JUVENATION

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As a fish stock is fished down from virgin levels, there will be a trend for the average age, length, and weight of fish in the catch to drop. This trend is an inevitable consequence of the additional mortality caused by fishing. The trend is called juvenation or juvenescence.

The concept of juvenation can best be explained graphically. When harvest begins from a virgin, or previously unfished, fish stock, the catch typically contains a relatively high proportion of older, larger individuals that have accumulated or stockpiled over time. For example, when midwater trawlers began targeting widow rockfish during the early 1980's, the age (and size and weight as well) composition of the catch looked like the curve shown in Figure 1.

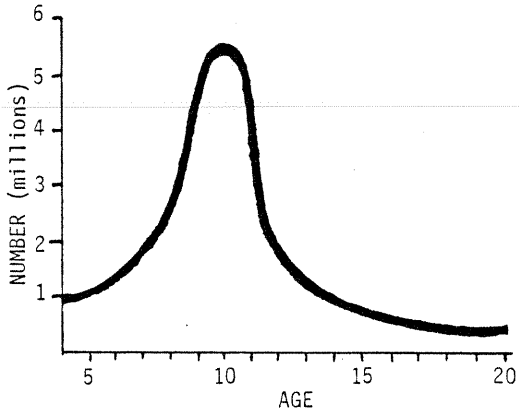

Figure 1

(Lenarz 1985)

This curve is the smoothed average age composition seen in the 1980 and 1981 widow rockfish catches (Lenarz 1985), and it is fairly representative of unfished populations in general. The left margin of the curve is approximately the age where the fishing gear begins retaining (selecting for) small widow rockfish. Then the curve usually increases gradually because widow (but not all species) become vulnerable to the fishing gear gradually; ie some but not all age 4, 5, 6, 7, and 8 widows are available to, or are retained by, the gear. This curve peaked at ages 10 and 11, which were the most abundant fully selected ages, and then declined--tailing out into the even less common older age classes.

Since the peak in Figure 1 is after age 9, the age of full maturity, the widow population in 1980 and 1981 appeared to contain a very high proportion of mature individuals as well as significant numbers of individuals in many age classes. A population with these characteristics is normally resilient biologically since there are lots of spawners, and also tends to support a relatively stable fishery since a wide range of year classes smooths out effects of strong and weak recruitment.

Variable recruitment usually causes relatively little variation in catches from near-virgin fish populations. The peak in Figure 1, for example, is only slightly exaggerated by the very strong 1970 and 1971 widow yearclasses. But in a stock with a reduced number of age classes (naturally or because of fishing), such as the one shown in Figure 2, variable recruitment will tend to be apparent. It would likely result in an unstable fishery as strong year class peaks move into, and out of, the fishery.

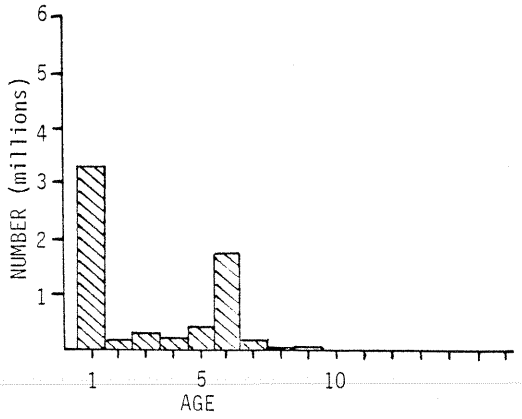

Figure 2

Initially, fishing may not have much effect on the age and size composition of fish in the catch from a near-virgin stock. However, as fishing proceeds and catches increase, the mortality due to fishing begins to reduce the number of older-aged individuals in the fish population. This causes the catch age structure curve to shift to the left--and juvenation begins. Figure 3 illustrates this process, and during this stage of a fishery juvenation is a useful indicator that the fishery is beginning to impact the stock--is fishing it down. The shaded area of the figure are the older, stockpiled fish that are removed during the fishing down (juvenation) process. These fish can be thought of as a non-renewable resource as long as the fishery continues.

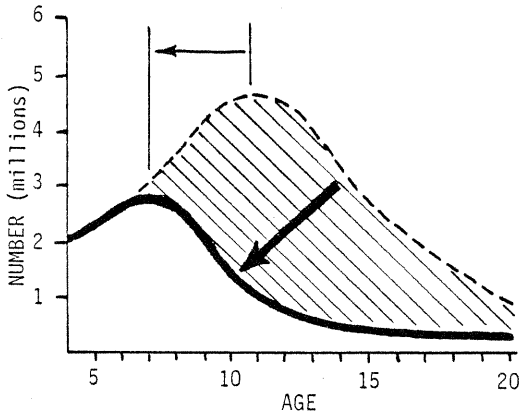

Figure 3

In a fish species like widow, which becomes available to the fishing gear slowly and is usually mature by the time it is fully vulnerable to the fleet, a reasonably stable fishing fleet should eventually push the fish stock toward a theoretical equilibrium age structure. This equilibrium probably seldom actually exists in nature, however, since most fisheries experience large variations in recruitment, availability to fishing gear, markets, and other driving factors. But it might come close. The equilibrium age structure contains the renewable portion of a fish stock.

An expected equilibrium age structure curve for widow rockfish at a fishing mortality (F) level of 0.3 and natural mortality (M) of 0.15 is approximated by the left-hand curve in Figure 3. This can be compared to the actual age structure observed in the 1983 and 1984 widow fishery shown in Figure 4 (Lenarz 1985).

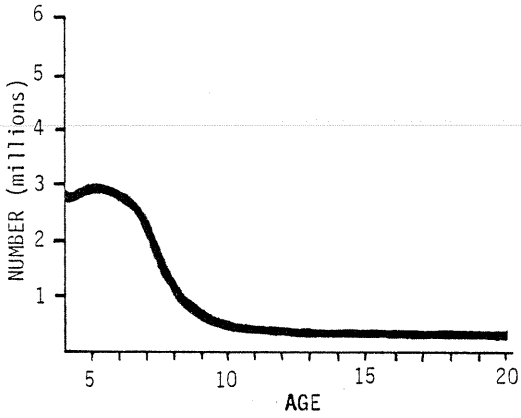

Figure 4

(Lenarz 1985)

This smoothed curve is obviously very different from the virgin stock age structure shown in Figure 1. There is also much less biomass present--typically about 25% of the virgin biomass for a stock with these mortality factors operative. Also, a much smaller proportion of the population are mature--in the widow example, about 40% after fishing vs 70% before fishing down. This means there is less inherent reproductive resilience in the population. And there are also relatively fewer significant age classes available to support a fishery. Near an equilibrium age structure, variable recruitment will likely be more evident to the fishery, and may result in widely fluctuating catches.

The particular species of fish is also important. In some species, boccacio for example, growth is fast and lifespan is relatively short. The fishing gear may begin selecting these species as early as the first year of life and immature fish may be fished heavily. The fishery will tend to be dependent upon single strong year classes. For example, bocaccio catches have been heavily dependent upon the strong 1977 year class since 1979, but no comparable replacement has as yet appeared (Figure 5). Juvenation is more difficult to interpret in these species since an equilibrium condition may never exist, and if the

number of recruits is dependent upon the number of spawners these stocks could be put at risk by overfishing.

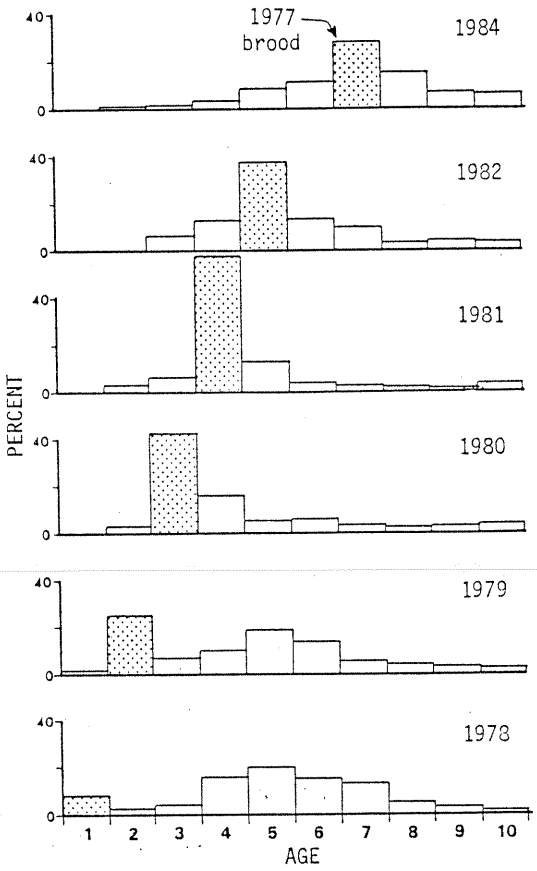

Figure 5

(Fig.2 of Thomas 1985)

Thus juvenation can be a very useful indicator that a fishery has begun to fish a stock down, and the rate of juvenation provides some indication of how fast the fishing-down process is taking place. But the significance of juvenation is also a function of specific fish stock characteristics--particularly the age selection curve of the fishery and the relationship of age at first capture and maturity.

Finally, it is important to note that the usefulness of juvenation as a tool also decreases as the stock age structure begins to actually approach equilibrium. This is because near equilibrium very large increases (or decreases) in fishing mortality no longer change the mean size of the population significantly. Figure 6 shows that even though increased fishing mortality changes the shape of the equilibrium curve in ways that result in a significantly smaller proportion of mature fish (spawners), the mean age (size) of fish in the catch changes very little.

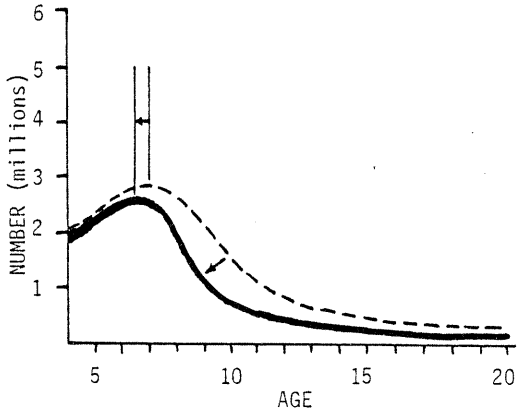

Figure 6

REFERENCES

Lenarz, W.H., and J.E. Hightower. 1985.
Status of the Widow Rockfish Fishery. DRAFT report to the PFMC Groundfish Management Team. NMFS, Tiburon, CA. 29pp. mimeo.

Thomas, D.H. 1985.
Status of California's Bocaccio Stock. Report to the PFMC Groundfish Management Team. Calif. Dept. Fish and Game, Menlo Park, CA. 9pp. mimeo.

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