Bait for the Longlining Fishery of Snapper (*Pagrus auratus*)

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Abstract

Natural baits such as squid and pilchard have been the favored choice of fishermen for the longline fishing of snapper (*Pagrus auratus*) in New Zealand. Overexploitation of fish stocks together with an increase in demand for fish for human consumption has decreased the resources of natural baits at cost effective prices. This has led to attempts in the development of artificial or reconstituted baits. In this study, baits were prepared using differing proportions of industry surplus Greenshell™ Mussel (*Perna canaliculus*) and gurnard (*Chelidonichthys kumu*), both known to be part of the snapper diet. These species also have shown high amounts of glycine and alanine, which are known to stimulate feeding behavior in snapper.

Acceptability tests with captive snapper showed that formulations containing 70% of mussel, 30% of gurnard, and 5% of sodium alginate elicited a response that was greater than other combinations of the three ingredients. This preferred formulation was then used in sea trials following extrusion into fibrous casings and gelification by immersion in baths of calcium chloride solution. The hardness obtained after a 7.5% calcium chloride bath was judged the most suitable for longlining sea trials.

Captures per 1,000 hooks of test bait were compared to the same quantity of hooks baited with control squid bait. Control bait was 83.93% more effective than the test bait. Although the catches on the test bait were low, the selectivity toward snapper was 29.25% higher.

Reasons for the reduced total catch compared to the control may be due to less desirable texture and taste of the test bait, compared to natural foods of snapper. In terms of ease of handling by the fishermen, the form and consistency were well liked.

Introduction

Snapper

Snapper (*Pagrus auratus*) is a member of the Sparidae family of sea breams. This species ranges throughout most of the temperate to subtropical water masses of the western Pacific Ocean. *Pagrus major*, *Chrysophrys auratus*, and *Chrysophrys major* are synonyms for *Pagrus auratus* (Paulin 1990). Snapper are opportunistic carnivores and eat a wide variety of benthic and demersal organisms (Muller 1998).

Longlining

Longlining is a method of catching fish using a line and series of baited hooks, which is known as "the gear." It is defined as a passive fishing method, i.e., the gear is stationary and the encounter between gear and fish is a result of the fish moving to the gear, based on the attraction of fish to bait. The bait serves as the source of smell and taste stimuli to lure the fish to the gear and to ingest the baited hook. The success of capture is also dependent on the ability of the hook to catch and retain the fish until it is brought on board the fishing vessel.

Longlining is the favored method for the capture of snapper in New Zealand, resulting in a higher valued fish compared to that obtained by trawling, because the fish does not get damaged in the trail net and is generally alive when brought aboard. It has been regarded as one of the most efficient and environmentally sound methods of fish capture, on the basis of size selection, species selection, survival after escape, ghost fishing, fish quality, energy consumption/pollution, and impact on the seabed (Bjordal and Løkkeborg 1996).

Hooks

The main variables of a fishhook are size, shape, and coating, which give an indefinite number of possible combinations. Fishhook terminology is a somewhat confusing subject, since there is no strict international standardization of definitions.

Baits

Fishing with baited hooks is based on the target species' demand for food, and on the bait properties of stimulating the food-searching behavior of fish through odor release. Once the fish has been attracted to the longline, the physicochemical nature of the bait triggers the fish to attack and ingest the baited hook. A key factor in this process is the smell and taste stimuli generated by the bait, i.e., the concentration and composition of the chemical compounds released by the bait (Bjordal and Løkkeborg 1996).

Traditionally natural baits have always been the choice for longlining, and the selection of which type is based mainly on the fisherman's experience, the availability, and price of those baits. The traditional natural baits used in the snapper longline fishery are pilchard (*Sardinops neopilchardus*) and arrow squid (*Notodarus gouldi*). However, these high quality natural bait resources are becoming less available at affordable prices.

The knowledge that specific chemicals can evoke feeding behavior (Atema 1980; Goh and Tamura 1980a,b; Carr and Derby 1986) has lead to efforts in the development of artificial and/or reconstituted baits (Bjordal and Løkkeborg 1996). These baits could have the following advantages: improving selectivity in targeting specific species and thus avoiding bycatch and bait loss; uniformity in shape and size of baits, thereby making mechanized baiting cheaper and more efficient; and finally, a bait prepared from recycling fishing industry surplus products would increase the overall efficiency of fishing operations.

Although no published research in this area has been reported for any species in New Zealand, some attempts have been made in some major fishing nations (Norway, Canada, United States, Spain) to develop suitable bait for particular species. Most of the prior mentioned research is not public knowledge, due to the commercial interest in this topic. However, three areas of importance have been identified:

1. Feeding attractants and stimulants

The ability of certain L-amino acids to modify behavioral activity has been confirmed for different species of the genera *Chrysophrys* = *Pagrus* (*C. major* = *Pagrus auratus*) by Goh and Tamura, (1980a,b), Fuke et al. (1981), and Shimizu et al. (1990). These authors have identified L-glycine and L-alanine as potent stimulants inducing feeding behavior.

Hughes et al. (1980) and Pickston et al. (1982) have evaluated the levels of 18 different amino acids on behavioral activity of 12 commercially harvested marine species in New Zealand waters. Three of those species are known to be part of snapper diet: gurnard (*Chelodinichthys kumu*), scallop (*Pecten novaezealandiae*), and Greenshell™ Mussel (*Perna canaliculus*) (Berquist 1994, Muller 1998).

Industry byproducts from Greenshell mussel and gurnard are available, and were chosen as a basic mixture to be tested for acceptability.

2. Binders

Binders can help to mix all of the nutritional composition evenly and stick them together to enable hook stability in the bait, avoid loss of nutrients/feed in water, and minimize pollution of the environment. Alginates have been the preferred binder on research done by the group lead by J. Boyer (Centre technologique des produits aquatiques, Ministere de l'Agriculture, des Pecheries et de l'Alimentation, Quebec, Canada, 1999, pers. comm.). Alginate, commercially available as alginic acid, commonly called sodium alginate, is already used in bulk quantities in the local fishing industry were it is mixed in low concentration with water as part of the glazing for frozen snapper.

Calcium chloride has been chosen as a calcium donor in the gelation process, based on previous studies (J. Boyer, pers. comm.), commercial availability, and dilution properties. However, the potential for calcium to influence preference by fish has not been studied, as it exceeded the scope of this work.

3. Reinforcement material

Sausage casings have been cited by Bjordal and Løkkeborg (1996) as suitable reinforcement material. Four types of casings were commercially available and included those made from intestine, collagen, cellulose, and plastic. The cellulose casings were used in this work because of strength, commercial availability, and size to fit the hooks.

Materials and methods

Bait sausage production.

Raw materials used were frozen Greenshell mussel meat and frozen gurnard heads and filleted bodies. Frozen raw materials were minced in a Dimak mincer model DMK-3000 to form a paste, then further mixed and homogenized in different proportions (see below) with Pronova Frostgel SFPH sodium alginate (Norpro NZ Ltd., Auckland) in a food processor Kenwood model Chef. The alginate was added at 2.5% and 5% by weight.

A Kenwood Chef sausage-making nose model A-12 was fitted to make the bait sausages. Nojax clear/black size 29/70 fibrous casings (Oppenheimer New Zealand Ltd., Wellington) were used to form 50 cm long bait sausages of approximately 250 grams each; both ends were tied using 2 mm diameter hemp string. Two to four sausages were made per treatment.

The gelation baths were carried out in 30 liters polystyrene bins containing 10 liters of Lancaster calcium chloride (Bronson & Jacobs PTY., Auckland) in tap water solution at 5%, 7.5%, and 10% by weight at ambient temperature. Bait sausages were labeled and immediately placed under refrigeration at 1°C. Sausage composition is shown in Table 1.

Preference evaluation

To evaluate the snapper preference for the different types of mixture, a modification of the methodology described by Fuke et al. 1981 for the identification of feeding attractants was used.

Two-year fry (23 to 28 cm in body length) from Pah Farm Snapper Breeding Station, Kawau Island, New Zealand, were used for experimentation. Thirty fish were transferred to a commercial 1 m^3 bin directly from the rearing ponds, with running seawater, temperature between 16 and 17°C during experimentation, and indoor artificial lighting.

Baits used in this experiment had not been submerged in the gelation baths. One of the two bait sausages, for each mixture ratio, was cut in half midway along the total length of the sausage, and a 2.5 cm length slice

Table 1. Composition of 10 experimental bait sausages.

Mixture	Gurnard %	Mussel %	Alginate %
1	0	100	5
2	30	70	5
3	50	50	5
4	70	30	5
5	100	0	5
6	0	100	2.5
7	30	70	2.5
8	50	50	2.5
9	70	30	2.5
10	100	0	2.5

was taken as a test sample. The sample was attached to the tip of a 1mm monofilament fishing line and suspended at 7 to 10 cm from the bottom of the tank, near the incoming seawater hose.

The responses of the 30 fish to the sample were measured as frequency of biting per minute. Each sample was tested three times, and the intervals between samples were of at least 5 minutes. A 2.5 cm length slice of a 2 cm diameter pale red and black striped garden hose was used as control during a minute before every test. Its presence in the water a minute before the test had the purpose of getting the fish accustomed to the presence of an unusual object. The samples were tested in numerical order during the morning and, using the second sausage, a duplicate assay at random sample order was completed during the afternoon using the same fish. Results were expressed as an average of biting per minute.

Bait sausage hardness

By direct visual and tactile observations during the acceptability tests, it was determined that bait hardness and casing adherence were inadequate to withstand sea and gear handling conditions. Consequently, increasing the hardness of the sausage bait became an objective of further research. The hardness of the bait sausage mixtures 7 and 2, containing 2.5% and 5% in weight of sodium alginate respectively, were measured after immersion in a gelation bath at increasing concentrations of calcium chloride.

The baths were carried out in 30 liter polystyrene bins containing 10 liters calcium chloride solution at the following concentration: 5.0%, 7.5%, and 10%.

All compression measurements were performed on a Texture Analyser (Stable Microsystems, Surrey, England), interfaced with Texture Expert Version 1.0 software program (Stable Microsystems, Surrey, England) on sample slices (3 cm diameter) placed longitudinally on a stainless steel flat plate (4 cm diameter) for uniaxial compression. The crosshead speed was maintained at 0.5 mm per second, with automatic force trigger sensor set at 0.2 N. Hardness (N) was defined as maximum force of peak at 40 seconds.

Sea trials

Longlining technique

The longlining equipment used for the sea trials was a Mustad Autoline gear. The spacing between hooks was fixed at 1 meter and for this experiment 550 hooks were used on an independent transferable rack. The trials were performed on board four vessels using the same longlining method and the same 550 hook rack. The trial was done once on each vessel during standard fishing operations. The hooks used were standard Tainawa Mustad # 17 (2.0 cm gap) on 1mm monofilament gangion, as they are the preferred type by the fisherman. Sliced arrow squid was used as control bait for the sea trials.

Baiting methodology

The method followed Løkkeborg (1990b, 1991) and Løkkeborg and Johannsessen (1992) for measuring the effectiveness of two different bait types by baiting the lines in alternate clusters of about 50 similarly baited hooks. Sausages were peeled, and cut into approximately 2.5 cm slices for each hook.

The following configuration was used to remove possible variations: (a) first 50 hooks of control bait, (b) 1-2 hook space and a color marker, (c) 50 hooks with test bait, (d) 1-2 hook space and a marker, and (e) 50 hooks with control bait until the line was set with 250 baited hooks for each type of bait.

The area selected to perform the trial is the east coast of the Coromandel Peninsula, a traditional longline snapper fishing ground. The depth of setting varied between 50 and 190 meters, as most of the gear was set following bottom contour. The data was collected during hauling of the line after an overnight set of approximately 9 hours, and the results transcribed to a preprinted form to be further analyzed once ashore.

Data analysis

Data collected from 20 clusters (1,000 hooks) lured with test bait were compared with the data obtained from the same number of clusters of hooks lured with control bait.

Table 2. Snapper bites per minute.

Mixture	Control	Bites/min numeric order			Bites/min random order			Avg.
1	0	24	27	23	26	20	27	24.50
2	0	30	a	a	a	a	a	a
3	1[b]	a	29	23	25	28	30	27.00
4	0	23	24	26	22	24	25	24.00
5	0	20	21	21	21	22	19	20.67
6	0	23	26	24	25	26	24	24.67
7	0	30	a	a	29	a	a	a
8	0	25	28	26	25	27	28	26.50
9	0	24	23	24	22	24	21	23.00
10	0	21	17	23	19	18	20	19.67

[a]Counting was impossible due to the high frequency of biting.
[b]This represents the single bite on the plastic hose control.

Results

Mixture preference evaluation

The results of the preference evaluation are summarized in Table 2. Mixtures 2 (70% mussel:30% gurnard:5% alginate) and 7 (70% mussel:30% gurnard:2.5% alginate) were the most appealing to snapper, with such a high frequency of biting that counting was impossible.

The results suggest that the preference toward the bait diminished as the relative amount of mussel meat was reduced in the composition; however, mussel meat itself (mixtures 1 and 6) does not induce the same level of feeding behavior as the mixtures. Thus, mixtures containing 100% gurnard mince (samples 5 and 10), triggered the lowest level of attraction among those measured. These results could suggest some form of synergism between components of the mixture and warrant further investigation in the future.

The concentration of sodium alginate did not seem to alter significantly the biting per minute count. Yet, the results for counts on 5% alginate were slightly higher in comparison to those on 2.5%. Mixture samples 2 and 7 were chosen for further experimentation on increasing hardness.

Bait sausage hardness

Result for hardness analysis on triplicates of mixture samples 2 and 7 after 5%, 7.5%, and 10% calcium chloride bath showed an increase in hardness as a function of the increasing concentrations of the sodium alginate and calcium chloride in the bath. The highest hardness values are for mixture sample 2. The lowest hardness values were found in samples treated with 5% calcium chloride baths for both mixture samples. However, the figures do not show marked differences in hardness on sample mixtures after treatment in the 7.5% and 10% calcium chloride geling baths.

Based on these results, 7.5% calcium chloride solution was chosen as a geling bath for mixture 2 for further experimentation at sea trials, and mixture 7 was abandoned as being softer, thus potentially less practical for fishing purposes.

Sea trials

The results of the sea trials indicated that squid was 83.93% more effective as bait compared to the test bait. However, the test bait was 29.25% more selective toward snapper than the squid bait (statistical significance was not studied). In other words, squid caught on average 34.85 fish per cluster (50 hooks) of which 20.3 were the target species. In contrast, the test bait caught only 5.6 fish per cluster of which 4.9 were snapper. The distribution of snapper along the clusters of test baited hooks did not show preference for the hooks in the proximity of squid bait in comparison to those in the middle of the cluster.

Based on these results the commercial suitability of the test bait was seriously compromised, since the bait "does not catch enough fish" to be able to compete with squid as an economically viable alternative. Nevertheless, the high selectivity toward snapper was highly encouraging and has potential for further investigation.

As a further result, the firm consistency of the sausage baits in mixture 2, after the treatment in geling bath, enable the casings to be removed prior to baiting the hooks, therefore the reinforcement material is not as critical as presupposed for this type of bait sausage.

Discussion

The test bait represents a novel food item that the fish has probably never experienced before. This may cause a somewhat restrained response toward the bait and explain why there was a fairly low proportion of attracted fish that apparently swallowed the baited hooks. This proportion is probably lower for smaller fish, because they have a narrower diet range and therefore show a more restrained response toward novel food items.

Variability in the results between fishing vessels was not analyzed, because the main interest of the experience was in the total catches, and not in the particulars of each boat. The main reason behind using four boats was that no boat owner would accept setting up 2,000 hooks (a whole trip) without having a guarantee that the catches would cover the fixed costs of the trip. The fishing operations took place over a period of two weeks, and no major differences were expected on the seasonal and diurnal foraging cycles of snapper. The abundance was not visibly compromised by any special factor.

The competition toward the bait by non-target species was a primary objective of this study. Glycine and alanine are two of the most frequently cited feeding stimulants being reported, and were shown to affect 28 (80%) and 26 (74%) (respectively) of the 35 species of marine organisms studied by Carr et al. (1996). It is expected that other species that share the same habitat are attracted to the bait as well.

It is important at this point to state that the sausage form and consistency were well liked by all fishermen involved in the study, since it was practical to store, clean to handle, and easy to bait.

Conclusions

Under the present bait composition and form, the results of this study can be summarized as follows:

1. The test bait effectiveness does not suit industry needs.
2. The test bait selectivity toward snapper, under the limitations of this study, was higher.
3. The test bait form and consistency does suit industry needs.
4. Casing material is not as critical as presupposed.
5. Modifications on the taste and texture characteristics of the mixtures could lead to more promising results.
6. Development of baits based on seafood industry byproducts is a viable alternative for further study.

References

Atema J. 1980. Smelling and taste underwater. Oceanus 23:4-18.

Berquist, R.M. 1994. Patterns of activity and movement in New Zealand snapper, *Pagrus auratus*. M.S. thesis, The University of Auckland, Auckland, New Zealand. 125 pp.

Bjordal, A., and S. Løkkeborg. 1996. Longlining. Fishing News Books, Osney Mead, Oxford, England. 156 pp.

Carr, W.E.S., and C.D. Derby. 1986. Chemically stimulated feeding behaviour in marine animals and involvement of mixture interactions. J. Chem. Ecol. 12: 989-1011.

Carr, W.E.S., J.C. Netherton, R.A. Gleeson, and C.D. Derby. 1996. Stimulants of feeding behaviour in fish: Analysis of tissues of diverse marine organisms. Biol. Bull. 190:149-160.

Fuke, S., S. Konosu, and K. Ina. 1981. Identification of feeding stimulants for Red sea bream in the extract of marine worm (*Perineris brevicirrus*). Bull. Jap. Soc. Sci. Fish. 47(12):1631-1635.

Goh, Y., and T. Tamura. 1980a. Olfactory and gustatory responses to amino acids in two marine teleosts: Red sea bream and mullet. Comp. Biochem. Physiol. 66C:217-224.

Goh, Y., and T. Tamura. 1980b. Effects of amino acids in the feeding behaviour in Red sea bream. Comp. Biochem. Physiol. 66C:225-229.

Hughes, J.T., Z. Czochanska, L. Pickston, and E.L. Hove. 1980. The nutritional composition of some New Zealand marine fish and shellfish. N. Z. J. Sci. 23:43-51.

Løkkeborg, S. 1990. Reduced catch of under-sized cod (*Gadus morhua*) in longlining by using artificial bait. Can. J. Fish. Aquat. Sci. 47:1112-1115.

Løkkeborg, S. 1991. Fishing experiments with an alternative longline bait using surplus fish products. Fish. Res. 12:43-56.

Løkkeborg, S., and T. Johannsessen. 1992. The importance of chemical stimuli in bait fishing: Fishing trials with presoaked baits. Fish. Res. 14:21-29.

Muller, C.G. 1998. Can snapper (*Pagrus auratus*) (Pisces: Sparidae) feed visually at night? Master's thesis, The University of Auckland, Auckland, New Zealand. 98 pp.

Paulin, C.D. 1990. *Pagrus auratus*, a new combination for the species known as "snapper" in Australasian waters (Pisces: Sparidae). N. Z. J. Mar. Freshw. Res. 24:259-265.

Pickston, L., Z. Czochanska, and J.M. Smith. 1982. The nutritional composition of some New Zealand marine fish. N. Z. J. Sci. 25:19-26.

Shimizu, C., A. Ibrahim, T. Tokoro, and Y. Shirakawa. 1990. Feeding stimulation in sea bream, *Pagrus major*, feed diets supplemented with Antarctic krill meals. Aquaculture 89:43-53.