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Factors affecting bycatch in a developing New Zealand scampi potting fishery

Robert N. Major[a,b,*], David I. Taylor[b], Stephen Connor[c], Geoffrey Connor[c], Andrew G. Jeffs[a]

[a] Institute of Marine Science & School of Biological Sciences, University of Auckland, Auckland, New Zealand
[b] Cawthron Institute, Nelson, New Zealand
[c] Waikawa Fishing Company, Picton, New Zealand

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ABSTRACT

Bottom trawling is a fishing method that typically produces high levels of bycatch and is associated with extensive benthic habitat damage. Pots (also known as creels or traps) are used as a less impactful alternative to trawling in a number of crustacean fisheries, although bycatch may still occur. Pots have been suggested as an alternative fishing method that would reduce the high levels of fish bycatch in the New Zealand scampi (*Metanephrops challengeri*) trawl fishery. This hypothesis was assessed by comparing the bycatch rates from four different designs of pots used in similar deep sea lobster fisheries overseas. The effects of bait and location on bycatch were also assessed by using three different bait types and fishing the pots at two different scampi commercial fishing sites around 200 km apart. The different pot designs were observed to significantly affect the bycatch of hagfish (*Eptatretus cirrhatus*) and total bycatch at both sites, while at the Chatham Rise site the bycatch of fish species and invertebrate was also affected by pot design. The pot design with the highest levels of bycatch at both sites was Pot 2, a two-chambered parlour pot which caught between 1.5–10.1 times more total bycatch than the other pot designs. Additionally, both hagfish and total bycatch showed significant spatial variation at two scales; among individual deployments of strings of pots within locations, and among locations within the sites. The bycatch from the pots included proportionately more invertebrates and hagfish, and less other fish species when compared to previous studies analysing the bycatch of the trawl fishery for New Zealand scampi. The results indicate that the development of potting methods for New Zealand scampi has the potential to reduce bycatch of some fish species, but will need to focus on reducing hagfish and invertebrate bycatch through improved pot design and spatially-targeted fishing.

1. Introduction

1.1. Bycatch in potting fisheries

Bycatch is the unintentional capture of non-target species during fishing, and is caused by low selectivity in fishing gear and represents a challenge to fishers and fishery managers around the globe (Suuronen et al., 2012). Around 8% of global fisheries catch is considered to be bycatch and is mostly discarded back into the ocean (Kelleher, 2005). Bycatch increases the amount of effort required to catch and process the target species, and has been linked to population declines in a number of seabird and marine mammal species (Abraham and Thompson, 2011). Crustacean trawl fisheries typically have high bycatch rates per kilogramme of the target species landed (Broadhurst et al., 2006; Catchpole et al., 2008; Suuronen et al., 2012). For example, tropical shrimp trawling has the highest discard rate among fisheries, contributing to 27% of estimated global fishery discards (Kelleher, 2005).

Pots (also known as traps or creels) are widely used for catching crab, lobster and some shrimp species (Miller, 1990). Pots tend to be more selective and produce less bycatch and benthic habitat disturbance than trawling methods and have been highlighted as a low impact and fuel efficient fishing method (Broadhurst et al., 2007; Eno et al., 2001; Suuronen et al., 2012). For these reasons potting methods are frequently used as a more sustainable alternative to trawl fisheries for Norway lobster, *Nephrops norvegicus*, and spot prawns, *Pandalus platyceros* (Favaro et al., 2010; Leocádio et al.,

* Corresponding author at: Institute of Marine Science & School of Biological Sciences, University of Auckland, Auckland, New Zealand.
E-mail address: rmaj027@aucklanduni.ac.nz (R.N. Major).

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2012). Pots are primarily limited to areas where trawler access is restricted due to the seafloor rugosity or legislation (Ungfors et al., 2013). However, pots can be economically advantageous as they require less fuel to fish and pot-caught animals often attract a premium price due to their superior size and condition (Leocádio et al., 2012; Morello et al., 2009; Ungfors et al., 2013). Large numbers of pots are typically required to be deployed in a developed fishery, and consequently even low bycatch rates in pots can result in significant impacts on the local ecology. For example, in the British Columbian pot fishery for spot prawns, the rockfish, *Sebastes* spp., is a common bycatch species which is also vulnerable to overfishing. As 3.4 million pots are lifted each year during the eight-week season, even though bycatch rates are low, the large number of pot lifts has contributed to the declining populations of rockfish, leading to the development of bycatch reduction devices (Favaro et al., 2013; Favaro et al., 2010).

Pot bycatch is determined by the selectivity of the pot and is affected by features such as the pot size and shape (Butcher et al., 2012), the size of the mesh (Archdale et al., 2006), number and position of entrances (Archdale et al., 2006; Archdale et al., 2007; Morello et al., 2009) and the number and size of escape windows (Arana et al., 2011; Boutson et al., 2009; Harada et al., 2007). Bycatch in pots typically consists of undesirable species and target species that are undersized or gravid (carrying eggs) which are discarded; or non-target fisheries species which are still collected and sold, such as European brown crab, *Cancer pagurus*, in some Norway lobster fisheries (Leland et al., 2013; Ungfors et al., 2013). Moreover, bycatch species are a nuisance as they take up valuable space, damage and consume the bait, and can impede the target species from entering the pot, ultimately reducing the number and value of the target species that are caught (Adey, 2007).

Bycatch in pot fisheries can be reduced by the inclusion of bycatch reduction devices (Favaro et al., 2013), by increasing the mesh size in the body of the pot or escape windows (Groeneveld et al., 2005; Ovegård et al., 2011) and the inclusion of escape windows (Arana et al., 2011). In fisheries where there is a minimum size of capture for the target species, regulations can mandate the inclusion, size and location of escape windows (Treble et al., 1998). Different construction materials for pots can also exclude some species. For example, steel entrance rings are promoted as being able to exclude crabs from pots targeting Norway lobster (Carapax, 2015). Bycatch in pots can also be reduced by how the pots are deployed, such as, the use of floating pots to target demersal cod can virtually eliminate the bycatch of benthic-dwelling red king crab (Furevik et al., 2008).

Baits are an integral part of any crustacean potting fishery and fishers strive to use baits that specifically attract target species as they can greatly influence the catch rates (Miller, 1990). Bycatch species are typically generalist scavengers (Moore and Howarth, 1996), and bycatch rates in commercial potting fisheries are generally not affected by bait choice (Favaro et al., 2010). However, benthic scavengers of European fishery discards show clear preferences among echinoderm, mollusc and crustacean baits, and are universally attracted to fish baits (Bergmann et al., 2002a; Groenewold and Fonds 2000). One scavenger frequently attracted to baits are sea lice (Order: Isopoda), which can consume the bait, reducing the effectiveness of the pot for catching the targeted species (Miller, 1990; Morello et al., 2009). To reduce the impact of sea lice and other scavengers, as well as target species, on the longevity of bait, plastic bait containers (also known as snifters) are used to protect the bait in many pot fisheries. However, sea lice can sometimes pass through the holes or meshes in the bait container, and consume the bait. Consequently, there is the potential to minimise bycatch by optimising the choice of baits and the bait containers to ensure the pots can fish as efficiently as possible.

1.2. Scampi pot fishery

New Zealand scampi (*Metanephrops challengeri*) are a highly valuable lobster species which are widely distributed on the continental shelf of New Zealand in depths of 250–550 m (Tuck et al., 2015). Scampi are fished in waters of around 300 m depth by bottom trawling with triple rigged otter trawls. The New Zealand scampi trawl fishery has the highest discard rate among deepwater fisheries in New Zealand, discarding on average 4.2 kg of bycatch for every 1 kg of New Zealand scampi caught (Anderson, 2012). Potting has been suggested as an alternative and more sustainable method for harvesting this species (MBIE, 2014). Potting is widely used for harvesting Norway lobster in Europe, a species sharing many biological and ecological similarities with *Metanephrops* species (Bell et al., 2013; Ungfors et al., 2013).

Previous attempts to catch NZ scampi in European-style pots resulted in a large bycatch of hagfish, *Eptatretus cirrhatus,* and sea lice (Martin Cryer, pers. comm. 2015). Hagfish secrete a large volume of mucous when entrapped which can make pots difficult to handle, reduce the ability of the pot to continue fishing and potentially suffocate any scampi inside the pots, as occurs in the white-spotted conger eel, *Conger myriaster,* fishery in Japan (Harada et al., 2007). Furthermore, there is a small hagfish fishery operating in New Zealand and concerns over the state of the stock of this species has led to recent recommendations for tighter control on the numbers of smaller hagfish being caught (MPI, 2014). For these reasons, reducing the amount of hagfish bycatch is one of the biggest concerns for a developing New Zealand scampi potting fishery.

1.3. Aim and objectives

The aim of this study was to identify the factors which influence the bycatch of non-target species in pots targeting New Zealand scampi. The factors that were considered to influence bycatch were; bait species, pot design, pot soak time, deployment event, individual string on which any pot is deployed, and effectiveness of the design of the bait containers as assessed by the presence of sea lice and residual bait in the container. The study investigated these factors at two well-known fishing sites for New Zealand scampi to ensure the results are not location specific. The results of this study will be used to guide the future design of scampi-specific baits and pots for a developing potting fishery targeting New Zealand scampi.

2. Methods

2.1. Fishing experiments

Four different pot designs that are widely used in the Northern Hemisphere for catching Norway lobster were experimentally deployed at two study sites in New Zealand waters that are well-known fishing grounds for New Zealand scampi (Fig. 1). Three different bait species were used in the pots (barracouta, *Thyrsites atun*; mackerel, *Scomber australasicus*; and New Zealand arrow squid, *Nototodarus sloanii*). At the first study site on the Chatham Rise (42–43°S, 176–177°E), a total of 279 pot lifts were undertaken by deploying a total of nine strings of pots over three separate deployment events from the fishing vessel *Sea Hawke II* during 26 November – 12 December 2014. Each deployment event consisted of three 500 m long strings of pots each made of a line with an anchor at each end and carrying 30 pots consisting of 10 each of three different designs, Pot 1, Pot 2 and Pot 3 (Fig. 2). The 30 pot attachment points were evenly spaced (roughly 17 m) along each string and the pots of the three different designs randomly allocated to each attachment point and connected to the string with a