ANTA 502

The Southern Ocean and the Patagonian Toothfish

Lorna Little
57522881

Southern Ocean Fishing and the Patagonian Toothfish

Extensive fishing industry is occurring in the area of the world known as the Southern Ocean (Kock *et al*., 2006). One of the main targets of this industry is *Dissostichus eleginoides*, commonly known as the Patagonian toothfish, or Chilean Sea Bass. Toothfish can commonly be found in the Southern Ocean and around Antarctica (Laptikhovsky *et al*., 2006). Toothfish are fished commercially for use in the food industry and it is known as a delicacy in some countries. It is a profitable market, as it is extremely viable with toothfish reaching high prices on legal and illegal markets (Lugten, 1997). Illegal fishing above, and beyond the established quota has led to this fish species becoming quite prominent due to sustainability issues and the regulation of fishing in the Southern Ocean (Vidas, 2000).

Life history and reproduction of *Dissostichus eleginoides*

Predictions and recommendations about sustainable levels of fishing for toothfish are needed for vital restrictions to be put in place, before regulation and monitoring of activities can be of use. To calculate these predictions, it is necessary to have an understanding about the life history, population structure and reproductive ability of the toothfish (Barerra oro *et al*., 2005). In order to establish this information, research devoted to the toothfish has been undertaken.

There are two Nototheniid species in the southern areas that are commonly referred to as toothfish. These are *Dissostichus eleginoides* and *D. mawsonii*. Commercial fisheries target both species of toothfish (Barrera oro *et al*., 2005), which are commonly known as the Patagonian toothfish and the Antarctic toothfish, respectively. Although the appearances and behaviour is similar in both species, they have been found to be two genetically distinct species (Ghigliotti *et al*., 2007), and the reasons for this are apparent. The Antarctic toothfish is restricted to the Antarctic continental slope and generally south of the Antarctic Convergence Zone, whereas the Patagonian toothfish is generally found in sub antarctic areas (Barerra oro *et al*., 2005). Further to this, genetic distinctions can be made between the Patagonian toothfish in sub antarctic and southern ocean waters in different regions, such as the Falkland Islands and South Georgia (Arhipkin *et al*., Williams *et al*., 2002). This is probably due to toothfish remaining in one region, without moving very far from where they are dispersed (Williams *et al*., 2002). This ecological trait could have important effects in relation to calculation of stock replenishment and limits set for toothfishing (REFERENCE).

The Patagonian toothfish is a top predator in the ecosystem of the southern ocean up to the Antarctic polar front (Laptikhovsky *et al*., 2006). Adult Patagonian toothfish are demersal and inhabit the continental slope and ocean floor (Laptikhovsky *et al*., 2006, Appleyard *et al*., 2002). Under optimum conditions, Patagonian toothfish reach up to two meters in length, and have a large bulky head with obvious canine teeth (Brickle *et al*., 2005). The life cycle of the Patagonian toothfish is like that of other nototheniids, where larvae is produced which grows into a juvenile fish inhabiting the continental slope, and then as the juvenile increases in size it can catch different prey at greater depths and moves to deeper water (Williams *et al*., 2002, Laptikhovsky *et al*., 2006). Sexual maturity is reached when males are approximately 85 cm in length, and females are approximately 90 cm in length (Barerra oro *et al*., 2005).

It is generally accepted that there is a relationship between depth of inhabitance and size of toothfish – the deeper the water, the larger in size the fish (Barerra oro *et al*., 2005, Arhipkin *et al*., 2003). Adult toothfish live at depths greater than 600m, while juveniles live and forage up to 600m (Laptikhovsky *et al*., 2006). This would suggest a likely change in diet between juveniles and adult fish, as prey species would be different in shallower waters to deeper water (Arhipkin *et al*., 2003). Diet also varies slightly depending on the region that the toothfish inhabit, such as the sub Antarctic areas near Australia compared to those closer to South Georgia (Arhipkin *et al*., 2003). Juvenile Patagonian toothfish from South Georgia area feed primarily on other nototheniids, such as *Lepidonotothen kempi, Chaenocephalus acerratus* and *C. gunnari*, according to Barerra oro *et al*. (2005). However Arhipkin *et al*. (2003) found that juveniles from the Falkland Islands were mainly feeding on *Patagonotothen ramsayi* and *Loligo gahi.* Similar patterns with changes in feeding depending on size can be observed at each toothfish population, with only different prey species being encountered rather than a total accumulative difference (Arhipkin *et al*., 2003). Further to this, the ontogenetic phases, or life stages, of the toothfish life can be characterised by differences in the diet (Arhipkin *et al*., 2003, Ghigliotti *et al*., 2007).

Climate change is causing issues not only around the world, but also in the ecosystem of the Southern Ocean. The presence of toothfish, as a top predator, is necessary to retain current ecosystem function (Brickle *et al*., 2005). Toothfish are likely to be affected in a significant manner in a changing climate scenario, as Patagonian toothfish larvae and juveniles have been found to survive to maturity, excluding predation, depending on climatic factors such as temperature and food availability (Belchier and Collins, 2008). As climate change is impacting the temperature and prey species in the southern ocean (REFERENCE), this effect needs to be taken into account when assessing Patagonian toothfish stocks.

Toothfish movement between regions and populations was fairly unknown (Williams *et al*, 2002) until recent studies. It has been ascertained that Patagonian toothfish generally do not move very far from their feeding grounds (Appleyard *et al*., 2002). This also has implications when related to fishing. If fishing, particularly IUU fishing, occurs extensively in one particular area, it is possible that the population of Patagonian toothfish in that area would decrease dramatically. Toothfish, as a predator and an opportunistic scavenger, play a vital role in the ecosystem of the Southern Ocean (Laptikhovsky *et al*., 2006). Impacts will be observable, not only in the area where fishing is occurring, but also in the areas surrounding fishing regions (Dodds, 2000).

Toothfish are slow growing, and therefore mature late (Laptikhovsky *et al*., 2006). This has severe implications in assessing viable commercial fishing limits. When these reproductive and physiological attributes, combined with the added fishing pressure from illegal vessels, are taken into account, fishing of the Patagonian toothfish is difficult to maintain sustainably. However, the Patagonian toothfish fisheries can be utilised as an example to investigate the ramifications of governance and management in the Southern Ocean (Dodds, 2000).

Dissostichus eleginoides and the Southern Fishing Industry

The southern ocean spans the entire globe and is home to many unique species as well as enclosing some of the world's largest fisheries and fishing reserves. This position gives it vital importance in world focus and need for regulation. Therefore, the fishing industry needs to be managed to ensure preservation and sustainability into the future. The Commission for the Conservation of Antarctic Marine Living organisms (CCAMLR) has been put in place to help regulate the southern areas, particularly those around Antarctica. There are two major principles of CCAMLR; to balance harvesting and conservation and to avoid changes that are irreversible within 20-30 years (Croxall and Nicoll, 2004). CCAMLR has been utilised in managing the toothfishing industry since around 1990 (Belchier and Collins, 2008).

The Patagonian toothfish is fished using long line techniques, where the line is set to reach down to the adult fish habitat (>1000m) and left to be collected about 10-20 hours after (Croxall and Nicol, 2004). Patagonian toothfish is a harvested species which matures relatively slowly, and reproduces slowly. Because of this, large catch sizes can greatly inhibit later reproductive success due to lack of individuals.

CCAMLR was implemented in order to provide a system that could potentially help regulate ecosystem effects in the Southern Ocean (Dodds, 2000) and this is pertinent to the regulation of toothfish fisheries in the area. One method used by CCAMLR in an attempt to reduce illegal fishing pressures was to expose and advertise illegal fishing parties and the centres used to transport the illegal fish to the wider community (Dodds, 2000). However, the reflagging of vessels and the lucrative bonuses from sale of toothfish have caused for other ways around the laws to be found such as using flags from non Antarctic Treaty states (Lugten, 1997, Dodds, 2000). The main issue of fishing is arising due to the illegal, unreported and unregulated fishing (IUU), rather than the legal operations. The legal commercial fisheries are operating within the proposed limits of sustainability (Croxall and Nicol, 2004), however this will only remain viable if there are no other mitigating factors on levels of Patagonian toothfish populations. While it seems logical to simply include IUU fishing effects in calculations of fishing limits, the IUU fishing influence on toothfish numbers is difficult to ascertain for various reasons (Williams *et al*., 2002).

There is information lacking about the Patagonian toothfish to allow traditional stock assessments to be made (Croxall and Nicol, 2004). While plenty of research has investigated the depths of where toothfish inhabit, relatively little on reproductive success, movement and diet was known until recently (Arhipkin *et al*., 2003). CCAMLR has dealt with assessing recruitment by including spread of individuals from populations into new areas (Croxall and Nicol, 2004) however it is generally assumed recently that toothfish do not disperse from their original habitat (Barerra oro *et al*., 2005, Laptikhovsky *et al*., 2006, Appleyard *et al*., 2002). Williams *et al* (2002) found that despite fishing regions around Heard and McDonald Islands being lumped together for stock assessments, in fact the fish sampled rarely moved more than 15 nm. Distinct populations could potentially be wiped out from around sub antarctic areas for the reason that Patagonian toothfish are fairly region specific and will not necessarily replenish other populations. Regulating and monitoring IUU fishing in the Southern Ocean however is logistically difficult. The Exclusive Economic Zones (EEZs) of southern countries encompass parts of the southern ocean, but due to logistical and political constraints, a regular presence is almost impossible to maintain (Vidas, 2000).

Overfishing of Patagonian toothfish has occurred under CCAMLR regulations in the past, however this has been remedied and fishing by CCAMLR flagged vessels is now seen to be at a sustainable level (Vidas, 2000). IUU vessels are undermining the CCAMLR regulations in various ways (Vidas, 2000). These include that the additional decimation of the toothfish population by illegal unreported and unregulated fishing implies that the legal quotas set for the commercial toothfishing industry are at risk of being unsustainable. Patagonian toothfish have been fished since the 1990s (Laptikhovsky *et al*., 2006) and effective methods of controlling illegal fishing are needed before Patagonian toothfish populations reach severely low levels.

A measure that could be implemented in targeting illegal fishing is the use of checking otoliths to ascertain the geographical origin and then taking action. It was found that the edge signatures of otoliths from Patagonian toothfish could distinguish between those caught off South America and those caught in the Antarctic maritime area (Ashford *et al*., 2005). While this method could be used in some manner, in reality there are problems arising with policing and patrolling areas where toothfish are being sold. Further to this, it does not help maintain Patagonian toothfish populations. It has been promoted that regulation of IUU fishing should begin with the business on land however (Vidas, 2000).

However, the toothfish population is not the only part of the southern ocean food chain and ecosystem that is suffering from illegal fishing. Seabirds and seals are also caught as bycatch (Wienecke and Robertson, 2000). There are many different methods used to avoid bycatch of albatross and other seabirds, such as setting lines at night and using flags to dissuade birds from feeding on the bait. One of the ways in which bycatch has been decreased in the Patagonian toothfishing industry is by prohibiting fishing in seabird breeding areas during breeding seasons. This method has been found to reduce bycatch of particular seabirds significantly (Croxall and Nicol, 2004).

Many issues that occur when attempting to apply law of the sea regulations and solutions to the specific Antarctic and Southern Ocean area (Vidas, 2000). The area is difficult to access and this is major factor in controlling activities in the Southern Ocean. Because of the Antarctic Treaty system, solutions under the Law of the Sea need to be resolved with regional regulations under the states included in the Treaty system (Vidas 2000).

Summary

In conclusion, the Patagonian toothfishing industry is encountering major problems when assessing sustainability. This is generally attributed to the IUU fishing in the sub antarctic areas. IUU fishing is proving difficult to monitor and control, due to the logistical aspect and the compromises needed between different state legislation and the Law of the Sea, and CCAMLR regulations. The Patagonian toothfish is slow to mature, is not seen to move significant distances from original habitats, and if nothing is resolved, it is facing a very uncertain future. The loss of this species would have huge ramifications at an ecosystem level, one that is intrinsically tied into the area of the Southern Ocean (Vidas, 2000).

References:

Arhipkin A., Brickle P. and Laptikhovsky V. 2003. Variation in the diet of the Patagonian toothfish with size, depth and season around the Falkland Islands. *Journal of Fish Biology* 63: 428-441.

Appleyard S. A., Ward R. D. and Williams R. 2002. Population structure of the Patagonian toothfish around Heard, McDonald and Macquarie Islands. *Antarctic Science* 14:364-373.

Ashford J. R., Jones C. M., Hofmann E., Everson I., Moreno C., Duhamel G. and Williams R. 2005. Can otolith elemental signatures record the capture site of Patagonian toothfish (*Dissostichus eleginoides)*, a fully marine fish in the Southern Ocean? *Canadian Journal of Fisheries and Aquatic Sciences* 62: 2832-2840.

Barerra-oro E. R., Carsau R. J. and Marschoff E. R. 2005. Dietary composition of juvenile Dissostichus eleginoides (Pisces, Nototheniidae) around Shag Rocks and South Georgia, Antarctica. *Polar Biology* 28: 637-641.

Belchier M. and Collins M. A. 2008. Recruitment and body size in relation to temperature in juvenile Patagonian toothWsh (*Dissostichus eleginoides*) at South Georgia. *Marine Biology* 155: 493-503.

Brickle P., Mackenzie K. and Pike A. 2005. Parasites of the Patagonian toothfish, *Dissostichus eleginoides* Smitt 1898, in different parts of the Subantarctic. *Polar Biology* 28: 663-671.

Croxall J. P and Nicol S. 2004. Management of Southern Ocean fisheries: Global forces and future sustainability. *Antarctic Science* 16: 569-584.

Dodds K. 2000. Geopolitics, Patagonian Toothfish and living resources in the Southern Ocean. *Third World Quarterly* 21: 229-246.

Ghigliotti L., Mazzei F., Ozouf-Costaz C., Bonillo C., Williams R., Cheng C. H. and Pisano E. 2007. The two giant sister species of the Southern Ocean, *Dissostichus eleginoides* and *Dissostichus mawsoni*, differ in karyotype and chromosomal pattern of ribosomal RNA genes. *Polar Biology* 30: 625-634.

Kock K. H., Purves M. and Duhamel G. 2006. Interactions between Cetacean and Fisheries in the Southern Ocean. *Polar Biology* 29: 379-388.

Laptikhovsky V., Arhipkin A. and Brickle P. 2006. Distribution and reproduction of the Patagonian toothfish *Dissostichus eleginoides* Smitt around the Falkland Islands. *Journal of Fish Biology* 68: 849-861.

Lugten G. L. 1997. The rise and fall of the Patagonian toothfish – food for thought. *Environmental Policy and Law* 27: 401-407.

Vidas D. 2000. Emerging Law of the Sea Issues in the Antarctic Maritime Area: A Heritage for the New Century? *Ocean Development and International Law* 31: 197-222.

Wienecke B. and Robertson G. 2000. Seabird and Seal – fisheries interactions in the Australian Patagonian *Disosstichus eleginoides* trawl fishery. *Fisheries Research* 54: 253-265.

Williams R., Tuck G. N., Constable A. J. and Lamb T. 2002. Movement, growth and available abundance to the fishery of *Dissostichus eleginoides* smitt, 1898 at Heard Island, derived from tagging experiments. *CCAMLR Science* 9: 33-48.