

Final Report

San Francisco Bay Estuary Acclimation of Central Valley Hatchery Raised Chinook Salmon Project

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Final Report Salmon Acclimation Project

Introduction

In the Spring of 2008, the Fishery Foundation of California (FFC) received a grant from the State of California, the Resources Agency, Department of Fish Game pursuant to Fish and Game Code Section §1501.5(b), to acclimate Central Valley hatchery raised Chinook salmon upon transport by hatchery truck to San Francisco Bay. The Bay Delta Sport Fishing Enhancement Stamp provided the grant funds. The purpose of acclimation is to reduce the transport stress of the young salmon before release into the Bay where they are subject to salinity and temperature shock and intense predation by birds, predatory fish, and marine mammals.

In 2006 no acclimation was attempted due to lack of a contract and in all but one of the twelve years prior to 2007 acclimation was achieved by releasing salmon smolts from hatchery trucks directly into net pens at a receiving site in the Bay. In 2003, salmon were acclimated in an experimental tank mounted on a barge. The barge system was tested as a means of cutting costs and further improving survival of trucked salmon. Tank acclimation, it was thought, might reduce stress and mortality of trucked salmon over pens by acclimating the salmon released from the trucks to Bay water conditions over a short period of time, as opposed to directly releasing the salmon into the Bay from the trucks or into pens. The experiment was successful but proved logistically difficult and so was abandoned in the following years. Prior to 1995, hatchery trucks released fish directly into the Bay or Delta locations. From 2007 to present, the Foundation has contracted with DFG to acclimate salmon using the net pen system with excellent results. Approximately 10 million fish in 2007, 20 million in 2008 and 12.5 million in 2009 were successfully received, acclimated and released into the Carquinez Strait from the net pens.

Trucking and net pen acclimation is generally considered a major factor in dramatically increased escapement of hatchery fish to Central Valley Rivers. Trucking has proven effective at increasing survival by reducing losses between the hatcheries and the Bay to poor water quality, water diversions, and predation. Previous tagging studies by DFG indicated that survival is also enhanced up to several fold by net-pen acclimation of trucked salmon smolts¹. Trucking and pen acclimation offer tremendous survival advantage over releasing young salmon at the hatcheries. The hatchery system is a controlled environment that allows a salmon to develop from an egg to a smolt in a safe, predation free background. Unlike in a river, hatchery pools afford fish with ample food and almost no predation pressure. In the hatchery there is no need for the young salmon to hide from predators and they develop without “learning” about the perils that are present in a natural aquatic environment. When these unsuspecting fish are released into a hostile environment such as a river or estuary they are easy prey for predatory birds and fish.

¹ Multiple paired lots of code-wire-tagged salmon smolts were released: one lot of a pair was released directly into the Bay from a truck and a second from a truck into net pens for several hours acclimation before mid channel release. Tag returns in the ocean fishery were up to three time higher for pen acclimated salmon. (DFG unpublished data)

Despite the obvious survival advantage of trucking and pen acclimation there remain opportunities to further improve survival of hatchery salmon. One of these is barge acclimation. The potential advantage of barge over pen acclimation is a reduction in temperature or osmotic shock from direct release from trucks into pens. While direct transfer of Chinook salmon smolts from freshwater to saltwater generally is considered safe, there have been studies that show that direct transfer leads to shock and increased vulnerability to predators (Robertson and Bradley 1991; Smith et al. 1999a and 1999b; and Carranza et al. 1994). Salmon migrating naturally downstream gradually move from freshwater to saltwater. The degree of osmotic shock is considered most severe in when juvenile salmon are transferred from freshwater to seawater directly, without the moderating influence of gradual transition to full salinity seawater afforded in nature. The scientific literature indicates that direct transfer increases salt levels in blood and tissues of young salmon and can disrupt biochemical processes and lead to stunted growth or even death. Although most species of salmonids undergo a physiological transformation that prepares them for the transition from freshwater to life in the dehydrating marine environment, a gradual rise in plasma ion concentration occurs as they experience an osmotic shock over several days. Young salmon gradually develop the ability to relieve their blood and tissue of salt by excreting salt via their kidneys and taking on more water through their gills and by drinking. The literature indicates that mortality from osmotic shock from direct transfer is on the order of 10 to 20 percent depending on circumstances. Some research indicates that the multiple stresses of transferring fish from hatcheries to salt-water exacerbates the stresses and leads to higher mortalities. In a conventional salmon farm, it's not unusual for up to 10 percent of the fish to die from osmotic shock, the trauma of being transferred from fresh to saltwater. Another 5 to 10 percent will become stunted. It also takes time for the survivors to adapt to their new surroundings and start growing again. And osmotic shock can stress fish and put them at risk for disease and predation.

Like salinity shock, thermal shock is another possible effect of direct transfer of salmon from trucks to the Bay, pens, or tanks. Thermal shock occurs if the receiving water is too warm, stress is evident as water temperature exceeds 65F and mortality occurs at about 77F. Mortality can occur at sub lethal temperatures if the change in temperature exceeds 20F. Generally temperature is not considered a factor in trucking; however, some trucking of hatchery salmon is conducted as late as July when receiving water temperatures maybe a factor. During the present 2009 study water temperature of the receiving water ranged from 57- 65F, with no significant temperature difference between the two release sites. Average temperatures in April, May and June were 59F, 63F and 64F respectively, well within the preferred range and did not reach 65F at any time

The purpose of this report is to describe the results of the 2009 net pen acclimation program. Our objectives do not include an assessment of the merits of trucking or its effect on salmon populations, wild stocks, or straying.

Background

Hatchery Chinook salmon production in California in recent years has been approximately 48 million smolts and approximately 10-12 million of these per season were transported by truck and released in upper San Francisco Bay (San Pablo Bay). Last year due to the drastic decline of fall run Chinook salmon in the Central Valley system CDFG doubled the number of acclimation fish resulting in over 20 million fish being trucked to the Bay for acclimation. Three California State hatcheries located in the Central Valley (Feather, Mokelumne, and Nimbus hatcheries) account for roughly 99% of these off-site releases in the Bay. The young salmon are transported to the Bay to reduce or eliminate the mortality associated with moving from the rivers through the Delta. Transported fish may contribute to ocean fisheries at rates of three fold and higher compared to fish released upstream or at the hatchery. Unpublished data from the DFG's CWT database show substantial increases in both ocean contribution rate (1153%) and hatchery recoveries (259%) for Feather River Hatchery smolts released in the western Delta. Average ocean fishery contribution rates by release location were 0.310% for Battle Creek, 0.369 for RBDD, 0.318 for Princeton, and 0.947 for Benicia in the upper Bay (USFWS, unpublished data). These differences in ocean contribution rates were observed during years of drought and below average flows in the Sacramento River and were prior to pen acclimation that began in the mid 1990's. There has been no subsequent information on contribution rates, except as mentioned earlier; more recent studies of pen acclimation by DFG indicate that acclimation increases contribution up to threefold. Overall the increase in ocean contribution from trucking and pen acclimation may be as high as tenfold. Increases in adult escapement to rivers are believed to be less because of extensive straying of off-site released (trucked) fish. Straying of these fish has been estimated to be as high as 70%.

The Chinook salmon smolts that are released off-site in the Bay come only from State hatcheries at Nimbus, Feather River, and Mokelumne hatcheries. These fish are for mitigation or enhancement from losses from dams and water diversions. The California Department of Water Resources provides funds for the Feather River Hatchery for mitigation of the State Water Project. The Salmon Stamp Program provides funding for enhancement fish for the Mokelumne and Feather River hatcheries. The Bureau of Reclamation provides funds for Nimbus hatchery fish. The East Bay Municipal Utility District provides funding for Mokelumne hatchery fish. The Four-Pumps Program of the State Water Contractors provides funding for Feather River hatchery fish through the Delta Fish Protection Agreement.

2009 Acclimation Program

Methods

Net Pen

The 2009 salmon acclimation project used the net pen method to acclimate salmon smolts. Net pens were towed daily from the Vallejo municipal Marina to either Mare

Island or in the Mare Island strait or Conoco Philips' Wickland pier in the Carquinez Strait at Selby where fish were received. The net pen consists of a sixty foot long by 30 foot wide aluminum herring barge which was modified for salmon acclimation.



Figure 1. Net pen with bird nets on at Conoco Philips receiving site, Carquinez Strait

The net pen has five bays fitted with nets and can receive up to five full tanker truck loads of fish per delivery. Each net is 25'L x 12'W x 8' D. Nets are hand deployed by the crew and weighted at each of the four corners with 35-40lb cement weights. Additional weights are used at the upstream end of nets to block currents that could potentially stress the acclimating fish.

Procedure

A tow boat with one captain is used to tow the net pen to and from the release site. An additional chase boat is secured to the net pen and used for docking the pen at the receiving sites and navigating in and out of the marina. Three crew members stay aboard the net pen. One drives the chase boat while the other two work the tow line and perform docking procedures. Once the net pen is secured at the receiving site crew members set the nets and weights and position the pen for transfer of fish. When all the fish have been transferred to the net pen bird nets are secured over each bay to prevent predation during acclimation. . Fish are generally kept for a minimum of one hour unless current or weather conditions become dangerous. In such cases fish are released as soon as schooling behavior is observed and fish are well below the surface of the water, which may take 20-45 minutes.

Environmental Parameters

While on site water temperature in degrees Celsius and specific conductivity in microSiemens per centimeter is measured with a YSI meter. Weather observations are made and presence or absence of predators noted.

Location

Two release sites are used to accommodate tidal conditions and also to reduce predation by avoiding a specific time and location which may begin to attract predators such as Striped bass, sea lions and fish eating birds. Multiple locations also helps in adapting to difficult weather conditions. For example there may be a small craft advisory in the Carquinez Strait while at the same time conditions are safe in the Mare island Strait.



Figure 2. Tow boat "BZ 1" net pen and chase boat

Conoco Philips

At the Wickland pair a rigid stationary fifty foot pipe is used to transfer fish from truck to net pen. The net pen is moved after each truck unloads. One load per bay is generally taken however, in some cases truck loads are light and two loads may be placed in one bay increasing capacity from 5-6 truckloads. Fish are released mid channel usually on a flood tide or on a gentle ebb.



Figure 3. Fish being transferred via rigid pipe at Wickland Pier, Conoco Philips

Mare Island

The Mare Island receiving site is located in the Mare Island Strait/Napa River near its confluence with the Carquinez Strait. A flexible tube is used to transfer fish at this site and the net pen remains stationary while the trucks each line up with a bay. Fish are taken exclusively on ebb tides at this site due to the need for a release pattern that will lead them into the Carquinez Strait and San Pablo Bay. Fish are never released on a flood tide at this location.

Acclimation

After all fish have been received, the crew observes the fish notes their condition and considers weather and current conditions to determine when tow and release will begin. If tide is slack or current is slow fish are often acclimated for 20-30 minutes at the release site before moving into the current for an additional 30-60 minutes of acclimation. If currents are running swiftly the pen is towed into the strait immediately to prevent stress on fish and acclimation is completed while drifting along with the tide. When fish have been in the net pen for an hour or more, and they are schooling well below the surface, they are released in the direction of the current near mid channel. The release is accomplished by crew members first manually removing the bird nets, then pulling up the

weights and finally inverting the nets in such a way that the fish are released into the current. After each release nets are secured and when all fish have been released the net pen is towed back to the marina.

The 2009 acclimation plan called for receiving up to 14 million salmon smolts from three state and one federal hatchery into mobile net pens at two locations; 1) the Wickland Oil Refinery dock on the southeast shoreline of San Pablo Bay and 2) Mare Island Strait on the west bank directly opposite the Vallejo Municipal launch ramp (Figure 1). The hatchery salmon were delivered by trucks between early April and early June. The Bodega Bay Fisherman's Marketing Association purchased an aluminum kelp barge for modification into net pens for the 2008 acclimation project, and the FFC retrofitted them for immediate use. The same net pen was reassembled and used again in 2009. Net pen reconstruction began in mid-March and took approximately 3 days. The net pens were launched and assembled in the water at the Vallejo Marina in late March where they were berthed for the remainder of the project. The FFC received salmon from April 1st through June 5th. In total, the FFC received 115 truckloads in 35 acclimation days. FFC crews took all truckloads and did not miss an acclimation day for any reason. Fish were delivered from Feather and Nimbus state Hatcheries, and Coleman federal Hatchery. Mokolumne River state hatchery was unable to participate in the 2009 acclimation project due to low escapement and lack of egg availability. At no time were fish from one hatchery mixed with fish from another hatchery. All fish from one hatchery were acclimated before the next hatchery began trucking fish. Total number of fish acclimated was 13,829,000. The Feather River Hatchery delivered a total of 8,572,550 fish, Nimbus hatchery delivered 3,921,900 fish and Coleman Fish Hatchery delivered 1,334,550 fish. Fish were generally delivered in good condition, successfully received and fully acclimated prior to release.

No specific predation studies were done during release of acclimated fish, however the following general observations were made. Alternating release sites appeared to reduce overall presence of predators. Release sites were determined by tidal conditions creating a release pattern of site alternation every 3-5 days. FFC crews generally did not observe a predictable pattern with regard to predators (birds, bass, and an occasional sea lion) this season. Overall predation by striped bass appeared minimal and fishing was poor around the net pen compared with previous seasons as evidenced by the absence of party boats and low numbers of fisherman in during the project. Pelicans arrived in early April and Caspian terns began showing up in the Mare Island Strait near the same time, both increasing predation after release due to their ability to capture fish below the water surface. Tern predation appeared to be quite intermittent and was not generally limited to the Wickland (Conoco Phillips) release site as it has been in past years. Striped bass predation appeared to be down from last year as evidenced by the fewer numbers of fisherman and party boats in the area. Gulls were usually present and preyed mainly on the small number of weak or dead fish floating near the surface after release.

Mortality in the net pens was not a significant factor. Most fish when given time to acclimate recovered from disorientation caused by transport along with temperature and

osmotic shock. The larger fish from Feather River Annex (18-20 per lb) clearly tolerated transport well and appeared physiologically ready and therefore transitioned very quickly compared with smaller fish from the same and other hatcheries. Coleman fish looked very healthy upon arrival and acclimated extremely well.

The overall success of this year's acclimation project was a direct result of continued excellent communication and coordination between hatchery managers, truck drivers, administrative staff and the contractor (FFC). All entities exercised flexibility, creativity and a professional attitude which was reflected throughout the project and resulted in a smoothly run acclimation year with excellent results.

Literature Cited

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Project Area and Receiving Sites



Figure 4. 2009 Receiving sites