

Marine Science Review - 212

Fish and fisheries

In this review:

- A. Recent articles – no abstract available
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A. Recent articles – no abstract available

Skewgar, E., Boersma, P.D., Harris, G., and Caille, G. **Anchovy fishery threat to Patagonian ecosystem.** *Science* 315(5808): 45, 2007.

Last, P.R. **The state of chondrichthyan taxonomy and systematics.** *Marine and Freshwater Research* 58(1): 7-9, 2007.

Zhang, J., Wei, F.W., Li, M., and Xu, M.Q. **Threatened fishes of the world: *Hemisanx prognathus* (Regan 1908) (Salangidae).** *Environmental Biology of Fishes* 78(3): 209-210, 2007.

Vecsei, P., Peterson, D., Suci, R., and Artyukhin, E. **Threatened fishes of the world, *Acipenser stellatus*, Pallas, 1771 (Acipenseridae).** *Environmental Biology of Fishes* 78(3): 211-212, 2007.

B. Recent publications available online

FAO. 2007. **The State of World Fisheries and Aquaculture 2006.** FAO, Rome. 162pp.

Available at: <ftp://ftp.fao.org/docrep/fao/009/a0699e/a0699e.pdf>

Notes: Key findings of the report include: 1. **The state of global stocks of marine fish:** • 52% of stocks are fully exploited, meaning they are at or near their maximum sustainable production levels; • 20% are moderately exploited; • 17% are overexploited; • 7% are depleted; • 3% are underexploited; • 1% is recovering from depletion. 2. **Captures of fish in the wild** have reached a record high of 95 million tonnes a year, with 85.8 million tonnes coming from marine fisheries and 9.2 million tonnes from inland fisheries. 3. Overall, **global fisheries production** (marine and inland capture fisheries plus fish farming) totals 141.6 million tonnes annually. Around 105.6 million tonnes of this (75%) is used for direct human consumption; the rest is used for non-food products, in particular the manufacture of fishmeal and oil. 4. **Aquaculture** remains the world's fastest growing food production sector, with 47.8 million tonnes of production each year. And with capture fisheries levelled off, fish farming is providing ever-greater amounts of fish for food. While in 1980 just 9 percent of the fish consumed by human beings came from aquaculture, today 43 percent does. 5. Fish and fishery products are widely traded. The **global trade in fish and fishery products** has also reached a record high, with an export value of US\$71.5 billion -- up 23 percent compared to 2000.

C. Recent articles with abstracts

Khan, A. **Sustainability challenges in the geoduck clam fishery of British Columbia: Policy perspectives.** *Coastal Management* 34(4): 443-453, 2006.

Notes: The geoduck clam fishery, worth approximately CDN \$40 million¹ in annual landed value, is British Columbia's most valuable invertebrate fishery. This fishery has been co-managed by the Department of Fisheries and Oceans (DFO) and the Underwater Harvesters Association (UHA) since 1989. Earlier input control measures such as effort regulation, seasonal closures, and licenses failed to work effectively for more than ten years, resulting in excess fishing capacity, overharvesting, poor economic returns, and unsafe fishing practices. Output control measures such as the individual vessel quota system (IVQ) have, to some extent, proven successful in improving revenues, controlling excess fishing capacity, gaining compliance with regulations, and involving fishers in the joint decision-making processes. However, there are public concerns about a common property resource at risk of being dominated by a few UHA license holders. Additionally, there are concerns about the job losses resulting from IVQ implementation, as well as distribution and equity issues. This article traces and examines the policy context for fisheries management in the British Columbia (BC) geoduck fishery, discusses the major concerns surrounding the exploitation of long lived Methuselah's clams and concludes with areas for further research in sustaining this lucrative fishery.

Gerlach, G., Atema, J., Kingsford, M.J., Black, K.P., and Miller-Sims, V. **Smelling home can prevent dispersal of reef fish larvae.** *Proceedings of the National Academy of Sciences [USA]* 104(3): 858-863, 2007.

Notes: Many marine fish and invertebrates show a dual life history where settled adults produce dispersing larvae. The planktonic nature of the early larval stages suggests a passive dispersal model where ocean currents would quickly cause panmixis over large spatial scales and prevent isolation of populations, a prerequisite for speciation. However, high biodiversity and species abundance in coral reefs contradict this panmixis hypothesis. Although ocean currents are a major force in larval dispersal, recent studies show far greater retention than predicted by advection models. We investigated the role of animal behavior in retention and homing of coral reef fish larvae resulting in two important discoveries: (i) Settling larvae are capable of olfactory discrimination and prefer the odor of their home reef, thereby demonstrating to us that nearby reefs smell different. (ii) Whereas one species showed panmixis as predicted from our advection model, another species showed significant genetic population substructure suggestive of strong homing. Thus, the smell of reefs could allow larvae to choose currents that return them to reefs in general and natal reefs in particular. As a consequence, reef populations can develop genetic differences that might lead to reproductive isolation.

Hoelzel, A.R., Shivji, M.S., Magnussen, J., and Francis, M.P. **Low worldwide genetic diversity in the basking shark (*Cetorhinus maximus*).** *Biology Letters* 2(4): 639-642, 2006.

Notes: The basking shark (*Cetorhinus maximus*) is found in temperate waters throughout the world's oceans, and has been subjected to extensive exploitation in some regions. However, little is known about its current abundance and genetic status. Here, we investigate the diversity of the mitochondrial DNA control region among samples from the western North Atlantic, eastern North Atlantic, Mediterranean Sea, Indian Ocean and western Pacific. We find just six haplotypes defined by five variable sites, a comparatively low genetic diversity of $p = 0.0013$ and no significant differentiation between ocean basins. We provide evidence for a bottleneck event within the Holocene, estimate an effective population size (N_e) that is low for a globally distributed species, and discuss the implications.

Lewin, W.C., Arlinghaus, R., and Mehner, T. **Documented and potential biological impacts of recreational fishing: Insights for management and conservation.** *Reviews in Fisheries Science* 14(4): 305-367, 2006.

Notes: While the impacts of high exploitation on fish populations and aquatic ecosystems are well-documented for commercial fishing, particularly in the marine environment, the potential biological impacts of angling received less attention. This paper discusses angling patterns within a framework of basic ecological and evolutionary literature and examines potential biological impacts of angling by focusing on study results associated with high exploitation rates and pronounced selective exploitation. The impacts range from impacts occurring directly on the exploited species (truncation of the natural age and size structure, compensatory mechanisms, loss of genetic variability, evolutionary changes), to those that occur on the aquatic ecosystem (changes in trophic cascades, trait-mediated effects). As a third category, impacts related to the angling activity per se are distinguished (habitat modifications, wildlife disturbance, nutrient inputs, loss of fishing gear). Although the main threats to fish often are localized outside recreational fisheries, there is growing evidence that angling and angling associated activities can lead to a decline of fish populations and affect aquatic ecosystems in various ways provided that the degree of the fishing mortality is high and the selective exploitation is intensive. In conclusion, management implications for sustainable recreational fisheries and areas for future research are outlined.

Stige, L.C., Ottersen, G., Brander, K., Chan, K.S., and Stenseth, N.C. **Cod and climate: effect of the North Atlantic Oscillation on recruitment in the North Atlantic.** *Marine Ecology Progress Series* 325: 227-241, 2006.

Notes: The impact of the environment on interannual variability in fish recruitment has proven difficult to establish empirically, and environment-recruitment correlations have often been found to break down when more data become available. This may suggest that the statistical models have failed to capture the essential explanatory variables, or that environment-recruitment relationships are non-stationary, and thus actually change. The present paper explores the effect of climate, measured by the North Atlantic Oscillation (NAO), on the recruitment of North Atlantic cod *Gadus morhua*. The literature on the topic is reviewed and compared with results from a new analysis, in which data from all 22 main stocks are combined in 1 overall model. Results of the new analysis demonstrate (i) a geographic pattern in the effect of the NAO on recruitment, which resembles the geographic pattern of the correlation between the NAO and sea surface temperature, and (h) trends in recruitment levels as well as in the effects of climate. These trends are not fully explainable through changes in spawning stock biomass. Summarizing the old and new insights, we arrive at the following general conclusions: NAO affects cod recruitment through local environmental variables such as sea temperature, salinity, oxygen, turbulence and advection. Cod recruitment is density-dependent, although the new analysis does not unequivocally support the existence of general patterns of density-dependent climate effects. There are trends in cod recruitment and in the relationship between climate and recruitment, possibly caused by demographic changes in the cod stocks (e.g. fishing-induced) and changes in the biotic or abiotic environment (regime shifts).

Sagarin, R.D., Ambrose, R.F., Becker, B.J., Engle, J.M., Kido, J., Lee, S.F., Miner, C.M., Murray, S.N., Raimondi, P.T., Richards, D., and Roe, C. **Ecological impacts on the limpet *Lottia gigantea* populations: human pressure over a broad scale on island and mainland intertidal zones.** *Marine Biology* 150(3): 399-413, 2007.

Notes: Here long-term monitoring data taken at 33 sites in southern and central California coast and islands were used to evaluate the size structure of the large intertidal limpet, *Lottia gigantea* in restricted-access and in easily accessible intertidal zones that encompass a wide range of ecological variables. Using multi-dimensional analysis of population size structures, we found that sites on islands and strictly protected mainland sites have significantly larger median limpet sizes and a greater range of limpet sizes than unprotected mainland sites, while no pattern occurs in latitudinal or regional comparison of sites. Although intertidal predators such as oystercatchers were not the primary focus of the monitoring efforts, extensive natural history notes taken during sampling visits support the argument that predation was not a primary cause for the size structure differences. Finally, substratum differences were determined not to have biased the observation of larger limpets in protected sites. In regard to human interactions with limpets, we conclude that the degree of enforcement against poaching is the better predictor of limpet size structure than proximity to population centers or visitation to intertidal sites.

Stunz, G.W. and Mckee, D.A. **Catch-and-release mortality of spotted seatrout in Texas.** *North American Journal of Fisheries Management* 26(4): 843-848, 2006.

Notes: Catch and release is becoming more common as a management tool in marine recreational fisheries. Clearly, a critical factor in determining different management scenarios that use this strategy is postcapture survival. We investigated the mortality associated with catch and release in the fishery for spotted seatrout *Cynoscion nebulosus* in south Texas. Specifically, this study investigated the mortality for hook-and-line-captured spotted seatrout as a function of bait type, hook type, angler skill level, and fish size. Using a variety of angling techniques, we captured 448 spotted seatrout ranging from 250 to 760 mm total length (TL) and assessed mortality in replicate field enclosures. The overall short-term mortality for all treatments was relatively low (11%); the majority of fish survived. The exception was angler skill level. Angling by novices produced a significantly higher mortality rate than angling by skilled anglers; however, mortality averaged only 18% even for inexperienced anglers. To evaluate long-term mortality, we monitored 27 spotted seatrout held in a laboratory facility for 30 d; the fish showed no signs of long-term mortality. We observed 11% mortality during the first 48 h and no mortality during the subsequent 28 d. In an attempt to increase the abundance of "trophy" (> 635 mm TL) spotted seatrout, Texas has adopted new slot limit regulations that allow only one trophy-size fish to be kept per person per day. We targeted larger (635-736 mm TL) fish to assess the mortality associated with this size-group. Regression analysis showed no size-related mortality. The location of hook-related injuries may be the most important factor in determining catch-and-release mortality. Anatomical hooking location was not a factor in the analyses but was treated as a component of experimental treatment level; however, we observed that mortality was typically associated with hooking location rather than angling method or bait type. These data suggest that management options involving the release of spotted seatrout, including those larger than 635 mm TL, are viable tools.

Parsons, D.M. and Eggleston, D.B. **Potential population and economic consequences of sublethal injuries in the spiny lobster fishery of the Florida Keys.** *Marine and Freshwater Research* 58(2): 166-177, 2007.

Notes: Animals that interact with but are not retained by fishing gears may later die. The population and economic consequences of these sublethal fishery interactions are seldom known but may be significant. In the present study, a population model was used to quantify potential population and economic consequences of injuries that Caribbean spiny lobsters (*Panulirus argus*) sustain from fishing activities in the Florida Keys, USA. Injuries generated by the fishery are known to reduce growth and elevate mortality. Simulation modelling results indicated that injuries may reduce adult lobster abundance and associated landings by $\geq 50\%$ in areas with high recreational fishing effort. When simulated injuries were ~ 20 times lower (representing areas with lower fishing effort), these injuries were only responsible for a 5 and 8% reduction in the adult lobster population and commercial landings respectively. Important parameters within the model (growth, time in stage and mortality of injured lobsters) were altered by $\pm 10\%$ to assess model sensitivity. Final results changed $< 10\%$ (with the exception of one 15% change), suggesting that model output was relatively insensitive to variation in key parameters. When the impact of sublethal injuries was applied to the entire spiny lobster fishery in the Florida Keys, adult stock biomass and annual commercial landings were reduced by 900 and 160 t (US\$ 1.6 million) respectively. These results suggest that sublethal fishery interactions can lead to high population and economic losses, and highlight the need to incorporate sublethal injuries into stock assessments and economic models.

Hannah, R.W. and Matteson, K.M. **Behavior of nine species of Pacific rockfish after hook-and-line capture, recompression, and release.** *Transactions of the American Fisheries Society* 136(1): 24-33, 2007.

Notes: We evaluated the effect of barotrauma on the behavior of nine species of Pacific rockfish *Sebastes* spp. after hook-and-line capture and release using a video-equipped underwater release cage. Sampling was conducted across a range of bottom depths (12-194 m), mostly where barotrauma resulting from an expanded swim bladder and gaseous release of dissolved blood gases would be expected. Behavioral impairment from barotrauma was depth related but highly species specific. Increased depth of capture was associated with lower behavioral scores for black rockfish *S. melanops*, blue rockfish *S. mystinus*, and yelloweye rockfish *S. ruberrimus*, but not for canary rockfish *S. pinniger*. Behaviorally impaired fish showed a decreased ability to maintain vertical orientation and were slower in exiting the release cage. Species differed in the degree of behavioral impairment resulting from barotrauma and in how rapidly behavioral impairment increased with depth of capture. When captured at depths between 40 and 99 m, blue rockfish showed the most serious behavioral impairment, 8 of 18 (44%) failing to swim away at the time of release and simply drifting off in a sideways or upside-down posture. In the same depth range all of the other species sampled showed only moderate behavioral impairment, which is indicative of some potential for survival after discard by the fishery. Surface observations of the external signs of barotrauma were variable among species and were poor indicators of which species would show behavioral impairment upon release at depth. Within individual species,

however, the external signs of barotrauma were associated with an increased probability of behavioral impairment at time of release.

Trzcinski, M.K., Mohn, R., and Bowen, W.D. **Continued decline of an Atlantic cod population: How important is gray seal predation?** *Ecological Applications* 16(6): 2276-2292, 2006.

Notes: The continental shelf ecosystem on the Eastern Scotian Shelf (ESS) has experienced drastic changes. Once common top predators are a small fraction of their historical abundance, and much of the current community structure is now dominated by pelagic fishes and invertebrates. Embedded within this food web, Atlantic cod and gray seal populations have recently exhibited nearly opposite trends. Since 1984, cod populations have decreased exponentially at a rate averaging 17% per year, whereas gray seals have continued to increase exponentially at a rate of 12%. We reexamined the impact of gray seals on Atlantic cod dynamics using more than 30 years of data on the population trends of cod and gray seals while incorporating new information on seal diet and seasonal distribution. The closure of the cod fishery over 10 years ago allowed for a better estimation of natural mortality rates. We quantified the impact of seals on ESS cod by (1) estimating trends in seal and cod abundance, (2) estimating the total energy needed for seal growth and maintenance from an energetics model, (3) using estimates of the percentage of cod in the total diet derived from quantitative fatty acid signature analysis (QFASA) and of the size-specific selectivity of cod consumed (derived from otoliths collected from fecal samples), and (4) assuming a gray seal functional response. Uncertainties of the model estimates were calculated using the Hessian approximation of the variance-covariance matrix. Between 1993 and 2000, cod comprised, on average, < 5% of a gray seal's diet. Our model shows that, since the closure of the fishery, gray seals have imposed a significant level of instantaneous mortality (0.21), and along with other unknown sources of natural mortality (0.62), are contributing to the failure of this cod stock to recover.

Hare, J.A. and Able, K.W. **Mechanistic links between climate and fisheries along the east coast of the United States: explaining population outbursts of Atlantic croaker (*Micropogonias undulatus*).** *Fisheries Oceanography* 16(1): 31-45, 2007.

Notes: Climate has been linked to variation in marine fish abundance and distribution, but often the mechanistic processes are unknown. Atlantic croaker (*Micropogonias undulatus*) is a common species in estuarine and coastal areas of the mid-Atlantic and southeast coasts of the U.S. Previous studies have identified a correlation between Atlantic croaker abundance and winter temperatures in Chesapeake Bay, and have determined thermal tolerances of juveniles. Here we re-examine the hypothesis that winter temperature variability controls Atlantic croaker population dynamics. Abundance indices were analyzed at four life history stages from three regions along the east coast of the U.S. Correlations suggest that year-class strength is decoupled from larval supply and is determined by temperature-linked, overwinter survival of juveniles. Using a relation between air and water temperatures, estuarine water temperature was estimated from 1930 to 2002. Periods of high adult catch corresponded with warm winter water temperatures. Prior studies indicate that winter temperature along the east coast is related to the North Atlantic Oscillation (NAO); variability in catch is also correlated with the NAO, thereby demonstrating a link between Atlantic croaker dynamics, thermal limited overwinter survival, and the larger climate system of the North Atlantic. We hypothesize that the environment drives the large-scale variability in Atlantic croaker abundance and distribution, but fishing and habitat loss decrease the resiliency of the population to periods of poor environmental conditions and subsequent weak year classes.

Neville, H., Isaak, D., Thurow, R., Dunham, J., and Rieman, B. **Microsatellite variation reveals weak genetic structure and retention of genetic variability in threatened Chinook salmon (*Oncorhynchus tshawytscha*) within a Snake River watershed.** *Conservation Genetics* 8(1): 133-147, 2007.

Notes: Pacific salmon (*Oncorhynchus* spp.) have been central to the development of management concepts associated with evolutionarily significant units (ESUs), yet there are still relatively few studies of genetic diversity within threatened and endangered ESUs for salmon or other species. We analyzed genetic variation at 10 microsatellite loci to evaluate spatial population structure and genetic variability in indigenous Chinook salmon (*Oncorhynchus tshawytscha*) across a large wilderness basin within a Snake River ESU. Despite dramatic 20th century declines in abundance, these populations retained robust levels of genetic variability. No significant genetic bottlenecks were found, although the bottleneck metric (M ratio) was significantly

correlated with average population size and variability. Weak but significant genetic structure existed among tributaries despite evidence of high levels of gene flow, with the strongest genetic differentiation mirroring the physical segregation of fish from two sub-basins. Despite the more recent colonization of one sub-basin and differences between sub-basins in the natural level of fragmentation, gene diversity and genetic differentiation were similar between sub-basins. Various factors, such as the (unknown) genetic contribution of precocial males, genetic compensation, lack of hatchery influence, and high levels of current gene flow may have contributed to the persistence of genetic variability in this system in spite of historical declines. This unique study of indigenous Chinook salmon underscores the importance of maintaining natural populations in interconnected and complex habitats to minimize losses of genetic diversity within ESUs.

Jackson, J.B.C. **Economic incentives, social norms, and the crisis of fisheries.** *Environmental Research* 22(1): 16-18, 2007.

Notes: This year's Kyoto prize signals the long overdue recognition of the fundamental interdependence of economic and ecologic systems for the protection and maintenance of ecosystem services and human well-being. Levin (2006) and Vincent (2007) point to several of the more important ways that interdisciplinary approaches will be essential to the better quantification and understanding of the economic contributions of ecosystem services, but they differ fundamentally in their relative faith in the evolution of new social norms versus economic incentives backed up by sanctions to achieve the necessary cooperation for environmental protection. In the case of marine fisheries, social norms have proven highly effective on small spatial scales but have not taken root in the face of increasingly global markets and free trade.

Molloy, P.P., Goodwin, N.B., Cote, I.M., Gage, M.J.G., and Reynolds, J.D. **Predicting the effects of exploitation on male-first sex-changing fish.** *Animal Conservation* 10(1): 30-38, 2007.

Notes: Sex change is widespread among tropical marine fishes, many of which are targeted by fisheries. Conservation concerns have been raised that sex-changing species may be particularly prone to overexploitation by size-selective fishing. In the case of male-first sex-changers, populations may become egg limited if large females are disproportionately killed. However, if males reduce the size at which they change sex in response to higher female mortality, the population may still be sufficiently productive. We develop an age-based model to explore the effects of fishing on two types of male-first sex-changing fish: one with flexibility in size-at-sex-change and one without. These effects were compared with those of non-sex-changing populations with similar life-history and population characteristics. The model predicts that if male-first sex-changers cannot respond to elevated female mortality by adjusting their size-at-sex-change, the population will be more prone to recruitment limitation and extinction than non-sex-changers. These effects will be amplified as smaller individuals become susceptible to fishing mortality. However, if size-at-sex-change is flexible, sex-changers may be as resilient to fishing as non-sex-changers. Knowledge of a species' size-at-sex-change, and the mechanisms controlling it, should be fundamental to the selection of fisheries conservation strategies.

McDowall, R.M. **On amphidromy, a distinct form of diadromy in aquatic organisms.** *Fish and Fisheries* 8(1): 1-13, 2007.

Notes: Amphidromy is a distinctive form of diadromy that involves some fish, decapod crustaceans and gastropod molluscs. Characteristic elements in amphidromy are: reproduction in fresh water, passage to sea by newly hatched larvae, a period of feeding and growing at sea usually a few months long, return to fresh water of well-grown juveniles, a further period of feeding and growing in fresh water, followed by reproduction there. This life-history strategy is observed in numerous fish species, primarily in islands of the tropics and subtropics (probably more than 75 species, especially sicydiine gobies), and extends to temperate countries as far as Japan in the north and New Zealand in the south. There has been considerable confusion about the nature of amphidromy and its distinctiveness from anadromy, another category of diadromy. The return to freshwater of small juveniles of amphidromous fishes is functionally and strategically different from the return of large mature adults, as happens in anadromy. The strategy is recognized as distinctive by numerous fish biologists who work with amphidromous fishes, although it has tended to be rejected or ignored by others, typically those who have no personal experience with them.

Jaensson, A., Scott, A.P., Moore, A., Kylin, H., and Olsen, K.H. **Effects of a pyrethroid pesticide on endocrine responses to female odours and reproductive behaviour in male parr of brown trout (*Salmo trutta* L.).** *Aquatic Toxicology* 81(1): 1-9, 2007.

Notes: Reproductive behaviour of brown trout (*Salmo trutta* L.) from an anadromous stock was studied in a large stream water aquarium. Four adult males and two ovulated females were placed in the aquarium together with eight mature male parr. Four of the parr were exposed during the previous 4 days to two concentrations (0.1 or 1.0 $\mu\text{g l}^{-1}$) of the pyrethroid pesticide cypermethrin (a disrupter of olfactory receptor function) and four of the parr to the solvent ethanol. The behaviour of all fish was followed for 24 h and then blood and milt was collected. Exposure to the higher concentration of cypermethrin disturbed the reproductive behaviour of the parr. They displayed fewer courting events, spent less time near the nesting females and had lower volumes of strippable milt. They also had significantly lower amounts of 11-ketotestosterone (11-KT) in the blood plasma than the control group. The higher cypermethrin group also had significantly lower levels of all these variables than the 9 lower cypermethrin group, apart from strippable milt that showed no significant differences between two groups. No significant differences in non-reproductive behaviours were observed between any of the groups. In the control fish, there were significant positive correlations between (a) the number of courting events and the amount of time spent near the female, (b) blood plasma levels of $17\alpha,20\beta$ -dihydroxy-4-pregnen-3-one ($17,20\beta$ -P) and time spent near the female and (c) plasma levels of $17,20\beta$ -P and the number of courting events. Further, in control fish, higher plasma levels of $17,20\beta$ -P were observed in parr-interacting with a female compared to those with no female contacts. A priming experiment confirmed a previous study that cypermethrin damages olfactory reception. Parr exposed to cypermethrin had significantly lower blood plasma levels of $17,20\beta$ -P and 11-KT than control males after exposure to ovarian fluid and urine (known to contain reproductive priming pheromones). When ethanol-exposed males were exposed to ovarian fluid and urine they had significantly higher plasma levels of $17,20\beta$ -P compared to those exposed to water only.

Madrid-Vera, J., Amezcua, F., and Morales-Bojorquez, E. **An assessment approach to estimate biomass of fish communities from bycatch data in a tropical shrimp-trawl fishery.** *Fisheries Research* 83(1): 81-89, 2007.

Notes: The biomass of the finfish as bycatch of the shrimp-trawl fishery in the southeastern Gulf of California was estimated by use of a heuristic approach for fish biomass, by the use of the central-tendency hypotheses on the proportion of fish landed, the proportion of fish in the bycatch estimated in our work, and from data available from previous studies on bycatch for the area. Data from 1950 experimental trawls made at depths of 8-76 m from 1992 to 2004 during the closed shrimp season were analyzed. The central tendencies were calculated using three methods: the arithmetic mean and the estimators of both Pennington and Kappenman. A total of 250 species were caught during these surveys. From these, 17 species are 50% of the total biomass of the species caught from shallow waters to 76 m. The most abundant species were the grunt *Orthopristis chalceus*, the pacific moon fish *Selene peruviana*, the lizardfish *Synodus scituliceps* and the panamanian grunt *Pomadasyd panamensis*. From our results we noted that the Kappenman estimator is more precise than the other two estimators, therefore, for the period 1993-2004 the available biomass of the total fish community was $(90 \pm 45) \times 10^3$ tonnes, the mean proportion shrimp:bycatch ranged from 6 to 31 kg and the mean value of the fish bycatch landed was 1.44 ± 0.54 kg/kg of shrimp.

Therkildsen, N.O. **Small- versus large-scale fishing operations in New England, USA.** *Fisheries Research* 83(2-3): 285-296, 2007.

Notes: Most fishing fleets are composed of a diverse range of vessel types and sizes. The different types of fishing operations may vary significantly in their ability to meet policy goals and hence, in order to plan for optimal resource use, we need to know more about the overall performance of the different sectors in a fishing fleet. This paper compares small and large-scale fishing operations in New England, USA, in terms of a number of socioeconomic and environmental parameters, including employment, total landings, number of individual fishing units, fuel consumption, discard rates, and the amount of catch used for direct human consumption. The analysis is based on an extensive data set obtained from several databases hosted by the National Marine Fisheries Service, USA, and the fishing fleet was divided into small and large-scale according to a set of criteria based on vessel size, gear type, and value of catch. The results suggest that in New England, the small-scale fishing sector employs more people per landed tonne, uses more vessels, and achieves a higher value per landed tonne than their large-scale counterpart. In addition, a much greater proportion of the small-scale sector's catch is used for direct human consumption. Data on by-catch and fuel use are inconclusive as they are based on observer data, which are not representative of the entire fishery and especially under-reports for the small-scale fishing operations. However, it appears that small-scale

fisheries may have a lower rate of by-catch, but that large-scale fisheries - at least for the majority of gear types - use less fuel per landed tonne than the small-scale operations. Similar results have been found in analogous comparisons fishing fleets in other countries. The evidence therefore suggests that while large-scale fisheries may perform better in terms of fuel efficiency and other variables, the small-scale fisheries may be better positioned to meet several policy objectives such as creating employment, maximizing the revenue for each tonne of fish removed from the ocean, maximizing the amount of catch that is used for direct human consumption, and perhaps minimizing by-catch.

Conover, D.O., Clarke, L.M., Munch, S.B., and Wagner, G.N. **Spatial and temporal scales of adaptive divergence in marine fishes and the implications for conservation.** *Journal of Fish Biology* 69(Supplement C): 21-47, 2006.

Notes: Knowledge of geographic and temporal scales of adaptive genetic variation is crucial to species conservation, yet understanding of these phenomena, particularly in marine systems, is scant. Until recently, the belief has been that because most marine species have highly dispersive or mobile life stages, local adaptation could only occur on broad geographic scales. This view is supported by comparatively low levels of genetic variation among populations as detected by neutral markers. Similarly, the time scale of adaptive divergence has also been assumed to be very long, requiring thousands of generations. Recent studies of a variety of species have challenged these beliefs. First, there is strong evidence of geographically structured local adaptation in physiological and morphological traits. Second, the proportion of quantitative trait variation at the among-population level ($Q(ST)$) is much higher than it is for neutral markers ($F-ST$) and these two metrics of genetic variation are poorly correlated. Third, evidence that selection is a potent evolutionary force capable of sustaining adaptive divergence on contemporary time scales is summarized. The differing spatial and temporal scales of adaptive *v.* neutral genetic divergence call for a new paradigm in thinking about the relationship between phenogeography (the geography of phenotypic variation) and phylogeography (the geography of lineages) in marine species. The idea that contemporary selective processes can cause finescale spatial and temporal divergence underscores the need for a new emphasis on Darwinian fishery science.

King, H.R., Pankhurst, N.W., and Watts, M. **Reproductive sensitivity to elevated water temperatures in female Atlantic salmon is heightened at certain stages of vitellogenesis.** *Journal of Fish Biology* 70(1): 190-205, 2007.

Notes: In order to compare the effects on reproductive performance of short-term or prolonged exposure to elevated temperatures during vitellogenesis, female Atlantic salmon *Salmo salar* were held at a water temperature of 22°C for periods of 4 or 6 weeks during the austral summer and autumn. Plasma levels of 17 β -oestradiol (E_2), testosterone (T) and vitellogenin (Vtg) were monitored and reproductive success was compared to that in groups of fish maintained at 14 or 22°C for 12 weeks from mid-January. Significant endocrine effects were observed within as few as 3 days of the commencement of exposure to 22°C when plasma levels of E_2 (*c.* 0.5 ng ml⁻¹) and Vtg (*c.* 1.4 mg ml⁻¹) were approximately half those observed in fish maintained at 14°C (*c.* 1.0 ng ml⁻¹ and 2.7 mg ml⁻¹ respectively). The fertility and survival to the eyed stage of ova from fish held at 14°C exceeded 85 and 70% respectively, whereas ova from fish held at 22°C for 6 or 12 weeks exhibited significantly reduced fertility (< 70 and < 45% respectively) and survival (*c.* 40 and 13% respectively). In spite of significant endocrine effects at all stages, a 4 week exposure to 22°C only generated significant reductions in egg fertility (< 65%) and survival (*c.* 30%) when it occurred between mid-February and mid-March. Together, these data confirm that high temperature spikes can affect reproductive success as strongly as more prolonged exposures, and indicate that there is a critical period of reproductive sensitivity to elevated temperature in late February and early March in this stock of Atlantic salmon.

Collette, B.B., McDowell, J.R., and Graves, J.E. **Phylogeny of recent billfishes (Xiphiidae).** *Bulletin of Marine Science* 79(3): 455-468, 2006.

Notes: Billfishes are genetically and morphologically distinct enough from scombroids to merit placement in a separate suborder, Xiphiidae. Two extant families are usually recognized: Xiphiidae (swordfish, Xiphias) and Istiophoridae, currently containing three genera, *Istiophorus* (sailfishes), *Makaira* (marlins), and *Tetrapturus* (spearfishes, white, and striped marlins). Phylogenetic analyses of molecular data from mitochondrial and nuclear gene sequences (mitochondrial control region, ND2, 12S, and nuclear MN 32 regions) show a different picture of relationships. *Makaira* is not monophyletic: blue marlin cluster with sailfish and placement of black marlin is unstable. Accepting the molecular phylogeny gives two possible classifications: (1) two genera: blue marlin + sailfish (as *Istiophorus*) and all the rest (as *Tetrapturus*), or (2) five genera: blue marlin (*Makaira*),

sailfish (*Istiophorus*), black marlin (*Istiompax*), striped and white marlin (*Kajikia*), and four spearfishes (*Tetrapturus*). We prefer the latter possibility. There is no genetic evidence to support recognition of separate species of Atlantic and Indo-Pacific sailfishes or blue marlins. Atlantic white marlin, *Kajikia albida* (Poey, 1860) is closely related to Indo-Pacific striped marlin, *Kajikia audax* (Philippi, 1887). The four spearfishes are closely related: the three Atlantic species, longbill (*Tetrapturus pfluegeri* Robins and de Sylva, 1963), Mediterranean (*Tetrapturus belone* Rafinesque, 1810), and roundscale (*Tetrapturus georgii* Lowe, 1841), and the one Indo-Pacific species, shortbill (*Tetrapturus angustirostris* Tanaka, 1915). The roundscale is the most divergent of the spearfishes. A fifth putative *Tetrapturus* sp., the "hatchet marlin" clusters with roundscale Spearfish but these two "species" could not be differentiated in this analysis.

Shivji, M.S., Magnussen, J.E., Beerkircher, L.R., Hinteregger, G., Lee, D.W., Serafy, J.E., and Prince, E.D. **Validity, identification, and distribution of the roundscale spearfish, *Tetrapturus georgii* (Teleostei: Istiophoridae): Morphological and molecular evidence.** *Bulletin of Marine Science* 79: 483-491, 2006.

Notes: The roundscale spearfish, *Tetrapturus georgii* Lowe, 1840, is known only from four specimens from the Mediterranean and eastern North Atlantic. Additional specimens have not been identified since 1961, making the validity and distribution of this species unclear. Analysis of 16 billfish specimens from the western North Atlantic on the basis of scale morphology, anus position, and mitochondrial DNA confirms the validity of this species and extends its distribution. Mid-lateral scales are soft, notably rounded anteriorly, and bear 2-3 points distinct from those of the sympatric longbill spearfish (*Tetrapturus pfluegeri* Robins and de Sylva, 1963) and white marlin (*Tetrapturus albidus* Poey, 1860). Position of anus relative to first anal fin and a related morphometric ratio (distance from anus to first anal fin origin: height of first anal fin) are intermediate between *T. pfluegeri* and *T. albidus*. These characteristics match those described by Robins (1974) from the four eastern North Atlantic specimens of *T. georgii*. The mitochondrial ND4L, ND4, and cyt *b* gene sequences strongly support reciprocal monophyly of the western North Atlantic specimens relative to other Atlantic istiophorids. The difficulty in distinguishing between morphologically similar *T. georgii* and *T. albidus* in the field and the previously unrecognized presence of *T. georgii* in the western North Atlantic has implications for stock assessments of *T. albidus*, a species that is severely overfished.

Bremer, J.R.A., Hinton, M.G., and Greig, H.W. **Evidence of spatial genetic heterogeneity in Pacific swordfish (*Xiphias gladius*) revealed by the analysis of ldh-A sequences.** *Bulletin of Marine Science* 79(3): 493-503, 2006.

Notes: DNA sequence polymorphisms contained in intron 6 of the lactate dehydrogenase-A (*ldh-A*) gene were used to examine the genetic population structure of Pacific swordfish (*Xiphias gladius* Linnaeus, 1758). Seven alleles defined by five polymorphic sites were identified among 305 swordfish. Comparisons of allele frequency were conducted for 11 samples, including Chile (multiple years), Ecuador (multiple years), Mexico, Hawaii (multiple years), eastern Australia, and western Australia. Although there was evidence of genic differentiation, global differentiation was low ($F_{st} = 0.001$). To increase the power of the tests of differentiation, samples within each region were pooled into four regional samples. No deviations from Hardy-Weinberg equilibrium were observed, and the global fixation index increased more than tenfold ($F_{st} = 0.013$). Global exact tests of genic and genotypic differentiation were significant, and so were the pair-wise comparisons between the south-eastern Pacific Ocean (SEPO) sample from Chile, and all other regions. In addition, the north-eastern Pacific Ocean (NEPO; Ecuador to Mexico) was different from the north-central Pacific Ocean (NCPO; Hawaii), which in turn was different from the south-western Pacific Ocean (SWPO; pooled eastern and western Australia). These results may have important implications for the fishery management of Pacific swordfish, particularly because of the heterogeneity observed between SEPO and NEPO.

Die, D.J. **Are Atlantic marlins overfished or endangered? Some reasons why we may not be able to tell.** *Bulletin of Marine Science* 79(3): 529-543, 2006.

Notes: Increasingly marine fish are being listed as endangered or threatened. Atlantic marlin stocks have been assessed to be overfished and suffer overfishing, yet the precise level of depletion and severity of overfishing is unknown. Much of this uncertainty stems from the underreporting of catch, the difficulty in interpreting abundance indices based on fishery data, and a lack of understanding of the spatial processes that determine the interactions between marlin populations and fishing gear. Annual indices of abundance are poorly correlated, failing to show an unequivocal trend, but seasonal indices are strongly

correlated at many of the locations investigated. This questions our ability to assess past changes in population size, estimate current biomass, and detect future changes in abundance. In response to concerns on stock status, international management has agreed on substantial reductions in harvest to recover stocks. The impacts of such actions is unlikely to be felt or be detectable for years, thus management must proceed in a precautionary manner.

Webster, D.G. **The marlin conundrums: Turning the tide for by-catch species.** *Bulletin of Marine Science* 79(3): 561-575, 2006.

Notes: The political economy of by-catch management is outlined with particular reference to the regulation of *Makaira nigricans* Lacepede, 1802 and *Tetrapturus albidus* Poey, 1860 in the Atlantic. As has happened in the US, national policy preferences can become more conservation-oriented as a result of lobbying by focused noncommercial interests, but these groups are most effective when bolstered by broad domestic institutions. Achieving legislation domestically prior to its introduction at the international level is important, because it gives national commercial fishing interests incentives to ensure that their competition from abroad is similarly regulated. Nevertheless, billfish management requires cooperation among decision-makers from many fishing countries, most of whom formulate policy under much different circumstances. Technological solutions that reduce the costs of avoiding by-catch are still the best option for sustainable billfish management.

Kitchell, J.F., Martell, S.J.D., Walters, C.J., Jensen, O.P., Kaplan, I.C., Watters, J., Essington, T. E., and Boggs, C.H. **Billfishes in an ecosystem context.** *Bulletin of Marine Science* 79(3): 669-682, 2006.

Notes: There is a rising tenor of calls for ecosystem-based approaches to fisheries management. Many billfishes are apex predators in pelagic food webs and, therefore, of potential ecological significance as keystone predators. Most billfishes are vulnerable to exploitation effects, especially those taken as by-catch where longline fishing occurs. We developed a series of ecosystem models that serve as tools for evaluating the role of billfishes and their fisheries across a range of scales. One of those models addressed ecological questions about responses to large marine protected areas. Another developed ecological and economic forecasts of billfish responses to reduced by-catch through specific changes in longline gear. A third posits the outcome of mandatory use of circle hooks by longline fisheries as a means for reducing sea turtle mortality. Changing to circle hooks in commercial fisheries has profound effects on catch rates for many fishes and, therefore, evokes substantial changes in food web dynamics. Enhanced catch-release practices for billfishes produce an ameliorative response that reduces mortality rates and furthers the economic benefits of recreational fisheries.

Hyde, J.R., Humphreys, R., Musyl, M., Lynn, E., and Vetter, R. **A central North Pacific spawning ground for striped marlin, *Tetrapturus audax*.** *Bulletin of Marine Science* 79(3): 683-690, 2006.

Notes: Istiophorid billfishes are notoriously difficult to identify to species, especially early life history stages. Traditional use of morphology and pigment based characters for species separation of larvae can fail when faced with moderate levels of intra-specific phenotypic plasticity. Unfortunately, as the early life history of marine fishes can play an important role in reproductive success and management strategies, we are potentially missing or confounding valuable data by misidentifying specimens. We recently presented a DNA based method of identification for near real-time processing of ichthyoplankton samples. Using this method we have unambiguously identified seven striped marlin larvae from Hawaiian waters. Additional analysis of DNA sequence data shows that these larvae all have unique mitochondrial haplotypes indicating they each had different mothers and were not the result of a single chance event. This represents the first detection of spawning activity in an area that historically has been regarded as only nursery habitat for this species. This finding has important ramifications for fishery management as striped marlin represent a significant portion of the billfish catch in the Hawaii-based longline fishery.

Luckhurst, B.E., Prince, E.D., Llopiz, J.K., Snodgrass, D., and Brothers, E.B. **Evidence of blue marlin (*Makaira nigricans*) spawning in Bermuda waters and elevated mercury levels in large specimens.** *Bulletin of Marine Science* 79(3): 691-704, 2006.

Notes: The gonads of 11 adult female blue marlin (*Makaira nigricans* Lacepede, 1803) caught mostly in July in Bermuda waters (2002-2005), and ranging in weight from 242-465 kg, were evaluated histologically for reproductive status. The gonadosomatic index (GSI) of these specimens ranged from 0.70%-6.22%; specimens with a GSI ≥ 3 were reproductively active. Based on gonad histology, 70% of the females caught in July were actively spawning or in spawning condition, with post-ovulatory follicles (POFs) or in final stages of oocyte maturation. These observations confirm that active spawning occurs in Bermuda waters in July and significantly extends the known northern spawning range of blue marlin in the western Atlantic Ocean. In addition, our largest specimen (465 kg) examined histologically was in spawning condition. This appears to be the first reproductively active specimen of this size ever reported. For the first time, a juvenile blue marlin (256 mm lower jaw fork length) was collected at Bermuda's northerly latitude (32°N). The estimated age of this specimen (42 d), obtained by counting daily growth increments on the sagitta, produced an estimated birth date in mid-July. White muscle tissue samples from 13 blue marlin (50-545 kg) specimens from the western North Atlantic (four from Bermuda), were analyzed for total mercury (THg) and had values from 1.77-12.7 ppm. These values are amongst the highest THg concentrations reported in any teleost. The high reproductive potential of the largest females, as well as their questionable food value due to THg contamination, suggests that consideration be given to reducing fishing mortality.
