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To: Mr. Jim Kellogg, President, Fish and Game Commission,

From: Peter B. Moyle and William A. Bennett, Center for Watershed Sciences

Re: Striped bass predation on listed fishes: can a control program be justified?

Recently, the Commission has been requested to remove all regulations from the striped bass fishery, as a way of reducing predation on salmon, delta smelt, and other threatened fishes. Our basic message is that the Commission should exercise extreme caution in making this change; new regulations to control striped bass are more likely to be harmful than helpful to native species of concern.

Striped bass are an abundant alien predator on fish and other aquatic organisms in the San Francisco Estuary and its tributaries (Moyle 2002). Salmon, delta smelt, and other native fishes are in decline. Therefore, it is presumed that reducing striped bass numbers can help to increase populations of threatened fishes. Over the past two years, this argument has been the focus of litigation, proposed legislation, and most recently a request by NMFS to the Fish and Game Commission to remove all restrictions on the striped bass fishery. Given the ample evidence that fishing can greatly reduce abundance of target species, it is a reasonable assumption that removing restrictions on striped bass would significantly reduce their numbers, particularly if fishing concentrated on immature fish and large, older females. However, whether or not threatened salmon, steelhead, and smelt populations would rebound is an open question. Here are some of the assumptions, or, untested hypotheses, that would need to be true and work in concert before native fishes might benefit from fewer striped bass.

Assumption 1. Predation by striped bass regulates populations of salmon, steelhead, and smelt, with other predators (other fish, birds, marine mammals, etc.) playing a minor role.

Assumption 2. Other predators will not exhibit compensatory increases in predation on threatened fish if striped bass are removed.

Assumption 3. Other species on which striped bass prey, such as Mississippi silverside, will not increase in abundance, causing harm by competing and preying on threatened species.

Assumption 4. Reducing striped bass numbers can measurably compensate for the massive changes to the estuary and watershed caused by water diversions and other factors, which also reduce fish populations.

Before any of the above assumptions can be accepted several factors need to be taken into consideration:

1. Striped bass are generalist and opportunistic predators that tend to forage on whatever prey are most abundant, from benthic invertebrates to their own young to juvenile salmon and shad (Stevens 1966, Moyle 2002, Nobriga and Feyrer 2008).

2. Delta smelt were a minor item in striped bass diets when they were highly abundant in the early 1960s (Stevens 1966), as well as in recent years at record low abundance (Nobriga and Feyrer 2008). Striped bass are unlikely to be a major predator of delta smelt because smelt are semi-transparent (hard to see in turbid water) and do not school (they aggregate loosely where conditions are favorable), unlike more favored prey such as threadfin shad, juvenile striped bass, and Mississippi silverside.

3. Striped bass will feed heavily on juvenile salmon and steelhead in the rivers, as they migrate seaward, which is well documented. However, most salmon eaten are likely to be naïve fish from hatcheries, high predation on them has little bearing on the degree of predation encountered by more wary juveniles from natural spawning. Predation on hatchery-reared juveniles may even buffer wild fish from such predation, given that wild fish are warier and less conspicuous than the more abundant hatchery fish. Lindley and Mohr (2003) present a model that suggests an annual loss of 9% to striped bass predation is sufficient to increase the probability of extinction of winter run Chinook salmon. However it is important to appreciate the considerable uncertainty associated with this modeling result, given the difficulty of estimating juvenile salmon abundance.

4. All measurements of predation and mortality are very rough, with high variation around any estimate. Unfortunately, such estimates are often presented as single values which tend to be taken as absolute values (e.g., Hansen 2009). The multiple sources of uncertainty that affect these values include abundance of adult striped bass, prey abundance, rates of prey encounter and consumption (which are now based only on stomach contents), as well as biases inherent in the designs and methods of different studies. Models, such as Lindley and Mohr (2003), can produce estimates of salmon loss to striped bass, but they are only as good as the information used to produce them, which is extremely limited in quality and amount. The Lindley and Mohr (2003) model, while excellent, has results that are merely a demonstration that striped bass *could* affect winter run Chinook numbers rather than a proof that they actually do.

5. There is a tendency to conflate all predation losses of salmon with striped bass and/or to dismiss the effects of other predators as being insignificant (e.g. Hansen 2009). In fact, there are a multitude of other predators on juvenile salmon in the system, from birds (e.g., mergansers, cormorants, terns) to other fish, native and non-native, including juvenile steelhead. The most abundant fish predator in the Delta today is probably largemouth bass, as the result of changes in hydrodynamics related to the ever-increasing export of water (Moyle and Bennett 2008). If a control program for striped bass can be justified, then it is likely one should also be instituted for largemouth bass, as well as for spotted bass, channel catfish, and other non-native predatory fish.

6. Applying mortality rates due to predation that were estimated using hatchery-reared salmon juveniles may have little bearing on those of fish from natural spawning. Thus, applying a predation mortality rate of 90% or so to represent what happens to out-migrating juvenile salmon from natural spawning has to done very carefully. Such a high predation rate is based only on observations of

hatchery juveniles, which are typically released in large numbers over limited time periods. Because these fish are adapted for life in crowded hatchery troughs, where food comes from above in the form of pellets, they have never experienced the threat of predation. It is astonishing in many respects that as many of these fish survive as do. Wild fish, in contrast, are more wary, spending much of their time in cover with well-developed predator avoidance behavior; they tend to migrate at night and spend the days along the shoreline hiding in whatever cover is available.

7. Much of the predation on juvenile salmon (from multiple predator species) seems to take in place in conjunction with artificial structures and poor release practices. These include releases of fish from hatcheries and those trucked to the estuary from the export facilities in the south Delta. Opportunistic predators, such as striped bass, are extremely quick to cue on predictable events, such as regularly timed releases of smolts at a single location. Changing the simple-minded protocols associated with fish releases may be a wiser approach for reducing such predation, rather than using observations of these events to blame striped bass and justify predator control programs. Reducing predation opportunities at various artificial structures may also have large benefits and needs investigation.

8. If the striped bass is indeed the dominant predator on other fishes in the Delta and Sacramento River (the reason for a control program), then this predatory effect should be greatest on populations of other species that are more frequently consumed. The 'release' from predation pressure associated with reducing striped bass numbers is thus highly likely to benefit many other alien fish which are also known predators and competitors on fishes of concern. This assertion is widely supported by ecological theory and numerous investigations in a variety of systems, including estuaries elsewhere. For example, Mississippi silversides are important in the diets of 1-3 year old striped bass, so bass predation could be regulating the silverside population. If true, then relieving silversides from striped bass predation pressure is likely to increase their numbers, which could have negative effects on delta smelt through predation on eggs and larvae (Bennett and Moyle 1996). This strongly suggests that any proposal to initiate a control program for striped bass should carefully consider the likely consequences, as well as involve an intensive study effort on the impact of program to make sure the alleged cure is not worse than the supposed disease.

The take home message from all this is that reducing the striped bass population may or may not have a desirable effect. In our opinion, it is most likely to have a negative effect. While the ultimate cause of death of most fish may be predation, the contribution of striped bass to fish declines is not certain. By messing with a dominant predator (if indeed it is), the agencies are inadvertently playing roulette with basic ecosystem processes that can change in unexpected ways in response to reducing striped bass numbers. Overall, the key to restoring populations of desirable species and to diminish populations of undesirable species (Brazilian waterweed, largemouth bass, etc.) is to return the Delta to being a more variable, estuarine environment. This is likely to happen naturally with sea level rise interacting with levee collapses (Lund et al 2007, 2008), but the populations of delta smelt and similar fishes may not be able to last that long. We stress that attempting to reduce striped bass and other predator populations is unlikely to make a difference in saving endangered fishes, and will serve only to distract attention from some of the real problems. However, efforts to reduce predation opportunities (not necessarily predators) in some locations with a focused effort may make a difference in the survival rates of depleted salmon and other species and provide some assistance to their recovery.

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