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Food and feeding relationships of three sympatric slickhead species (Pisces: Alepocephalidae) from northeastern Chatham Rise, New Zealand

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ABSTRACT

The food and feeding relationships of mid-slope slickheads in New Zealand waters are little known compared with those from the northern hemisphere. This study examines the feeding relationships of three common slickhead species from approximately 1000 m on Chatham Rise, New Zealand: *Alepocephalus antipodianus* (Parrot, 1948), *A. australis* (Barnard, 1923), and *Xenodermichthys copei* (Gill, 1884). The *Alepocephalus* species were predominantly benthopelagic feeders with a small benthic component to their diets. *Alepocephalus australis* fed on pelagic tunicates, notably *Pyrosoma atlanticum* Péron, 1804. *Alepocephalus antipodianus* fed on fish and pelagic tunicates, and also crustaceans. *Xenodermichthys copei* fed primarily on crustaceans. Considerable material was recovered from the intestines of all three species, and much of it was identifiable and only partially digested, including the remains of pelagic tunicates. There was little dietary overlap between the stomach contents of the three slickhead species indicating a degree of niche partitioning. Intestinal contents differed from stomach contents in weight, but not in number of items for all three species. The composition of stomach and intestinal contents differed for *A. australis*, but not for *A. antipodianus* or *X. copei*, which suggests that intestinal contents could be potentially useful in lieu of stomach content. There was a high level of overlap between the intestinal contents of *A. antipodianus* and *A. australis*, suggesting a possible closer dietary relationship between these two species than that indicated by stomach contents alone. Despite limitations in sample size and spatial and temporal coverage, the results from this study indicate that the three slickhead species could play an important role in the structuring of the demersal community at mid-slope depths on northeastern Chatham Rise.

1. Introduction

The slickheads (Alepocephalidae) have a global distribution in temperate and tropical waters, with about 90 species extant, although the taxonomy of the family is need of revision (Poulsen et al., 2009). The composition and abundance of species varies between biogeographic regions (Koslow et al., 1994; Clark et al., 2010), but appears to be most abundant in in the north Atlantic where they are one of the dominant deep-sea families at mid-slope depths (ICES, 2012). As such they have been the focus of, and bycatch in, deep-sea fisheries, with up to 14,000 t of *Alepocephalus bairdii* Goode & Bean, 1879 landed annually in the north Atlantic (Durán Muñoz et al., 2012; ICES, 2012). Although landings decreased since 2005 (ICES, 2012), and *A. bairdii* may be vulnerable to overfishing (Cheung et al., 2007; ICES, 2012). Slickheads are also taken as bycatch in deep-sea fisheries elsewhere (e.g., Clark et al., 2000; Bulman et al., 2002; Niklitschek et al., 2010; ICES, 2012).

Slickheads occupy an enigmatic position in deep-sea mesopelagic and bathypelagic food webs (Crabtree and Sulak, 1986). Owing to their relatively large body size and ubiquity they potentially constitute a significant biomass in the deep-sea contributing to the “biological pump” transporting organic carbon into the deep (Ramirez-Llodra et al., 2010). However, the ecology of most species is poorly understood, and most well known for northern hemisphere species, particularly *A. bairdii* and *A. rostratus* Risso, 1820 (e.g., Mauchline and Gordon, 1983; Roe and Badcock, 1984; Moralis-Nin et al., 1996; Allain, 2001). Both species feed mainly on zooplankton (Mauchline and Gordon, 1983; Moralis-Nin et al., 1996; Carrassón and Matallanas, 1998; Carrassón and Cartes, 2002; Follesa et al., 2007), giving them a generally low trophic position in comparison to other fishes at similar depths (Iken et al., 2001; Polunin et al. (2001); Bulman et al., 2002). *Xenodermichthys copei* (Gill, 1884) is an exception

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with a relatively high trophic level (Iken et al., 2001). There are variations in diet between species and region (Mauchline and Gordon, 1983; Macpherson, 1983; Moralis-Nin et al., 1996; Carrassón and Cartes, 2002), and season (Carrassón and Matallanas, 1998). But generally speaking most slickheads have been reported to have benthopelagic or mesopelagic diets.

While dietary studies have shed some light on the ecology of some slickhead species their behavioural ecology is largely unknown. Although slickheads are caught in demersal trawls they rarely appear in still or video footage from baited cameras (Preide et al., 2012; Zintzen et al., 2012), or manned submersibles (Trenkel et al., 2004; Pakhorukov and Parin, 2011). Trenkel et al. (2004) suggested that this absence from video footage, was due to the slickheads swimming several metres above the seabed, and being out of the field of view of the submersible, while Pakhorukov and Parin (2011) suggested that slickheads were avoiding their submersible's lights. It is also possible that the pressure wave of the submersible has an effect, as has been shown for orange roughy (*Hoplostethus atlanticus* Collett 1889) reacting to a falling iron bar off Tasmania (Koslow et al., 1995).

There are several challenges faced by researchers working on the diets of non-commercially valuable deep-sea fish. Deep-sea research is expensive (Bailey et al., 2007; Durán Muñoz and Sayago-Gill, 2011; Stewart and Callagher, 2011), and samples from deep-sea fisheries can be hard to obtain, as commercial vessels often have to travel great distances to trawl grounds and can be reluctant to give up freezer space to fish of little or no commercial value (Bremner et al., 2009). As a consequence samples can be obtained from opportunistic sources (Jones, 2008, 2009; Pethybridge et al., 2010, 2011). On one hand, this can limit the scope of possible research as the collection of samples for dietary work was not the focus of the voyage, nor the gear used (Doonan et al., 2006, 2009). However, on the other hand, opportunistic sampling can urge researchers to innovate, and find novel solutions to these sampling issues (Drazen et al., 2001; Jones, 2008, 2012; Dunn et al., 2010). Stomach eversion is a common issue with deep-sea fish samples (e.g., Drazen et al., 2001). The use of intestinal contents has proved useful in describing the diets of deep-sea fish species with high rates of stomach eversion and few stomach contents (e.g., Merrett and Marshall, 1981; Jones, 2008, 2012). Slickheads can be fragile fish with watery flesh, do not possess a gas-filled swimbladder (Childress and Nygaard, 1973), and stomach eversion would appear to be rare (Mauchline and Gordon, 1983). Even so, large numbers of slickheads may need to be analysed to obtain an adequate dietary sample (e.g., Mauchline and Gordon, 1983; Carrassón and Cartes, 2002) (although Bulman et al., (2002) provide an exception).

As worldwide fisheries management moves towards more ecosystem-based approaches, the trophic relationships of non-commercially valuable, but ecologically important, species have become more pertinent (Francis et al., 2007; Link, 2007, Curtin and Prellezo, 2010). New Zealand fisheries are also moving towards a more ecosystem-based approach to fisheries management (New Zealand Ministry of Fisheries, 2010), which necessitates knowledge of the feeding interactions of the major components of the ecosystem, and not just the commercially exploited species. The abundance of slickheads in deep-water fisheries trawls (e.g., Doonan et al., 2006, 2009; Anderson, 2011; ICES, 2012; Tracey et al., 2012) suggests that they probably play an important role in the structuring of mid-slope demersal communities, and as such, are likely ecologically important consumers of gelatinous zooplankton (e.g., Clark et al., 1989; Moralis-Nin et al., 1996; Bulman et al., 2002; Carrassón and Cartes, 2002).

In comparison to the slickheads of the north Atlantic and Mediterranean Sea, the biology and feeding of slickheads in New Zealand waters are little known as they have little commercial value and are usually discarded (Anderson, 2011). *Alepocephalus australis* Barnard 1923 and *A. antipodianus* (Parrot 1948), and *X. copei* are three common slickheads frequently caught as bycatch in orange roughy demersal trawls in austral waters at mid-slope depths (800–1200 m) (Bulman et al., 2002; Doonan et al., 2006, 2009; Anderson, 2011). Clark et al. (1989) described the stomach contents of 26 *A. australis* from south-western Chatham Rise, and found a diet of mainly pelagic invertebrates, particularly salps (*S. thompsoni* and *I. zonaria*), and hyperiid amphipods (*Vibilia stebbingi*, *Cyllopus magellanicus*, and *Parathemisto gaudichaudii*). Off Tasmania, Bulman et al. (2002) reported a low trophic level pyrosome-based diet for two unnamed *Alepocephalus* species (likely *A. australis* and *A. antipodianus*). Pakhomov et al. (2006) described the diet of "*A. antipodiana* Parrott, 1948" based on the contents of six stomachs from the vicinity of the Prince Edward Archipelago in the sub-Antarctic. They found squid to have the greatest mass in the stomachs contents followed by pyrosomes. Parin et al. (2008) described the diet of *A. australis* from an undetermined number of stomachs from Mozambique Seamount, and characterised it as shrimp, squids, fish, salps, and holothurians.

This paper describes aspects of the diet and feeding relationships of three sympatric slickhead species from northeastern Chatham Rise, New Zealand. In addition, it evaluates the use of intestinal contents to augment the collection of stomach contents for deep-sea fish species which can be hard to obtain, and may not feed frequently.

2. Methods

2.1. Sample area and collection of material

In New Zealand waters, the Chatham Rise is a large broad, relatively flat-topped submarine feature extending eastwards from New Zealand's South Island at approximately 43° South (Fig. 1). The subtropical convergence (STC) forms over Chatham Rise and is a major southern hemisphere front separating subtropical water in the north from sub-Antarctic water in the south (Heath, 1985; Sutton, 2001; Chiswell, 2002; Nodder et al., 2007). The STC is a continuous feature around southern New Zealand (Heath 1985), and flows eastward between 43–44°S over the Chatham Rise, where it is a continuous feature over the southern flanks creating a region of relatively enhanced primary productivity (Bradford-Grieve et al., 1999; Chiswell, 2001; Sutton, 2001), and supports several high value deep-water fisheries, notably hoki (*Macruronus novaezealandiae* Hector 1871), and orange roughy (Ministry for Primary Industries, 2012).

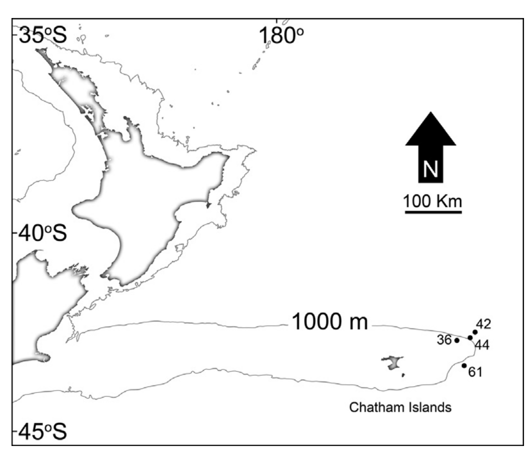

Fig. 1. Location of the trawls from cruise TAN0408 on northeastern Chatham Rise, New Zealand, from which the slickheads were sourced. Grey line indicates the 1000 m isobath.