1. Evaluating deepwater fisheries management strategies using a mixed-fisheries and spatially explicit modelling framework

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Publication info: ICES Journal of Marine Science 70.4 (Jul 2013): 768-781.
ProQuest document link

Abstract (English): We have used in this study a spatially explicit bioeconomic modelling framework to evaluate management strategies, building in both data-rich and data-limited harvest control rules (HCRs), for a mix of deepwater fleets and species, on which information is variable. The main focus was on blue ling (Molva dypterygia). For that species, both data-rich and data-limited HCRs were tested, while catch per unit effort (CPUE) was used either to tune stock assessments, or to directly trigger management action. There were only limited differences between the performances of both HCRs when blue ling biomass was initialized at the current level, but blue ling recovered more quickly with the data-rich HCR when its initial biomass was severely depleted. Both types of HCR lead, on average, to a long-term recovery of both blue ling and saithe (Pollachius virens) stocks, and some increase in overall profit. However, that improvement is not sufficient to guarantee sustainable exploitation with a high probability. Blue ling CPUE did not always adequately reflect trends in biomass, which mainly resulted from fleet dynamics, possibly in combination with density-dependence. The stock dynamics of roundnose grenadier (Coryphaenoides rupestris), black scabbardfish (Aphanopus carbo) and deepwater sharks (Centrophorus squamosus and Centroscymnus coelolepis) were little affected by the type of HCR chosen to manage blue ling.

2. Sustainability of deep-sea fisheries

Author: Norse, Elliott A1; Brooke, Sandra; Cheung, William WL; Clark, Malcolm R; Ekeland, Ivar; Froese, Rainer; Gjerde, Kristina M; Haedrich, Richard L; Heppell, Selina S; Morato, Telmo; Morgan, Lance E; Pauly, Daniel; Sumaila, Rashid; Watson, Reg1 Marine Conservation Institute, 2122 112th Ave NE, Suite B-300, Bellevue WA 98004, USA, elliott.norse@marine-conservation.org

Publication info: Marine Policy 36.2 (Mar 2012): 307-320.

ProQuest document link

Abstract (English): As coastal fisheries around the world have collapsed, industrial fishing has spread seaward and deeper in pursuit of the last economically attractive concentrations of fishable biomass. For a seafood-hungry world depending on the oceans' ecosystem services, it is crucial to know whether deep-sea fisheries can be sustainable. The deep sea is by far the largest but least productive part of the oceans, although in very limited places fish biomass can be very high. Most deep-sea fishes have life histories giving them far less population resilience/productivity than shallow-water fishes, and could be fished sustainably only at very low catch rates if population resilience were the sole consideration. But like old-growth trees and great whales, their biomass makes them tempting targets while their low productivity creates strong economic incentive to liquidate their populations rather than exploiting them sustainably (Clark's Law). Many deep-sea fisheries use bottom trawls, which often have high impacts on nontarget fishes (e.g., sharks) and invertebrates (e.g., corals), and can often proceed only because they receive massive government subsidies. The combination of very low target population productivity, nonselective fishing gear, economics that favor population liquidation and a very weak regulatory regime makes deep-sea fisheries unsustainable with very few exceptions. Rather, deep-sea fisheries more closely resemble mining operations that serially eliminate fishable populations and move on. Instead of mining fish from the least-suitable places on Earth, an ecologically and economically preferable strategy would

be rebuilding and sustainably fishing resilient populations in the most suitable places, namely shallower and more productive marine ecosystems that are closer to markets.

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3. Spatial management of deep-sea seamount fisheries: balancing sustainable exploitation and habitat conservation

Author: Clark, Malcolm R1; Dunn, Matthew R1 National Institute of Water and Atmospheric Research, Private Bag, Wellington 6021, New Zealand, m.clark@niwa.co.nz

Publication info: Environmental Conservation 39.3 (Sep 2012): 204-214.
ProQuest document link

Abstract (English): Seamounts throughout the world's oceans can support diverse and abundant fish communities. Many have been subject to commercial deep-sea bottom trawl fisheries and have exhibited 'boom and bust' characteristics. There is growing concern about the effect of fishing on fragile and vulnerable benthic invertebrate species. This review examines why deep-sea fisheries have generally failed, and recommends measures that are necessary to improve their sustainability. Much is based on lessons learned in the south-west Pacific that may be more generally applicable to global deep-sea fisheries. Sustainable fisheries require highly precautionary feature-based catch limits, and credible and timely stock assessment advice. Management also needs to consider fishing impacts on the benthic habitat, and while reducing and spreading fishing effort on seamounts is beneficial for fish stocks, it can have a negative effect on the benthos. To balance exploitation and conservation, elements of spatial management are required, whereby some seamounts are protected before any fishing has occurred. Protected areas should include entire seamounts, and multiple seamounts in a network. A management regime should incorporate closed seamounts, open seamounts for fishing, and management of adjacent slope areas where these are important for the productivity of fish and invertebrate populations.

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4. Sustainability of deep-sea fisheries

Author: Norse, Elliott A1; Brooke, Sandra; Cheung, William WL; Clark, Malcolm R; Ekeland, Ivar; Froese, Rainer; Gjerde, Kristina M; Haedrich, Richard L; Heppell, Selina S; Morato, Telmo; Morgan, Lance E; Pauly, Daniel; Sumaila, Rashid; Watson, Reg1 Marine Conservation Institute, 2122 112th Ave NE, Suite B-300, Bellevue WA 98004, USA, elliott.norse@marine-conservation.org

Publication info: Marine Policy 36.2 (Mar 2012): 307-320.
ProQuest document link

Abstract (English): As coastal fisheries around the world have collapsed, industrial fishing has spread seaward and deeper in pursuit of the last economically attractive concentrations of fishable biomass. For a seafood-hungry world depending on the oceans' ecosystem services, it is crucial to know whether deep-sea fisheries can be sustainable. The deep sea is by far the largest but least productive part of the oceans, although in very limited places fish biomass can be very high. Most deep-sea fishes have life histories giving them far less population resilience/productivity than shallow-water fishes, and could be fished sustainably only at very low catch rates if population resilience were the sole consideration. But like old-growth trees and great whales, their biomass makes them tempting targets while their low productivity creates strong economic incentive to liquidate their populations rather than exploiting them sustainably (Clark's Law). Many deep-sea fisheries use bottom trawls, which often have high impacts on non-target fishes (e.g., sharks) and invertebrates (e.g., corals), and can

often proceed only because they receive massive government subsidies. The combination of very low target population productivity, nonselective fishing gear, economics that favor population liquidation and a very weak regulatory regime makes deep-sea fisheries unsustainable with very few exceptions. Rather, deep-sea fisheries more closely resemble mining operations that serially eliminate fishable populations and move on. Instead of mining fish from the least-suitable places on Earth, an ecologically and economically preferable strategy would be rebuilding and sustainably fishing resilient populations in the most suitable places, namely shallower and more productive marine ecosystems that are closer to markets.

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5. Sustainability of deep-sea fish species under the European Union Common Fisheries Policy

Author: Villasante, Sebastian et al11 Department of Applied Economics, Faculty of Economics and Business Administration, University of Santiago de Compostela, Av. Burgo das Nacions s/n, 15782 Santiago de Compostela, Spain Spain

Publication info: Ocean and coastal management 70 (2012): 31-37.
ProQuest document link

Abstract (English): The historical expansion of fishing industries into the deep sea has been described at the global level, but corresponding patterns are less well known at other geographical scales. The International Council for the Exploration of the Sea (ICES) has stated that most deep-sea species exploited by European fishing industries are harvested outside safe biological limits. As a result, the European Union commenced regulating exploitation of deep-sea stocks with total allowable catches (TACs). These regulations have been operational since 2002, but no detailed overview of their effectiveness is hitherto available. The objectives of this paper are: 1) to analyse changes in mean depth of fishing of the EU fleet before (1950-1982) and after (1983-2006) the adoption of the Common Fisheries Policy (CFP), 2) to analyse the degree to which the European Council follows scientific advice on sustainable catches provided by ICES and 3) to investigate the degree to which the fishing industry complies with agreed catch limits. Our results indicate that the EU fleet has experienced a bathymetric expansion by an average of 78 m depth for the 1950-2006 period, or almost twice the value (42 m) previously reported for the global fleet. This pattern of expansion towards deep-sea fishing grounds has not changed under the CFP. Additionally, the paper demonstrates that the mean longevity of species caught by the EU fleet increased with depth, from about 13 years for shallow water species to about 25 years for intermediate species and about 60 years for deep-sea species. Thus, fishing deeper means fishing for increasingly long-lived and vulnerable species. This study also shows that approved TACs for deep-sea fish stocks did not follow scientific advice. Scientifically proposed TAC levels were not respected in about 60% of the cases investigated and these approved TACs were not complied. Member States exceeded agreed quotas in about 50% of the cases during the 2002-2011 period. Reported catches were on average 3.5 times greater than approved for deep-sea species, but in some cases catches even 10-28 times higher than agreed. The identified pattern that Member States fail to respect approved quotas indicate a lack of incentives to comply, likely as a consequence of limited enforcement and sanctioning mechanisms. Ensuring long-term sustainability of deep-sea stocks is urgently needed but requires dramatic change to the existing management system

6. **Scientists Find Most Deep-Sea Fisheries Are Unsustainable**

Author: Anonymous

Publication info: Sea Technology 52.10 (Oct 2011): 64-64.
ProQuest document link

Abstract: The deep sea provides less than 1 percent of the world's seafood. Since the 1 970s, when coastal fisheries were overexploited, commercial fishing fleets have moved further offshore.

7. **Deep-sea fishing for chondrichthyan resources and sustainability concerns- A case study from southwest coast of India**

Author: Akhilesh, K V1; Ganga, U; Pillai, NGK; Vivekanandan, E; Bineesh, K K; Shanis, CPR; Hashim, M1 Central Marine Fisheries Research Institute, P.B. No. 1603, Ernakulam North PO, Cochin 682 018, Kerala India, akhikv@gmail.com

Publication info: Indian journal of Geo-marine sciences 40.3 (Mar 2011): 347-355.
ProQuest document link

Abstract (English): Elasmobranchs comprising sharks, skates and rays have traditionally formed an important fishery along the Indian coast. Since 2000, Indian shark fishermen are shifting their fishing operations to deeper/oceanic waters by conducting multi-day fishing trips, which has resulted in considerable changes in the species composition of the landings vis- a-vis those reported during the 1980's and 1990's. A case study at Cochin Fisheries Harbour (CFH), southwest coast of India during 2008-09 indicated that besides the existing gillnet-cum- hooks and line and longline fishery for sharks, a targeted fishery at depths and gt; 300-1000 m for gulper sharks (Centrophorus spp.) has emerged. In 2008, the chondrichthyan landings (excluding batoids) were mainly constituted by offshore and deep-sea species such as Alopias superciliosus (24.2%), Carcharhinus limbatus (21.1%), Echinorhinus brucus (8.2%), Galeocerdo cuvier (5.4%), Centrophorus spp. (7.3%) and Neoharriotta pinnata (4.2%) while the contribution by the coastal species such as Sphyrna lewini (14.8%), Carcharhinus sorrah (1.4%) and other Carcharhinus spp. has reduced. Several deep-sea sharks previously not recorded in the landings at Cochin were also observed during 2008-09. It includes Hexanchus griseus, Deania profundorum, Zameus squamulosus and Pygmy false catshark (undescribed) which have been reported for the first time from Indian waters. Life history characteristics of the major fished species are discussed in relation to the fishery and its possible impacts on the resource.

8. **Do we have enough information to apply the ecosystem approach to management of deep-sea fisheries? An example from the West of Scotland**

Author: Heymans, Johanna J1; Howell, Kerry L; Ayers, Morag; Burrows, Michael T; Gordon, John DM; Jones, Emma G; Neat, Francis1 1 Scottish Association for Marine Science, Scottish Marine Institute, Oban PA371QA, UK, sheilaheymans@yahoo.com

Publication info: ICES Journal of Marine Science 68.2 (Jan 2011): 265-280.
ProQuest document link

Abstract (English): Heymans, J. J., Howell, K. L., Ayers, M., Burrows, M. T., Gordon, J. D. M., Jones, E. G., and Neat, F. 2011. Do we have enough information to apply the ecosystem approach to management of deep-sea fisheries? An example from the West of Scotland. - ICES Journal of Marine Science, 68: 265-280.There is currently a global call for more use of an ecosystem approach to fisheries management (EAFM), and ecosystem models such as Ecopath with Ecosim (EwE) are being used to provide a holistic view of ecosystem-fisheries interactions. Although these can be useful for an EAFM, the relative paucity of data available for deep-sea ecosystems raises concerns whether we can effectively apply an EAFM to the deep sea. The deep-sea ecosystem off the west coast of Scotland has been studied for longer and in more detail than most. This study assimilates the significant published and unpublished information available on this ecosystem into an EwE model. The results suggest that there are sufficient data available to construct an ecosystem model, but the quality of the data varies and serious potential sources of error are present in biomass and discard estimates. The assumptions needed to produce a model are varied and must be considered when interpreting the outputs of the model. Ecosystem modelling provides a unique view of the deep-water ecosystem and facilitates hypothesis development concerning predator-prey and inter-fishery interactions. Sharks are used to illustrate the benefits of using an ecosystem model to describe changes in their biomass and their prey species. The results show that both fishing for sharks and fishing for their prey affect the biomass of sharks.

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9. Experimental fisheries for black scabbardfish (Aphanopus carbo) in the Azores, Northeast Atlantic

Author: Machete, Miguel1; Morato, Telmo; Menezes, Gui1 Department of Oceanography and Fisheries, University of the Azores, 9901-862 Horta, Portugal, miguel@uac.pt

Publication info: ICES Journal of Marine Science 68.2 (Jan 2011): 302-308.

Abstract (English): Machete, M., Morato, T., and Menezes, G. 2011. Experimental fisheries for black scabbardfish (Aphanopus carbo) in the Azores, Northeast Atlantic - ICES Journal of Marine Science, 68: 302-308. In this study, we used fisheries observers' data to analyse and describe the experimental fishing of black scabbardfish in the Azores in terms of type of gear, fishing operation, catch per unit effort (cpue), and fish size compositions. Standardized catch in numbers per 1000 hooks varied from 103 to 210 fish with an overall average of 132 fish per 1000 hooks. Recorded cpue values were similar to those recorded for Madeira and mainland Portugal in early 2000 but were higher than those observed in mainland Portugal for recent years. Bycatch was similar to that observed for other longline fisheries but much lower than in the North Atlantic deep-water trawl fishery. Fish size composition showed differences between locations in the Azores. Fish in Pico and Sao Jorge/Graciosa were consistently smaller than in other areas sampled and this may reflect the occurrence of an additional species, Aphanopus intermedius, in this area as proposed by gene analyses. Black scabbardfish (of possibly two species) may be considered an alternative resource for Azorean fisheries. Based on experience from other scabbardfish fisheries, however, it is suggested that fishing mortality should be maintained at a low level, traditional fishing methods should be encouraged, and bycatch should be closely monitored. Future studies of biology and distribution, stock assessments, and fisheries management advice should take into account the probable occurrence of two very similar species in the area. This study also highlights the importance of maintaining the fishery monitoring programme for the black scabbardfish fisheries in the Azores.

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10. **Comparative assessment of population genetics and demographic history of two congeneric deep sea fish species living at different depths**

Author: White, Thomas A1; Fotherby, Heather A; Hoelzel, ARus1 School of Biological and Biomedical Sciences, University of Durham, Durham DH1 3LE, UK, a.r.hoelzeldurham.ac.uk

Publication info: Marine Ecology Progress Series 434 (2011): 155-164.
ProQuest document link

Abstract (English): The mechanisms that determine population genetic structure in the marine environment are poorly understood, as are the processes that drive population dynamics. One potential factor is depth, with especially those species living in the abyss inhabiting a distinct environment with respect to habitat complexity, pressure, the distribution of resources and environmental change over time. Here we consider a deep sea fish genus, Coryphaenoides, which has many named species, including 8 abyssal species. We provide data in support of the existence of 2 distinct evolutionary lineages within the genus, associated with depth, and also provide detailed population genetic data for the abyssal species (C. brevibarbis) for comparison with available data on a congeneric species inhabiting shallower waters (C. rupestris). The abyssal species showed no sign of population genetic structure across a thermal oceanographic boundary (the Sub-Polar Front), for which C. rupestris showed differentiation. An assessment of historical demographics suggested a decline in population size for both species, but a faster and more severe decline for the abyssal species. We consider these data in the context of environmental gradients and potential evolutionary mechanisms. Relatively low effective population size estimates for both species emphasize the importance of understanding these processes for the effective conservation and management of deep sea fish stocks.

11. **Size at maturity and length-weight relationships of the blurred lantern shark Etmopterus bigelowi (Squaliformes: Etmopteridae) caught off southeastern Brazil**

Author: Mourato, B L1; Coelho, R; Amorim, A F; Carvalho, F C; Hazin, FHV; Burgess, G1 Universidade Federal de Pernambuco, Departamento de Oceanografia, Cidade Universitaria, 50670-901, Recife, PE, Brasil, bruno.pesca@gmail.com

Publication info: Ciencias Marinas 36.4 (Dec 2010): 323-331.
ProQuest document link

Abstract (Spanish): The blurred lantern shark Etmopterus bigelowi, a deep-water squaloid shark, is globally widespread in temperate and tropical waters, but there is little available information about its biology owing to its relative rarity of capture and taxonomic confusion with its sibling species Etmopterus pusillus. Specimens used in this study were collected from July to December 2004 as by-catch in the commercial deep-water trawl fishery targeting red shrimp Aristaeomorpha foliacea in the southwestern Atlantic. We examined 55 specimens (22 males and 33 females) ranging in total length (TL) from 31.5 to 73 cm and in total weight from 103 to 1600 g. Length-weight relationships were explored for each sex and significant differences were found in the slope coefficients of the male and female regressions. The size at maturity for each sex was evaluated fitting a logistic regression. Females matured at larger sizes than males, with estimated sizes at first maturity of 56.0 cm TL for females and 45.1 cm TL for males. The present study provides important preliminary information about E. bigelowi that can be incorporated in risk assessment and stock assessment models, essential for efficient management practices aimed at avoiding overexploitation of these vulnerable deep-sea sharks.Original Abstract: E1 tiburon de profundidad Etmopterus bigelowi se distribuye globalmente en aguas templadas y tropicales; sin embargo, hay poca informacion disponible sobre su biologia ya que raramente se captura y existe confusion taxonomica con su especie hermana Etmopterus pusillus. Los ejemplares utilizados en este trabajo se obtuvieron de julio a diciembre de 2004 como captura incidental de la pesca comercial de arrastre de aguas

profundas dirigida al camaron rojo Aristaeomorpha foliacea en el Atlantico sudoccidental. Se examinaron 55 ejemplares (22 machos y 33 hembras) de 31.5 a 73 cm de longitud total (LT) y de 103 a 1600 g de peso total. Se analizo la relacion peso-talla para ambos sexos, observandose diferencias significativas en las pendientes de las regresiones, tanto de hembras como de machos. La talla de madurez para cada sexo se evaluo ajustando una regresion logistica. La talla de primera madurez de las hembras (56.0 cm LT) fue mayor que la de los machos (45.1 cm LT). E1 presente trabajo aporta informacion preliminar esencial sobre E. bigelowi que puede ser incorporada en modelos de evaluacion de riesgo y evaluacion de la poblacion, cruciales para practicas de gestion dirigidas a evitar la sobreexplotacion de estos vulnerables tiburones de aguas profundas.

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12. A review of the sensory biology of chimaeroid fishes (Chondrichthyes; Holocephali)

Author: Lisney, Thomas J11 Department of Animal Ecology, Evolutionary Biology Centre, Uppsala University, Norbyvaegen 18D, 752 36, Uppsala, Sweden, tom_lisney@hotmail.com

Publication info: Reviews in Fish Biology and Fisheries 20.4 (Dec 2010): 571-590.
ProQuest document link

Abstract (English): The chimaeroid fishes (Chondrichthyes: Holocephali) are a small, ancient and poorly studied group of cartilaginous fishes that have puzzled and intrigued taxonomists, ichthyologists and evolutionary biologists for over 100years. Like their close relatives, the elasmobranchs (sharks, skates and rays), chimaeroids possess an extensive battery of sense organs that allow them to detect information about the external environment in order to find mates, locate food and preferred habitats and avoid predators. In recent years the sensory systems of elasmobranchs have received an up-swell of attention from biologists, which has resulted in a greater understanding of the sensory capabilities and behaviour of these fishes. However, very little recent work has been done on the chimaeroids. The aim of this review is to provide a survey of the existing literature on the major senses (vision, smell, taste, mechanoreception, hearing and electroreception) in chimaeroids, in order to stimulate and identify areas for future research. In chimaeroids information on sensory systems is largely restricted to one or two species (with the exception of some aspects of the visual system) and for some sensory systems essentially nothing is known. Most studies are anatomical in nature and so there is a demand for a greater degree of neurophysiological and behavioural assessment of sensory capability in these fishes. The majority of chimaeroids occupy deep-sea habitats and are becoming increasingly threatened by the expansion of deep-sea fisheries, so an understanding of the sensory biology and behaviour of chimaeroids may be important for the protection and management of these fascinating fishes.

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13. Biological patterns and ecological indicators for Mediterranean fish and crustaceans below 1,000m: a review

Author: Sarda, F1; Company, J B; Rotllant, G; Coll, M1 Institut de Ciencies del Mar (CSIC), Passeig Maritim de la Barceloneta 37-49, 08003, Barcelona, Spain, siscu@icm.csic.es

Publication info: Reviews in Fish Biology and Fisheries 19.3 (Sep 2009): 329-347.
ProQuest document link

Abstract (English): The Mediterranean Sea is a relatively deep, closed sea with high rates of fisheries exploitation. In recent years fishing activity has tended to shift towards deeper depths. At the same time, the

Mediterranean displays some rather special hydrographic and biogeographic conditions. The present paper reviews the present state of knowledge of the fisheries, biology, and ecology of the deep-sea fish and crustacean species in the Mediterranean dwelling below 1,000m with potential economic interest, placing special emphasis on the western basin, for which more data are available, as a basis for future studies of the ecology, biodiversity, and effects of climate change and exploitation in this zone. This review reveals that mediterranean deep-sea fishes and crustaceans employ highly conservative ecological strategies, and hence the low fecundity and low metabolic rates in a stable environment like the deep-sea make these populations highly vulnerable. Moreover, ripe females of the main species mentioned here concentrate in the deepest portions of their distribution ranges. Deep-sea fish and crustaceans have high trophic levels and low to medium omnivory index values. The ecological indices discussed here, in combination with the limited knowledge of deep-sea ecosystems, clearly call for an approach based on the Precautionary Principle.

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14. Limited potential to recover from overfishing raises concerns for deep-sea sharks, rays and chimaeras

Author: Simpfendorfer, Colin A1; Kyne, Peter M1 School of Biomedical Sciences, University of Queensland, St. Lucia, Queensland 4072, Australia, colin.simpfendorfer@jcu.edu.au

Publication info: Environmental Conservation 36.2 (Jun 2009): 97-103.
ProQuest document link

Abstract (English): As global fishing effort increasingly expands into deeper water, concerns exist over the ability of deep-sea fishes to sustain fisheries. There is however little quantitative evidence to support these concerns for the deep-sea cartilaginous fishes (Chondrichthyes: sharks, rays and chimaeras). This paper compiled available life history data for this group to analyse their ability to rebound from population declines relative to continental shelf and pelagic species. Deep-sea cartilaginous fishes have rates of population increase that are on average less than half those of shelf and pelagic species, and include the lowest levels observed to date. Population doubling times indicate that once a stock has been depleted, it will take decades, and potentially centuries, before it will recover. Furthermore, population recovery rates decrease with increasing depth, suggesting species that occur deepest are those most vulnerable to fishing. These results provide the first assessment of the productivity of deep-sea chondrichthyans, highlighting that precautionary management of developing deep-sea fisheries is essential if stocks and biodiversity are to be maintained.

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15. Deep-sea fishes in Canada's Atlantic: population declines and predicted recovery times

Author: Baker, Krista D; Devine, Jennifer A; Haedrich, Richard L

Publication info: Environmental Biology of Fishes 85.1 (May 2009): 79-88.
ProQuest document link

Abstract (English): Because of their slow growth rates, late maturity, low fecundity and long potential lifespans, deep-sea fishes are vulnerable to and theoretically slow to recover from overexploitation and bycatch. As industrial fishing moved into the deep sea, population declines were predicted and five species were shown to meet The World Conservation Union (IUCN) criteria for endangered species in Atlantic Canadian waters and two other deep-living species were listed as threatened by the Committee on the Status of Endangered Wildlife in Canada. We used data from scientific surveys to determine population trends in a 17-year time series for an

additional 32 deep-sea fishes from the same geographic region. Eight species exhibited significant population declines, five increased, two were data deficient, and 17 showed no significant trends. Thus approximately 38% of the deep-sea bottom-living fishes in that well-investigated region could be at-risk, but definitive assignment to an IUCN category for most species is hampered by a lack of basic biological information, especially species specific generation times. Lack of biological information also limits efforts to determine possible recovery times, especially with respect to calculating intrinsic rates of population growth (r). For two Atlantic grenadiers (where r could be estimated using life-history parameters and standard life table techniques), the time to recovery with no fishing mortality could range from over a decade to over a century. This broad range results from the general uncertainty on life-history characteristics of these deep-sea species. Given the documented declines, the lack of basic data on life-history parameters, and the conservative assumption that recovery rates are likely to be prolonged, we argue that it is imperative to conduct additional studies pertaining to life history characteristics of deep-sea fishes and implement conservation measures in the deep sea immediately.

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16. The Giant Grenadier in Alaska

Author: Clausen, D M11 U.S. National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratories 17109 Point Lena Loop Road, Juneau, Alaska 99801, USA, dave.clausen@noaa.gov

Publication info: American Fisheries Society Symposium 63 (2008): 413-450.
ProQuest document link

Abstract (English): This report summarizes biological, fishery, and survey information on giant grenadier, Albatrossia pectoralis, in Alaskan waters. Catch estimates of giant grenadier in Alaska for the years 1997-2005 have averaged over 16,000 metric tons (mt), and most of this catch has been taken as bycatch in longline fisheries for sable-fish, Anoplopomafimbria, and Greenland halibut, Reinhardtius hippoglossoides. The giant grenadier catch is all discarded, and none of the fish survive due to the pressure change when they are brought to the surface. Most of the catch is from the Gulf of Alaska. Data from bottom trawl and longline surveys in Alaska indicate that giant grenadier are extremely abundant in depths 300-1,000 m, and it appears this species is very important ecologically in this environment. Greatest abundance is in the western Gulf of Alaska, eastern Aleutian Islands, and in some areas of the eastern Bering Sea; abundance declines in the eastern Gulf of Alaska. Relative abundance of giant grenadier is much higher off Alaska than off the U.S. West Coast. Fish in the eastern Bering Sea and Aleutian Islands were consistently larger than those in the Gulf of Alaska. Mean size of females was larger in shallower water, and decreased with depth. Females and males appear to have different depth distributions, with females greatly predominating in depths less than 800 m. Although sex composition of giant grenadier caught in the fishery is unknown, nearly all the fishing effort is believed to be in waters less than 800 m, which indicates females are disproportionately harvested. Because of the great abundance of giant grenadier in Alaska and the relatively modest catch, overfishing of giant grenadier does not appear to be a problem at present. However, because information on the population dynamics of giant grenadier is very sparse, and because of the 100% discard mortality, the disproportionate harvest of females, and the general susceptibility of deep-sea fish to overharvest, fishery managers should monitor this species closely if catches increase in the future.

17. **Reconciling Fisheries with Conservation on Seamounts**

Author: Morato, T1; Pitcher, T J1 Univeridade dos Acores, Departamento de Oceanografia e Pescas, 9901-862 Horta, Portugal, t.morato@fisheries.ubc.ca

Publication info: American Fisheries Society Symposium 49.2 (2008): 1623-1634.
ProQuest document link

Abstract (English): With the collapse of traditional stocks on continental shelves and with general decline of global catches, the fishery industry has moved to deepwater alternative fishing grounds and species. Seamounts are among those newly targeted ecosystems that have been intensively exploited in all world oceans. Serious stock depletion has been detected in every case. The life history characteristics of deep-sea and seamount associated species place them at the extreme end of vulnerability spectrum. Past experience has shown that seamount fish stocks can collapse within 5-10 years. The prevention of further negative impacts on these sensitive ecosystems is now an important policy objective. Because of the extensive trophic links on seamounts and of data-limited situations, ecosystem-based modeling approaches are essential to understanding the ecosystem functioning and to ensure an effective management. In this paper, we used previous ecosystem modeling work to address the question of what types of fisheries might be sustainable on seamounts. The analyses are not meant to provide truthful fishing policy evaluation for seamount fisheries, but some ideas can be inferred. The analyses conducted showed that simulations with policy objectives that maximize economic performance would favor a fleet configuration based on deepwater trawling, but have a cost for the ecosystem. Maximizing ecological performance will favor a fleet configuration based on small pelagic and bottom longline fisheries, but would scarify total catches and jobs, while maximizing biomass of long-lived species and the biodiversity of the ecosystem. The overall study suggested that sustainable seamount fisheries with tolerable ecosystem impacts appeared to be closer to those found by maximizing the "ecological" objective function.

18. **Growth analysis and age validation of a deepwater Arctic fish, the Greenland halibut (Reinhardtius hippoglossoides)**

Author: Treble, Margaret A; Campana, Steven E; Wastle, Rick J; Jones, Cynthia M; Boje, Jesper

Publication info: Canadian Journal of Fisheries and Aquatic Sciences 65.6 (2008): 1047-1059.
ProQuest document link

Abstract (French): The accuracy of age interpretations on a deep-sea, Arctic fish species, the Greenland halibut (Reinhardtius hippoglossoides) was tested using several age validation methods. Consistent annual growth increments were either not formed or not visible in either whole or sectioned otoliths from three fish marked with oxytetracyline and recaptured after 2-4 years at liberty. Bomb radiocarbon assays based on a local reference chronology indicated that both whole and sectioned otoliths underestimated age by 1-15 years, with an average of 6 years. Growth rates estimated using the tag recapture model GROTAG were consistent with growth rates based on the radiocarbon assays and were less than half that of previously reported growth rates. The failure of otolith sections to provide an accurate age is unusual, but may be symptomatic of very slow-growing species with unusually shaped otoliths. Greenland halibut living in the deep-sea, Arctic environment are slower growing and longer lived than previously suspected, suggesting that the age-structured basis for current fisheries

management warrants careful examination. Our results highlight the importance of using rigorous tests of ageing accuracy for exploited species and confirm that such age validation methods can be applied successfully in challenging environments such as the deep sea or the Arctic.

Original Abstract: Nous vérifions, a l'aide de plusieurs méthodes de validation de l'âge, la précision des interprétations de l'âge chez une espèce de poisson marin arctique, habitant les eaux profondes, le flétan du Groenland (*Reinhardtius hippoglossoides*). Chez trois poissons marqués à l'oxytetracycline et recapturés après 2-4 années de liberté, il ne s'était pas forme d'incréments uniformes de croissance annuelle ou alors ces derniers n'étaient pas visibles dans des otolithes entiers ou sectionnés. Des dosages du radiocarbone relié aux essais nucléaires basés sur une chronologie locale de référence montrent que l'utilisation des otolithes entiers ou sectionnés sous-estime l'âge de 1-15 ans, avec une moyenne de 6 ans. Les taux de croissance estimés à l'aide du modèle de récupération des étiquettes GROTAG s'accordent avec les taux de croissance basés sur les analyses de radiocarbone et ils équivalent à moins de la moitié des taux de croissance signalés antérieurement. L'incapacité des coupes d'otolithes à permettre une détermination précise de l'âge est rare, mais elle peut être caractéristique des espèces à croissance très lente qui possèdent des otolithes de forme inhabituelle. Les flétans du Groenland qui vivent dans un environnement arctique en mer profonde ont une croissance plus lente et une longévité plus grande qu'on ne le croyait antérieurement, ce qui indique que la gestion actuelle de la pêche commerciale structurée d'après l'âge devrait être réexaminée avec soin. Nos résultats illustrent bien l'importance d'utiliser des tests rigoureux de l'exactitude des déterminations de l'âge chez les espèces exploitées et ils confirment que de telles méthodes de validation peuvent être utilisées avec succès dans des environnements qui présentent des défis considérables, comme les profondeurs de la mer ou l'Arctique. [Traduit par la Redaction]

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19. Can deep water fisheries be managed sustainably?

Author: Sissenwine, M P; Mace, P M

Publication info: FAO fisheries report 838 (Nov 2007): 61-111.
ProQuest document link

Abstract (English): Governance of deepwater fisheries has a high profile in the international community, including the explicit attention of the United Nations General Assembly (UNGA). This attention reflects concerns about the sustainability of deepwater fisheries and the fragility of deepwater ecosystems, and concern that there is a gap in the international fisheries governance framework when it comes to deepwater fisheries on the high seas. Deepwater fisheries are considered by Food and Agriculture Organization of the United Nations (FAO) as those fisheries that occur beyond the continental shelf/slope break which typically occurs at about 200 metres (m). The current technological limit of these fisheries is about 2 000 m. However, many species not usually considered as deepwater are fished at depths well above 200 m (e.g. the North Pacific walleye Pollock fishery, one of the world's most productive, occurs over a range of 90- 500 m). According to the FAO statistical database, deepwater fisheries produced 5.9 million metric tonnes (t) in 2004 or less than 4 percent of the total production from fisheries and aquaculture (including freshwater). Most of this catch is of species that generally occur in depths of less than 500 m, and some of the species that account for much of the catch occur in shallow nearshore waters as well as beyond 200 m in depth. Deepwater fisheries should not all be 'painted with the same brush' (or, in other words, hairtails and blue whiting are not the same 'kettle of fish' as orange roughy and oreo dories) as there is a great deal of difference between the species fished in the shallow end of the range of deepwater fisheries, and species that are fished at depths centered below 500 m. Species fished in the shallow end of the range have similar biological characteristics to shelf species. They are productive compared to some deeper water species, such as orange roughy. The discourse about deepwater fisheries would be well served by

a common understanding of what constitutes a deepwater fishery and what makes them different from other fisheries. Deepwater fisheries beyond 500 m generally have a history of less than three decades, during which early expectations of sustainable yield have often been too optimistic, the biomass on many fishing grounds has been depleted, and biogenic habitats have been impacted. The deepwater fisheries that have attracted the most attention are those for orange roughy at depths of about 700 m and below. Simply stated, the global track record for sustainable management of deepwater fisheries beyond 500 m is not good. Deepwater fisheries have failed to be sustainable for one or more of the following fundamental reasons: 1)they have been unregulated; 2)initial scientific assessments based on limited data have often been too optimistic; and/or 3)management has not responded to, or has been slow to respond to, scientific advice calling for improved conservation. This experience clearly points to the need to strictly adhere to the precautionary approach and apply an ecosystem approach. More specifically: a)all deepwater fisheries should be authorized by a competent management authority with constraints set cautiously, and new fisheries should have a development plan that ensures the rate of development is consistent with the gathering of knowledge; b)management strategies for deepwater fisheries need to be re-examined in light of the poor track record to date; in particular biological reference points should be set more conservatively and explicit 'fishing down' phases should be avoided; c)steps need to be taken to address habitat and biodiversity impacts of deepwater fisheries; d) research is needed to improve resource assessments, knowledge about the distribution of resources off fishing grounds, understanding of stock structure, and understanding the functional value and vulnerability of habitat and biodiversity; e)new multilateral arrangements are needed to manage high-seas fisheries in some areas, although individual nations could prevent overfishing on the high seas if they consistently applied the FAO Code of Conduct for Responsible Fisheries (CCRF) and the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement); and d)there is a need to improve compliance with fishery conservation measures and reporting of fishery-dependent data. It is time to seriously consider extending catch documentation schemes, such as the Commission for the Conservation of Antartic Marine Living Resources (CCAMLR) scheme used to reduce illegal, unregulated, and unreported (IUU) fishing of toothfish, to all fish that enter into international trade. An unanswered question is, will the benefit-cost ratio for deepwater fisheries for long-lived, low-productivity species be positive if the full costs of research and management are taken into account?

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20. Intrinsic vulnerability in the global fish catch

Author: Cheung, William WL1; Watson, Reg; Morato, Telmo; Pitcher, Tony J; Pauly, Daniel1 Fisheries Centre, The University of British Columbia, Aquatic Ecosystems Research Laboratory (AERL), 2202 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada, w.cheung@fisheries.ubc.ca

Publication info: Marine Ecology Progress Series 333 (Mar 2007): 1-12.
ProQuest document link

Abstract (English): We have identified the marine fish taxa that are most vulnerable to exploitation, by compiling an index of intrinsic vulnerability based on life history traits. Since 1950, the global fish catch has been increasingly dominated by species with low intrinsic vulnerability, indicated by a decline in mean vulnerability of the taxa in the catches. This decline is strongest in catches of coral reef fishes, probably as a result of overexploitation of the more vulnerable species. The change is less apparent in estuaries, where fish communities are more transient. The opposite is observed at seamounts, where more vulnerable species have become exploited and serially depleted in recent years. Rates of change in the mean vulnerability index in the catches from different areas are negatively correlated with the number of threatened fishes on the IUCN Red

List. Particularly, catches from the Indo-Pacific and Caribbean regions are characterized by a high abundance of threatened fishes and by strong declines in the mean vulnerability index. Our findings suggest that fishing largely alters the community structure of coral reef fishes, which may detrimentally affect the ecosystem. Attention should also be given to deep water demersal and benthopelagic fish assemblages, especially those around seamounts, which are intrinsically vulnerable to fishing. The index of intrinsic vulnerability thus provides a novel tool for fisheries management and conservation.

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21. Seamounts, deep-sea corals, and fisheries in the Pacific Ocean

Author: Clark, M1; Tittensor, D; Rogers, AD1 National Institute of Water &Atmospheric Research, Private Bag 14-901, Wellington, New Zealand, m.clark@niwa.co.nz

Publication info: North Pacific Marine Science Organization (PICES), P.O. Box 6000 Sidney B.C. V8L 4B2 Canada, 2007.
ProQuest document link

Abstract: Seamounts are widespread features of the world's underwater topography, and may number 10s of thousands in the Pacific Ocean. They can support high biodiversity and unique biological communities. They are often highly productive, and bottom trawl fisheries target deepwater commercial fish species such as orange roughy, oreos, alfonsino, pelagic armourhead and redfishes. However, seamount habitat is ecologically vulnerable to such exploitation. In this talk we present results of recent studies by CenSeam (the Census of Marine Life programme on seamounts) that examine the relationships between seamounts, deepwater corals, and fisheries. The known distribution of stony corals worldwide is related to their physical environment, and then applied to potential seamount locations derived from satellite altimetry to estimate the likelihood of the seamount having suitable conditions for corals. Habitat suitability is then related to the distribution and depth ranges of deepwater trawl fisheries to assess their vulnerability. The North Pacific has a broad band of predicted habitat for stony corals at depths down to 250m, which becomes more restricted with depth. The South Pacific was similar, although habitat suitability was widespread through the 750m to 1250m depth range. This makes deeper seamounts in the South more vulnerable to fisheries targeting orange roughy and oreos, while the North Pacific seamounts are mainly at depths for species like alfonsino, pelagic armourhead and some of the shallower Sebastes spp. Careful management is required for all these seamount fisheries to avoid overexploitation of the fish stocks, and associated damaging effects of trawling on the coral habitat.

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22. Fishing down the deep

Author: Morato, Telmo1; Watson, Reg; Pitcher, Tony J; Pauly, Daniel1 Departamento de Oceanografia e Pescas, Universidade dos Acores, PT 9901-862, Horta, Portugal Fisheries Centre, AERL Building, 2202 Main Mall, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada, t.morato@fisheries.ubc.ca

Publication info: Fish and Fisheries 7.1 (Mar 2006): 24-34.
ProQuest document link

Abstract (English): Global landings of demersal marine fishes are demonstrated to have shifted to deeper water species over the last 50 years. Our analysis suggests deep-water fish stocks may be at serious risk of depletion, as their life histories render them highly vulnerable to overfishing with little resilience to over-exploitation. Deep-sea fisheries are exploiting the last refuges for commercial fish species and should not

be seen as a replacement for declining resources in shallower waters. Instead, deep-water habitats are new candidates for conservation.

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23. Fisheries: Deep-sea fishes qualify as endangered

Author: Devine, Jennifer A; Baker, Krista D; Haedrich, Richard L

Publication info: Nature 439.7072 (Jan 5, 2006): 29-29.
ProQuest document link

Abstract (English): Criteria from the World Conservation Union (IUCN) have been used to classify marine fish species as endangered since 1996, but deep-sea fish have not so far been evaluated -- despite their vulnerability to aggressive deepwater fishing as a result of certain life-history traits. Here we use research-survey data to show that five species of deep-sea fish have declined over a 17-year period in the Canadian waters of the northwest Atlantic to such an extent that they meet the IUCN criteria for being critically endangered. Our results indicate that urgent action is needed for the sustainable management of deep-sea fisheries.

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24. Providing management advice for deep-sea fisheries: lessons learned from Australia's orange roughy fisheries

Author: Bax, N J1; Tilzey, R; Lyle, J; Wayte, SE; Kloser, R; Smith, ADM1 CSIRO Marine Research, PO Box 1538, Hobart, Tas. Australia

Publication info: FAO, Rome (Italy), Dec 2005.
ProQuest document link

Abstract: Recent statistics indicate that 18% of the world's fisheries are overexploited and a further 10% are significantly depleted. Deep-water fisheries are particularly prone to a boom and burst cycle. One of the core reasons for the failure to manage fish for sustainability is uncertainty. An examination is made of how scientific uncertainty and mistakes in judgement, combined with management and implementation shortcomings, led to the decline of the Australian orange roughy (Hoplostethus atlanticus) fisheries, in particular the Eastern Zone fishery. The exploitation of this fishery has been characterized by uncertainty in stock structure, standing stock and sustainable exploitation rates. For this fishery, uncertainty has been characterized almost uniformly by overly optimistic interpretations of the present and future states of the fishery.

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25. In Retrospect the Assumption of Sustainability for Atlantic Fisheries has Proved an Illusion

Author: Caddy, J F1; Surette, Tobie1 Marista University, Merida, Yucatan, Mexico, jfcaddy@yahoo.co.uk

Publication info: Reviews in Fish Biology and Fisheries 15.4 (Nov 2005): 313-337.
ProQuest document link

Abstract (English): Fishery landings data series from 1970 to 2002 for the Northeast (FAO Area 27) and Northwest Atlantic (Area 21) with 73 and 42 species or species groups respectively, were mapped onto single charts as a diagnostic of the overall state of fisheries in these two regions, and could be appreciated simultaneously for the entire exploited suite of species as a series of contiguous bar charts. Charts were

compared with that for a similar data set of 42 species or species groups from the Mediterranean and Black Seas (FAO Area 37). A 'traffic light convention' partitioned the range of landings by species over the period into four equal intervals; coloured respectively red, yellow, green and blue between zero and the highest annual landing of the species. This allowed a model-free display of changes in the timing of species' landings at the overall ecosystem level, as represented by the important commercial resources in the three areas. The year T sub(50) by which 50% of species landings had been harvested over the period, was considered a comparable measure of the response of individual species to exploitation. For a significant proportion of groundfish and pelagic fishes, the time to reach T sub(50) occurred early in the Atlantic time series. The hypothesis was tested that this measure of the depletion schedule is related to some aspect of species biology, as judged by data from the FISHBASE database. Except for commercial invertebrates where landings peaked late in the Northwest Atlantic time series, no significant regression was found between T sub(50) values per species and any biological characteristic of the species of finfish tested, suggesting that scheduling may reflect overcapacity and targeting by fisheries and/or regime changes. A decline in peak landings proceeded sequentially over time for the large proportion of all finfish species in the North Atlantic following a broadly similar trajectory. Possible exceptions were deeper water species where fisheries began later, suggesting that 'fishing down the bathymetry' has occurred. A more synchronous 'pulse' of high landings occurred in the Mediterranean and Black Seas in the mid-late 1980s, which was postulated as due to an increase in system productivity. Although regime changes and quota management cannot be excluded as partly responsible for the persistent low landings late in many time series, the main conclusion is that for all three areas, the effects of fishing overshadow those resulting from differing biological characteristics, habit, or species interactions. Although quota control may in part be responsible for low landings of some species late in the time series, the fishery management regimes that applied during 1970-2002 cannot be considered sustainable. This was confirmed by comparative analysis fitting a variety of models to the raw landing data. Of the mathematical models considered, the Hubbert curve, first used to predict the trajectory of extraction of non-renewable petroleum resources globally over time, best fitted the largest proportion of species time series. This seems to confirm that a hypothesis of harvest sustainability cannot be supported by the landing data.

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26. Genetic population structure in the black-spot sea bream (Pagellus bogaraveo Bruennich, 1768) from the NE Atlantic

Author: Stockley, B; Menezes, G; Pinho, M R; Rogers, AD11 Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, UK, ADR2@bas.ac.uk

Publication info: Marine Biology 146.4 (Mar 2005): 793-804.
ProQuest document link

Abstract (English): The depletion of shallow-water fish stocks through overexploitation has led to increasing fishing pressure on deep-sea species. Poor knowledge of the biology of commercially valuable deep-water fish has led to the serial depletion of stocks of several species across the world. Data regarding the genetic structure of deep-sea fish populations is important in determining the impact of overfishing on the overall genetic variability of species and can be used to estimate the likelihood of recolonisation of damaged populations through immigration of individuals from distant localities. Here the genetic structure of the commercially fished deep-water species the blackspot sea bream, Pagellus bogaraveo is investigated in the northeastern Atlantic using partial DNA sequencing of mitochondrial cytochrome b (cyt-b) and D-loop regions and genotyping of microsatellite loci. An absence of variation in cyt-b and low genetic variation in D-loop sequences potentially indicate that P. bogaraveo may have undergone a severe bottleneck in the past. Similar bottlenecks have been detected in other Atlantic species of fish and have possibly originated from the last glaciation. P. bogaraveo may

have been particularly vulnerable to the effects of low temperature and a fall in sea level because stages of its life history occur in shallow water and coastal sites. However, there are other explanations of low genetic variability in populations of P. bogaraveo, such as a low population size and the impacts of fishing on population structure. Analysis of population structure using both D-loop and microsatellite analysis indicates low to moderate, but significant, genetic differentiation between populations at a regional level. This study supports studies on other deep-sea fish species that indicate that hydrographic or topographic barriers prevent dispersal of adults and/or larvae between populations at regional and oceanographic scales. The implications for the management and conservation of deep-sea fish populations are discussed.

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27. Marine fish and fisheries

ProQuest document link

Abstract: Fishing has had the major impact on fish stocks over the past 50-100 years. In most regions, the level of fishing on demersal stocks remains too high and if maintained, will continue to lead to unsustainable fisheries in the long term. In key pelagic stocks, management action has been successful in reducing fishing mortality and these stocks have increased substantially over the past decade. Throughout the regions, valuable Nephrops stocks also continue to be exploited at sustainable levels. Once stocks become depleted, then other sources of mortality such as predation and environmental factors including climate change may become more important. In these situations, it may be necessary to reduce fishing mortality even more severely in order to ensure that stocks can rebuild to safe biological levels. TACs alone have not been successful in regulating fishing mortality rate on a number of stocks and management increasingly includes direct effort control (days at sea), technical measures and recovery plans. The UK has actively implemented decommissioning to reduce fishing effort, and legislated for the introduction of square mesh panels in Nephrops trawls. Over the past decade the stock status of some key demersal species has deteriorated. In contrast there have been significant improvements in the state of pelagic species such as herring. During the past 10 years the state of the stocks for most demersal roundfish and flatfish species in the North Sea (Regions 1 and 2) has deteriorated. Only three of the eight main commercial stocks are within safe biological limits. The cod stock remains at historically low levels and is subject to emergency management measures and a recovery plan from 2005. However, herring stocks have increased substantially and Nephrops are exploited sustainably. Over the past decade Irish Sea cod and whiting stock status has deteriorated, causing concern for stock collapse. The recovery plan for Irish Sea cod includes a lower TAC, a closed area, effort regulation and other technical measures. It was introduced in 2000 and is still in place. Most demersal stocks in the Southwest Approaches are harvested outside precautionary limits. The northern hake stock is the subject of a management recovery plan introduced in 2004 that includes a lower TAC and technical measures (mesh size restrictions). Haddock and Nephrops in the west of Scotland are harvested sustainably but the status of many of the other demersal species are either uncertain or considered to be at low historical levels. Cod in VIa is below the Precautionary Limit Reference point (Blim) and is subject to a recovery plan. Many factors can cause changes in the abundance and distribution of fishes, including natural variation, climate change, biological interactions and human activities. Activities that are known to affect the structure and diversity of fish communities include fishing, changes to habitat quality caused by, for example, pollution, eutrophication and habitat destruction, and the introduction of non-native species. Time-series datasets have provided some valuable insights into changes in the marine environment during the past century. Determining the relative impacts of these various factors is, however, difficult and whereas many studies have demonstrated a correlation between environmental variables and biological indices, there are few cases that prove causal relationships. Commercial exploitation of fish also has impacts on the wider marine environment. These impacts

include those on the abundance, size and genetic diversity of target species, on seabed habitats and non-target animals such as marine mammals fish and benthic fauna that are also caught during fishing operations, on the genetic diversity of both species and populations, and on the food web itself.Fishing affects non-target species caught as by-catch, and has caused reductions in large bodied and vulnerable species such as skates and rays.Monitoring programmes to determine the quantity and composition of discarded catches are in place in many UK fisheries. Many larger target and bycatch species in the North Sea and Irish Sea are now reduced to under 10% of their expected abundance without fishing, and the mean weight of fish has declined. Bycatches of common dolphins in thebass fishery and harbour porpoises in the North Sea gill net fisheries are a concern, and mortality rates are thought to exceed ASCOBANS advised limits. The distribution of fishing activity is patchy. Some areas are repeatedly trawled each year while others are impacted less than once in 7 years. Unfished areas with low levels of natural disturbance are more vulnerable to fishing than naturally dynamic areas that are trawled regularly. The natural biogeographic trend from the SW to NE of the British Isles, and the recent changes in climate, can lead to difficulties in identifying ecosystem changes caused by fishing. Life-history characteristics of some deep-sea fishes will make them susceptible to overexploitation.

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Corporate/institutional author: Centre for Environment, Fisheries and Aquaculture Science, Lowestoft (UK), Fisheries Research Services, Aberdeen (UK), Department of Agriculture and Rural Development Northern Ireland, Belfast (UK)

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28. The Rockall Trough, Northeast Atlantic: the cradle of deep-sea biological oceanography that is now being subjected to unsustainable fishing activity.

Author: Gordon, JDM11 Scottish Association for Marine Science, Dunstaffnagee Marine laboratory, Oban, PA37 1QA UK

Publication info: Sep 2003.

Abstract (English): The Rockall Trough or Channel is a clearly delimited deep-water area lying to the west of the British Isles. The eastern and western boundaries are formed by the continental margin and the Rockall Plateau, respectively. To the north it is separated from the colder Norwegian Sea by a ridge at about 500 m depth. To the south the depth steadily increases to abyssal depths. In the 1860s and 1870s some of the earliest descriptions of deep-water fishes were from this area. This review documents the late 19th century investigations

of the fish populations. The U.K. and Germany carried out deep-water exploratory fishing surveys in the 1970s and 1980s and detailed biological studies by the Scottish Association for marine science began in 1975. These, and other more recent studies, have added considerably to knowledge of biology and ecology of the deep-water fishes. General accounts are given of the key features of the target and non-target species and families. This paper revisits the documented concerns about the vulnerability of the fish stocks and their habitat and describes the transition from what is probably one of the best-studied deep-water ecosystems to an area that is being subjected to unsustainable exploitation of its fish populations.

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29. **Are deepwater fisheries sustainable? -- the example of orange roughy (Hoplostethus atlanticus) in New Zealand**

Author: Clark, M11 National Institute of Water and Atmospheric Research (NIWA), PO Box 14-901, Wellington 6003, New Zealand, m.clark@niwa.cri.nz

Publication info: Fisheries Research (Amsterdam) 51.2-3 (May 2001): 123-135.
ProQuest document link

Abstract (English): The deep-sea environment is generally regarded as being one of low energy and productivity. Species exploited at depths of over 600 m like orange roughy (Hoplostethus atlanticus), oreos (e.g. Allocyttus niger, Pseudocyttus maculatus), and macrourid rattails (e.g. Coryphaenoides rupestris, Macrourus berglax) have slow growth rates and high longevity compared to traditional commercial species from the continental shelf. They have low levels of sustainable yields, are vulnerable to overfishing, and have slow recovery rates. Yet, they are often high-value species, and this has maintained interest in developing new fisheries for deepwater species. In New Zealand waters orange roughy has been fished for 20 years. Familiar patterns of rapid fishery development with large catches, followed by contractions in stock distribution, and reductions in catch levels as the stocks become over-exploited, have occurred. Quotas in a number of New Zealand fisheries were reduced in the early 1990s, and this enables an insight into how stocks respond with reduced levels of exploitation, and how resilient and sustainable these fisheries may be in the long term. Examples are given for several New Zealand and Australian orange roughy fisheries. Changes in abundance, fishery performance, and biological characteristics are examined. In some cases fish stocks appear to be holding their own, and are supporting relatively stable catch rates, but in others stocks are still declining. There are few signs of biological compensation, and recruitment levels appear to be low. Lack of good data on levels and patterns of recruitment is a major source of uncertainty in current stock assessments, and a principal concern for long term sustainability of such fisheries.

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30. **Is the deep sea prawn fishery of Kerala sustainable?**

Author: Nandakumar, G1; Rajan, K N; Chellappan, K1 Central Marine Fisheries Research Institute, Cochin India

Publication info: Marine Fisheries Information Service technical and extension series 170 (Mar 2001): 5-9.
ProQuest document link

Abstract (English): The communication reports the result of a study on deep-sea prawn fishery in the second season (2000-01) of exploitation. The paper also discusses the future prospects of this important fishery along Kerala coast with possible management measures. The catch of all deep-sea prawn species declined in

2000-01 season indicating overexploitation of the deep-sea prawn stock in the second year of the fishery itself. There is urgent need to reduce the number of trawlers and to explore new fishing grounds.

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31. **Deep-sea seamount fisheries: Seeking the elusive goal of sustainability**

Author: Clark, M R11 National Institute of Water and Atmospheric Research, Private Bag 14-901, Wellington, New Zealand

Publication info: National Oceanography Center, Southampton, UK.
ProQuest document link

Abstract: Deepwater fisheries on the upper continental slope have become an important component of commercial fisheries in a number of countries, and continue to be of potential interest to nations whose coastal and shelf fisheries are fully or over-exploited, These fisheries include well-known species like orange roughy, cardinalfish, oreos, and grenadiers, and often take place on seamounts. Typically the catch histories of these show rapid development to a relatively high level, and then a dramatic decline. Associated with such apparent boom and bust type situations, have come concerns about the sustainability of seamount fisheries, and the deepwater benthic habitat. In this paper I will present recent information on a number of deepwater fisheries around the world, and then focus in on experience with orange roughy around New Zealand and Australia. Fisheries for orange roughy were substantial and valuable fisheries through the 1980s and 1990s, with annual catches often over 30,000 t, and over 70,000 t at its peak in 1991. Much of this catch came off seamount features, but these fisheries proved vulnerable. Many seamount stocks have shown rapid decline, and catch levels have been cut dramatically. These limits are now thought to be at sustainable levels, but recovery response is slow and time is required to see if this is really the case. A lot of lessons have been learnt the hard way about the biology and ecology of the fish, fisheries characteristics, information needs, stock assessment techniques, and management strategies. In addition to fisheries issues, the physical impact of bottom trawling on the benthic habitat has become of increasing concern in recent years. A number of seamounts have been closed to trawling around both Australia and New Zealand, and total protection is an increasing element of seamount management in many countries. The overall experience in New Zealand with orange roughy is one of mixed results, but a lot of fishery, research, and management lessons have been learnt, and with these being applied there is good reason to believe that deepwater fisheries on seamounts can prove resilient, and exploitation and conservation can co-exist.

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32. **Sustainable management of deep-water fisheries and their impact on marine biodiversity**

Author: Howell, K L1; Gordon, JDM; Jones, E; Duncan, JAR; Burrows, M T1 University of Plymouth, School of Biological Science, Drake Circus, Plymouth, PL4 8AA, UK

Publication info: National Oceanography Center, Southampton, UK.
ProQuest document link

Abstract: Deep-water species currently comprise approximately 3% of the global marine catch and it is estimated that 40% of the world's trawling grounds are now in waters deeper than the continental shelves. In the north-east Atlantic deep-sea fisheries have already had a devastating impact on the fish populations, such that,

in their 2004 report ICES recommended an immediate reduction in established deep-sea fisheries unless they can be shown to be sustainable. For some species like roundnose grenadier a 50% reduction in effort was specified. For deep-water sharks ICES recently recommended a zero catch, **stressing that fisheries taking deep-water sharks as bycatch must be reduced if means to avoid their bycatch cannot be found**. Deep-water fish stock decline is in part a result of poor management of the stock. Deep-sea species/stocks have been depleted before appropriate management measures have been implemented. Only in the last 2 years have total allowable catch limits (TACs) been introduced by the European Union for some deep-water species including black scabbardfish, blue ling, orange roughy, and roundnose grenadier. There are currently no such regulations regarding deep-water sharks. This project will use both historical and current data from deep-water trawl surveys in the Rockall Trough region to inform the development of an ecosystem based approach to management of the deep-water fisheries through the use of mass balanced trophic models (Ecopath with Ecosim). The impact of the removal of deep-water fish species on the deep-water ecosystem and the impact of changes in management regime (gear restrictions, closed areas) will be modelled. In addition, historical pre-fishing data on the fish populations of the continental slope will be compared with the most recent data to elucidate changes in the fish communities