up and
11 down in the water column. A variety of different types of lure are available
12 (Fig. 1) and in each case lures are designed to trigger fish feeding behaviour.
13 Some of the more popular and commonly used lures include rubber eel tube
14 lures, imitation sand eels, lures designed to imitate octopus and squid, and a
15 variety of other plastic and metal lures designed to mimic small injured prey
16 species. Lures are also sold in a wide variety of colours. The use of
17 fluorescent material as an added stimulus has been adopted by some
18 manufacturers. More recently lures designed to emit sonic vibrations, which
19 are thought to act as a fish attractant, have been developed and are being
20 marketed. However, the success of artificial lures is still, to a great extent,
21 highly dependant on the feeding motivation of the target species and this can
22 be affected by a number of environmental factors.

23 In Shetland there is a common belief among fishermen that the use of specific
24 lure types and colours result in higher catches. There is also a great deal of
25 speculation regarding which colours and types of lure catch greater quantities

1 of fish and, as such, views can often be contradictory. One common
2 perception is that red coloured lures have a tendency to out fish others.
3 Furthermore, some fishermen believe that imitation sand eels such as rubber
4 eel tube lures and Red Gill rubber eels produce higher returns.
5 In order to test these hypotheses we recorded and compared the catches of
6 rubber eel tube lures in five different colours (black, pale blue, fluorescent
7 green, fluorescent red, white). We also investigated the effectiveness of five
8 commonly used, commercially available lure types (Red Gill rubber eel, rubber
9 eel tube, muppet, Sonic lure, spoon).

10

11 2. Materials and methods

12 Fishing trials were undertaken on the *Atlantia II* LK502, a 10 m wooden hulled
13 fishing vessel, using five Oilwind automated jigging reels. The study took
14 place between 21 August and 15 September 2006 and in March 2007. Fishing
15 locations were chosen based on previous experience and weather conditions.
16 Locations are shown in Fig. 2.

17 Jigging reels were programmed to the original factory setting. The gear on
18 each reel was lowered to the seabed then raised by 0.9 m, jigged up and
19 down five times, by a distance of 9.1 m each time, before being dropped to
20 the seabed to repeat the cycle. The cycle was repeated until either fish on the
21 hooks triggered automatic hauling or the operator set the machine to haul.

22 Each reel was equipped with 300 m of 181 kg Dynema main line, an 18.3 m,
23 136 kg monofilament shock leader, and a nylon ring of 40 mm inside diameter
24 attached to the end of the leader. Terminal fishing gear consisted of six hook

1 lure rigs weighted by a 3.2 kg lead sinker attached to the end of the rig. Lures
2 were numbered 1 to 6 from top to bottom respectively.

3 2.1. Coloured lures

4 Rubber eel lure rigs were constructed from Marlin 113.1 kg / 1.60 mm clear
5 main line with size 3/0 (58 kg) black brass barrel swivels attached to the main
6 line. Swivels were attached at intervals of 0.9 m on either side of each lure.
7 Coloured lures were constructed from Mustad rubber eel hooks size 10/0,
8 coloured PVC or silicone tubing with 6 mm inside and 8 mm outside diameter,
9 and size 1/0 (79 kg) nickel crane swivels. The five colours of PVC or silicone
10 tubing used were black, pale blue, fluorescent green, fluorescent red and
11 white. Lures were attached to loops made in the main line at approximately
12 1.83 m intervals.

13 2.2. Lure types

14 Red Gill rubber eel, rubber eel tube, muppet, spoon and sonic lure rigs were
15 each constructed from Marlin 250lb (113.1 kg / 1.60 mm) clear main line with
16 size 2/0 (58 kg) three way barrel swivels attached to the main line, by the eye
17 on opposite ends of the swivel. Swivels were attached at approximately 1.83
18 m intervals. Red Gill lures and muppets were equipped with size 8/0 Mustad
19 O'Shaughnessy hooks while spoons and sonic lures were supplied with hooks
20 (approximately size 8/0) attached. Each of the lures were then attached to the
21 remaining eye on the swivel of their respective rigs using an 8-10 cm length of
22 1.1 mm nylon fishing line and a crimp, which provided rigidity in the snood.
23 In each experiment a modified Latin square design was employed with
24 periodical rotations of gear ensuring that each lure type or lure colour was
25 positioned on each reel once and next to each of the remaining lure types or

1 colours twice throughout a total of five rotations. For each fish captured, the
2 jigging reel number, lure type and species of fish were recorded. The hook
3 number on which each fish was caught was also recorded.
4 One-way and 2-way ANOVAs were used as appropriate to test for differences
5 in catches and to investigate possible hook preferences. Where appropriate,
6 post-hoc Tukey tests were also undertaken.

7

8 3. Results

9 3.1. Comparison of lure colour

10 Twenty hours fishing, consisting of five gear rotations, yielded a total of 492
11 fish represented by five different species (Table 1). Catches were highly
12 variable between the five rotations, however, there was no significant
13 difference in the total number of fish caught by lure colour ($F_{4,20} = 0.614$,
14 $P > 0.05$). By species, there was no significant effect of lure colour on the
15 numbers of pollack ($F_{4,20} = 0.553$, $P > 0.05$), cod ($F_{4,20} = 0.430$, $P > 0.05$) or
16 saithe ($F_{4,20} = 0.046$, $P > 0.05$) that were caught. Only small quantities of ling
17 and tusk were caught.

18 The total numbers of fish caught at each of the six hook positions for each lure
19 colour are shown in Fig. 3. Catches of cod varied significantly between hook
20 position on the black lure rig ($F_{5,29} = 4.08$, $P < 0.01$), with a post-hoc Tukey test
21 indicating that catches on hook position 6 were significantly higher than
22 positions 1, 2, 3 and 4 ($P < 0.05$). The number of cod caught on each of the
23 remaining four colours did not vary significantly between the 6 hook positions
24 (Black: $F_{5,29} = 1.24$; White: $F_{5,29} = 0.94$; Fluorescent red: $F_{5,29} = 0.35$;
25 Fluorescent green: $F_{5,29} = 1.82$, all $P > 0.05$). Pollack catches varied

1 significantly between the hook positions on the blue lure rig ($F_{5,29} = 3.46$,
2 $P < 0.05$). A post-hoc Tukey test indicated that the significant differences lay
3 between catches on hooks 5 and 6 ($P < 0.05$). Catches of pollack on the
4 remaining four colours did not vary significantly between the 6 hook positions
5 (White: $F_{5,29} = 2.08$; Fluorescent red: $F_{5,29} = 1.94$; Pale blue: $F_{5,29} = 0.49$;
6 Fluorescent green: $F_{5,29} = 1.56$, all $P > 0.05$). There was no significant effect of
7 hook position on catches of saithe on the five different colours (: Black: $F_{5,29} =$
8 0.04, White: $F_{5,29} = 0.07$; Red: $F_{5,29} = 0.06$; Blue: $F_{5,29} = 0.01$; Green: $F_{5,29} =$
9 0.13, all $P > 0.05$). The small quantities of ling and tusk were all caught on hook
10 6.

11 3.2. Comparison of lure type

12 A total of 237 fish representing 6 species, (including a by catch of Atlantic
13 mackerel (*Scomber scombrus*)), were caught during 10 hours fishing (Table
14 2). There was a significant difference in the total number of fish caught on the
15 different lure types ($F_{4,20} = 0.95$, $P < 0.05$). The greatest numbers of fish were
16 caught on muppet lures followed by rubber eel, spoon, Red Gill and Sonic
17 lures respectively. There was a significant effect of lure type on the numbers
18 of pollack that were caught ($F_{4,20} = 3.20$, $P < 0.05$) with a post hoc Tukey test
19 indicating that significant differences lay between sonic and muppet as well as
20 sonic and rubber eel lures. Lure type did not have a significant effect on the
21 numbers of saithe that were caught ($F_{4,20} = 0.27$, $P > 0.05$). Catches of cod, ling
22 and tusk were low during this experiment.

23 The total catch at each hook position on the five lure rigs for pollack and
24 saithe are shown in Fig. 4. Pollack did not exhibit a significant pattern of hook
25 preference for any of the lure designs (Red Gill: $F_{5,29} = 1.18$; rubber eel: $F_{5,29}$

1 = 0.23; muppet: $F_{5,29} = 2.00$; sonic: $F_{5,29} = 1.14$; spoon: $F_{5,29} = 0.61$, all
2 $P > 0.05$). Similarly, there was no significant pattern of hook preference found
3 in saithe catches on the five lure designs (Red Gill: $F_{5,29} = 0.88$; rubber eel:
4 $F_{5,29} = 0.59$; muppet: $F_{5,29} = 0.25$; sonic: $F_{5,29} = 0.83$; spoon: $F_{5,29} = 0.25$, all
5 $P > 0.05$). The small numbers of cod, ling and tusk were all captured on hook 6.

6

7 4. Discussion

8 The work presented here represents a first attempt at determining whether
9 catch rates differ between artificial lures commonly deployed by jig fishermen
10 in Shetland. Previous studies on the catch rates of artificial lures are limited
11 (Hsieh *et al.*, 2001) and this study is the first of its kind for commercially
12 important whitefish species in the north east Atlantic.

13 The results of the study indicate that pollack, saithe and cod do not exhibit
14 significant preferences for any of the lure colours deployed. Hsieh *et al.*,
15 (2001) also reported that, of ten different coloured lures trialled, no single
16 colour exhibited significantly higher hooking rates of the spotted mackerel
17 (*Scomber australasicus*).

18 The success of different coloured lures may alter at various times of year as a
19 result of changes in light levels, water clarity and available prey species.

20 During the months that this study was conducted, August and September,
21 pollack in the North Sea are known to feed mainly on lesser sandeels
22 (*Ammodytes marinus*), while Atlantic herring (*Clupea harengus harengus*) is
23 thought to be the main component of saithe diet during the same period
24 (Hoines and Bergstad, 1999).

1 Catch rates of coloured lures may also be affected by the visual detection
2 abilities of the target species. Gadoid species such as cod and saithe are
3 known to utilize available light by attacking prey from below, using the
4 increased visibility of prey items against downwelling light (Jobling, 1996).
5 However, visual cues are limited to a relatively small distance with many fish
6 being unable to see more than ten or fifteen metres (Diana, 1995). Other
7 stimuli known to assist predators in the detection of food items, possibly to a
8 greater degree than colour vision, include sounds generated by feeding fish,
9 low pressure frequency waves and chemoreception (Bone *et al.*, 1996).
10 Therefore, visual cues such as colour may only perform a minor role in the
11 overall decision of determining whether to attack or reject a prey item.
12 Results also indicate that pollack and saithe do not exhibit significant
13 preferences towards any of the lure designs trialled in this study. However,
14 although there was no overall significant difference in the number of fish
15 caught on the five different lure types, significantly lower numbers of pollack
16 were caught on sonic lures. The sonic lure is a novel artificial lure which was
17 being trialled for the first time in Shetland waters. This suggests that, for
18 pollack at least, the lure is less efficient than the more commonly used Red
19 Gill, rubber eel, muppet and spoon lures. It also implies that these more
20 frequently used lures are relatively effective for attracting and capturing the
21 species targeted in this fishery.
22 Each of the lure types deployed here was designed to imitate species that the
23 target fish would ordinarily prey upon. Red Gill and rubber eels are designed
24 to imitate sand eels and other small fish. The movement of the fish in the
25 water during jigging cycles is intended to imitate injured fish, possibly

1 suggesting an easy target to the predator. Muppet lures are designed to
2 imitate small octopus and squid, with the jigging motion providing lifelike
3 movements and jerks. Spoon lures, generally silver in colour, provide flickers
4 of light during jigging intended to resemble injured fish. Sonic lures were
5 reportedly developed to create a vibration that fish find difficult to resist.

6 The similar catch rates of saithe and pollack on the four commonly used lure
7 designs (excluding sonic lures) may be indicative of relatively low levels of
8 feed selectivity exhibited by these species. Saithe and pollack are known to
9 have a varied diet including Atlantic herring, Norway pout (*Trisopterus*
10 *esmarkii*), poor cod (*Trisopterus minutus*), haddock (*Melanogrammus*
11 *aeglefinus*) and lesser sandeel (Hoines and Bergstad, 1999).

12 As with lure colour, the effectiveness of a specific lure type at a given time of
13 year does not necessarily guarantee its efficacy at other times. A number of
14 commercially targeted species including cod and haddock are known to
15 exhibit seasonal variation in the diet (Hoines and Bergstad, 1999). As such,
16 specific lure types may be more effective in certain conditions than in others.

17 The species caught during this study are representative of the species caught
18 by vessels using jigging gear at Shetland. Catches by those vessels are
19 predominantly of saithe and pollack which are typically caught on unbaited
20 artificial lures. Terminal gear aimed at targeting cod, ling and tusk is more
21 traditionally baited, which may explain the relatively low numbers of those
22 species caught here. Conventional differences in gear deployment are
23 indicative of the various bathymetric distributions of the target species. Saithe
24 and pollack are pelagic to benthopelagic species while cod, ling and tusk are
25 typically benthic or benthopelagic (Cohen *et al.*, 1990). As such it may be

1 difficult to identify one specific lure which may be equally efficient at capturing
2 all of the target species in the fishery. Distinctions in the bathymetric
3 distribution of the species were evident from catches on the various hook
4 positions. For both parts of the study pollack and saithe catches were
5 distributed somewhat evenly between the 6 hook positions while catches of
6 cod, ling and tusk were primarily on hook 6, the closest to the seabed. This
7 suggests that the use of multiple hooks on each jigging reel when targeting
8 saithe and pollack may increase returns while catches of ling, cod and tusk
9 are more reliant on hooks fishing on or near the seabed.

10 Variability in catches during the rotations was typical of the temporal and
11 spatial variability in catch rates encountered in our wider study. This highlights
12 the considerable potential for further investigations into the effects of factors
13 such as time of day and water depth on the catch rates of specific gear types.
14 The preference for lower hook positions exhibited by cod and pollack also has
15 the potential to be further investigated to determine a possible optimum gear
16 configuration for these species.

17

18 5. Conclusion

19 The results of this study indicate that commercially important species such as
20 saithe and pollack did not exhibit significant preferences for any one specific
21 colour or design of artificial lure commonly used in automated handline
22 fisheries. However, a significantly lower catch rate of the previously untried
23 sonic lure suggests that species including pollack do exhibit preferences
24 towards the lures traditionally deployed by fishermen. As such, the success of
25 novel artificial lures is not guaranteed, suggesting the need for trial periods

1 prior to full scale utilization. Further work, including a long term study, may
2 highlight changes in the effectiveness of specific lures in differing
3 environmental conditions. Such information has the potential to assist
4 fishermen in selecting the most appropriate lures for different conditions,
5 consequently maximising returns.

6

7 Acknowledgements

8 This study was carried out during a wider investigation into the commercial
9 viability of jig fishing in Shetland coastal waters, partly funded by the
10 European Union under the Financial Instrument for Fisheries Guidance
11 (FIFG). We are grateful to all the fishermen who provided information on
12 fishing grounds around Shetland.

13

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1 Table 1 Summary of catches of each species on different coloured lures.

Scientific Name	Common Name	Lure colour				
		Black	White	Fluorescent Green	Fluorescent Red	Pale Blue
<i>Pollachius pollachius</i>	Pollack	54	51	35	72	51
<i>Gadus morhua</i>	Atlantic cod	13	12	9	12	5
<i>Pollachius virens</i>	Saithe	39	42	25	36	32
<i>Molva molva</i>	Ling	1	0	0	0	0
<i>Brosme brosme</i>	Tusk	0	1	0	1	1
	All species	107	106	69	121	89

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1 Table 2 Summary of catches of each species on different lure types.

Scientific Name	Common Name	Lure type				
		Red Gill	Rubber eel	Muppet	Sonic	Spoon
<i>Pollachius pollachius</i>	Pollack	21	27	28	4	25
<i>Gadus morhua</i>	Atlantic cod	0	0	0	0	0
<i>Pollachius virens</i>	Saithe	18	28	29	15	28
<i>Molva molva</i>	Ling	0	0	0	0	1
<i>Brosme brosme</i>	Tusk	1	1	3	1	0
<i>Scomber scombrus</i>	Atlantic mackerel	1	0	2	3	1
	All species	41	56	62	23	55

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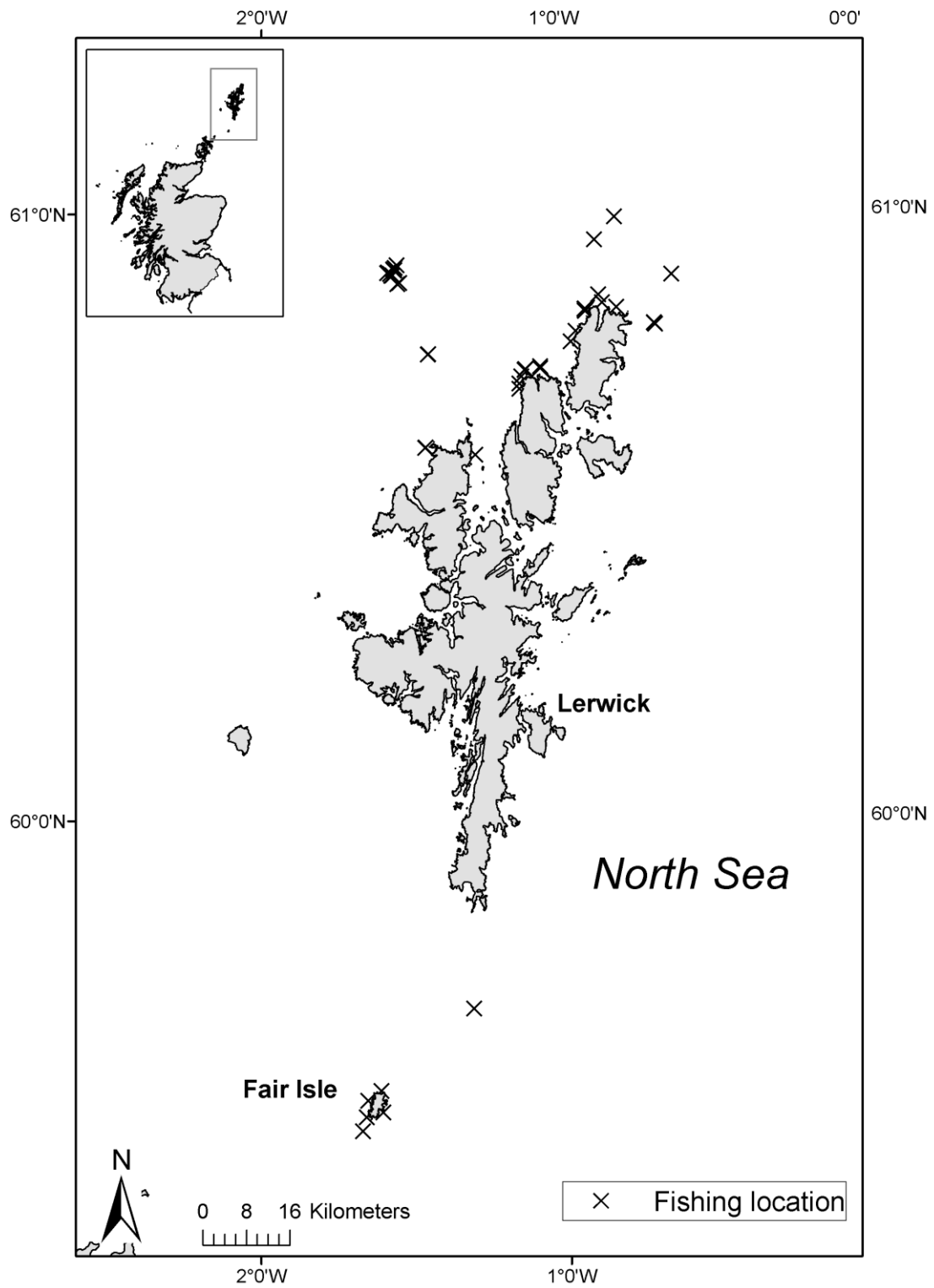
- 1 Fig. 1 Artificial lures commonly deployed by commercial fishing vessels at
- 2 Shetland.
- 3 From top left: Mustad rubber eels; plastic squid or 'muppets'; spoon lures; Red
- 4 Gill rubber eels.



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1 Fig. 2 Map of the Shetland Isles with specific fishing locations highlighted.

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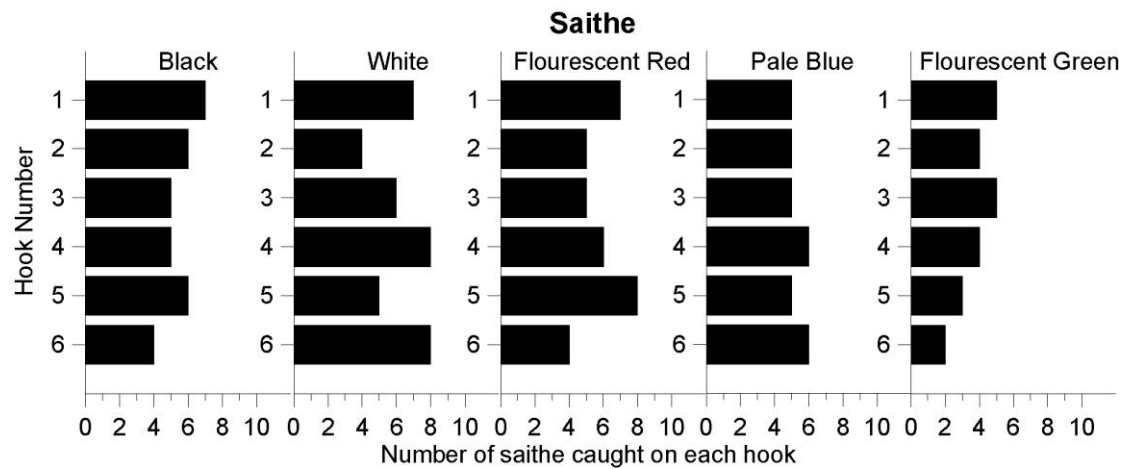
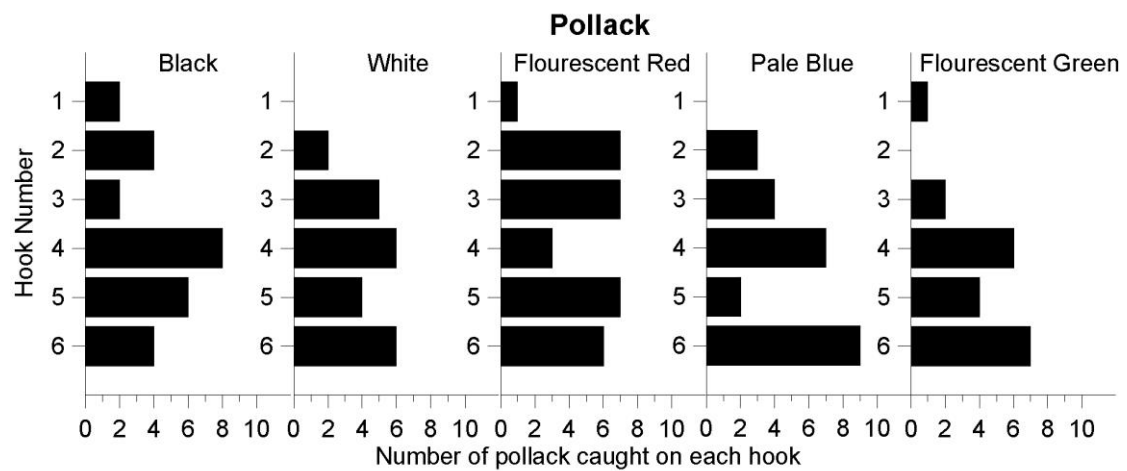
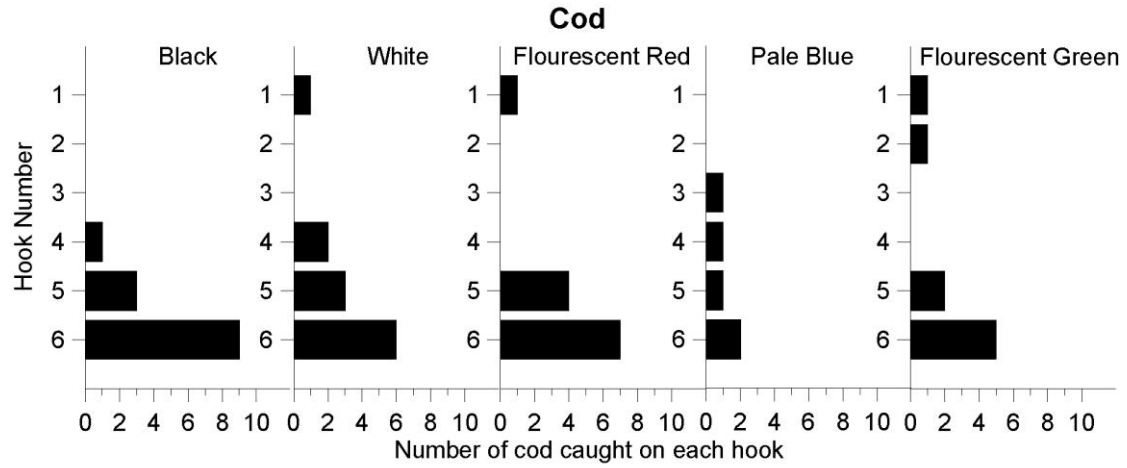


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1 Fig. 3 Numbers of cod, pollack and saithe caught at each hook position on
 2 each of the coloured lure rigs.

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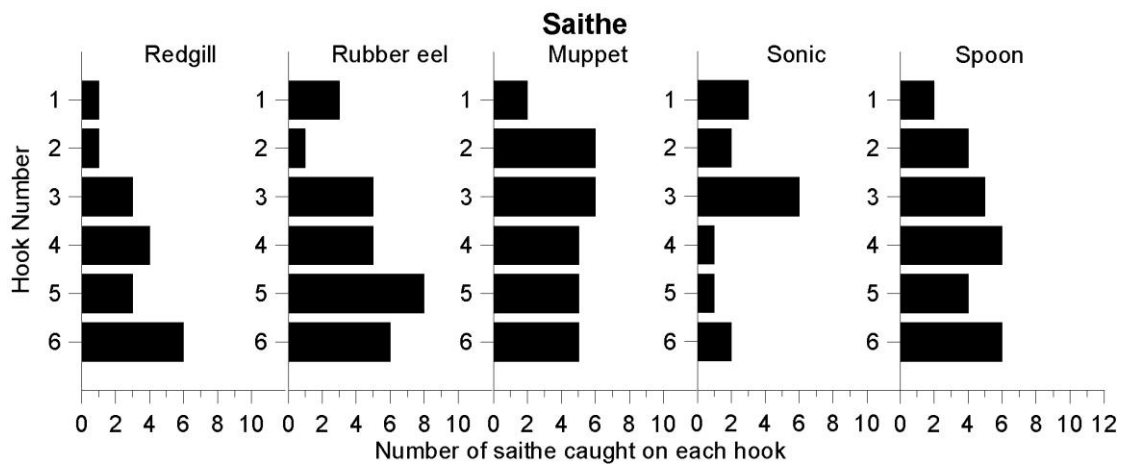
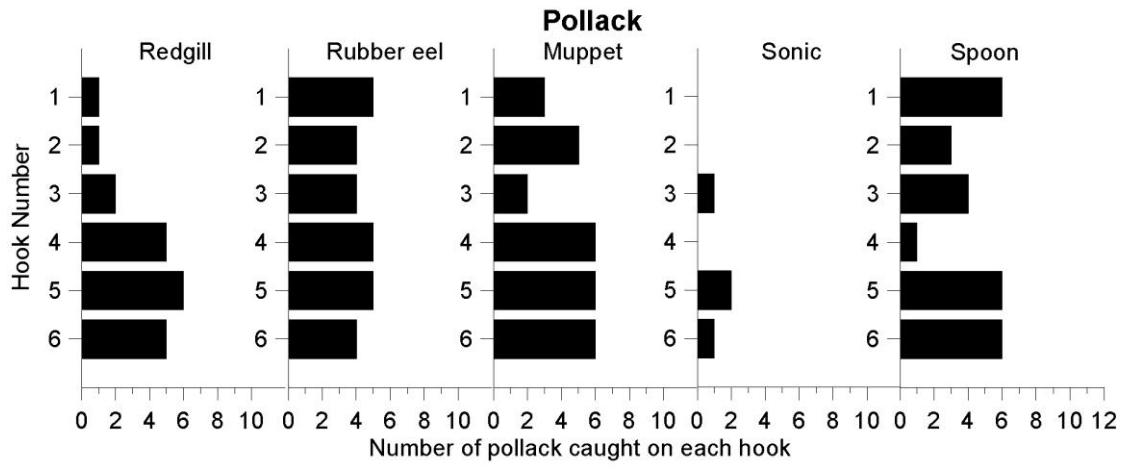
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1 Fig. 4 Numbers of pollack and saithe caught at each hook position on each of
 2 the lure types.

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