ANALYSIS OF THE IMPACTS OF CALFED ALTERNATIVES ON FISHERY RESOURCES

INTRODUCTION

Each CALFED alternative is a combination of variable components associated with Water Storage and Conveyance facilities and components associated with a set of common programs. The common programs are the Ecosystem Restoration Program, Water Quality Program, Water Use Efficiency Program and the Delta Levee System Integrity Program. While the common programs will be basically the same for each Storage and Conveyance alternative, some differences will occur to accommodate specific characteristics of each alternative.

Ideally, an impact analysis would describe effects integrated over all components for each alternative to indicate the net effect on each fishery resource or group of resources. Knowledge is simply insufficient, however, to do that. Generally speaking, a fair degree of consensus exists as to the degree of benefit which would be likely for specific biological characteristics, but much less agreement exists as to which characteristics are most important in controlling population responses. For example, reasonable agreement exists as to the relative magnitude of fish losses in diversions for the various alternatives, but much less agreement as to the relative roles of losses in diversions and losses due to toxicants in controlling population abundance. Hence the following analysis makes only limited attempts at such integration.

Another aspect of the impact analysis is that while the CALFED Program will be directed towards making broad changes in the ecosystem, most likely impacts can best be judged based on the varying needs of individual fish species. Hence this analysis focuses on responses of individual species.

The conveyance components considered in the impact analysis are the idealized versions developed by the Interagency Development Team (IDT) for each of the three basic conveyance approaches considered by the CALFED Program. Those approaches are Alternative 1, continuing use of Delta channels essentially as they exist today; Alternative 2, modification of channels in the northern and southern Delta to convey a larger fraction of the water from the Sacramento River to the export pumps through that portion of the Delta rather than through the western Delta as presently occurs, and Alternative 3, a new isolated channel from the Sacramento River to the export pumps with continuing conveyance of some water through existing Delta channels.

The fishery resources are divided into three ecological groups for analysis. One group is estuarine and migratory fish which a half century of observations indicates are quite vulnerable to having their behavior disrupted by the transport of water from the Sacramento River to the export pumps in the south Delta. Representative members of this group include chinook salmon, delta smelt, splittail, striped bass and white catfish. A second group of fish is those which reside in the Delta, but appear relatively invulnerable to being drawn to the export pumps. Representative members of this group are tule perch, largemouth bass, and several members of the sunfish family. The third group of fish is those which live primarily downstream of the Delta, and are thus have little vulnerability to diversion to the export pumps but are potentially affected by the changes in the amount of water flowing from the Delta through San Francisco Bay to the ocean. This group includes starry flounder, longfin smelt, bay shrimp and many others. Note that these ecological groupings include both native and introduced species, with striped bass, white catfish, largemouth bass and the sunfishes on the above lists being the introduced species.

The CALFED program has defined eighteen Distinguishing Characteristics to denote factors which are most likely to indicate differences among alternatives. Three of those; Diversion effects on fish, Delta flow circulation, and Brackish water habitat; are related primarily to fish in the first and third groups and receive major treatment in the following analysis. Other characteristics which are also important to fish and depend primarily on the common programs are also considered in the analysis.

IMPACTS ASSOCIATED PRIMARILY WITH COMMON PROGRAMS

Tidal Wetlands- A major feature of the common programs is the restoration of tidal wetlands in the Delta and Bay. Such wetlands are now only a small fraction of those which existed a century ago. Such wetlands will benefit fishes in all three groups both directly and indirectly. All will benefit indirectly from the increased production of organic matter which will help support the food web for fishes. Biological treatment of some contaminants is likely to be another indirect benefit.

Direct benefits will vary by species. Those species in the second group are fishes which generally live in the remnants of this type of habitat, and thus limit their exposure to transport by water flows. These are the species most certain to benefit from the new wetland habitat.

For fish in group 1, benefits tend to be species specific. Chinook salmon which migrate to the estuary prior to becoming smolts (the stage at which they are physiologically ready to migrate to the ocean) also use wetland habitat extensively and are likely to benefit considerably. Such salmon are much more likely to migrate to the estuary in wet years. Salmon smolts migrate through the estuary rather rapidly and are more likely to migrate in the main channel, so they are likely to receive less benefit from this habitat. A second fish from group 1 likely to benefit substantially is splittail. They spawn in inundated wetlands and uplands during the spring. Their spawning success is much greater in wet years than in dry years, almost certainly due to the much greater access to inundated areas for spawning. Hence the more new wetlands can be designed to accommodate that need the greater will be the probable benefits for splittail. Another fish in group 1 which probably depends on near shore habitat for spawning is delta smelt. Thus they are likely to benefit from the new wetlands, but their dependence on such habitat is less certain. Benefits for other species in group 1 are more problematical.

Some fish in group 3 will benefit directly from tidal wetlands, but no specific hypotheses concerning major such benefits are available.

Upstream Habitat Restoration- The Ecosystem Restoration Program Plan includes a major set of actions directed towards fishery restoration in all river systems upstream from the Delta. Such actions include improvements in minimum flows, gravel restoration, restoration of stream meanders and other natural flood plain processes, and protection and increase of riparian habitat. These measures were planned with the specific needs of chinook salmon and steelhead in mind. Those two species should be the primary beneficiaries, and the upstream habitat restoration benefits for chinook salmon in the Sacramento system and for steelhead will likely exceed benefits for the species realized by actions taken in the estuary. For chinook salmon in the San Joaquin system, potential benefits in the estuary depend greatly on the conveyance alternative and may exceed the upstream benefits.

Water Quality- CALFED's Water Quality Program describes programmatically a series of actions designed to complement existing programs to control point and nonpoint sources of pollutants throughout the watershed. Some of these are directed towards problems, such as abandoned mines, known to be causing direct mortalities of fish. A larger number of actions are directed towards toxicants known to be having some adverse effect fish and their food supply, but for which population level effects are uncertain. Species for which adverse effects have been documented include chinook salmon, striped bass and starry flounder. Benefits are probable for all species, but the magnitude of benefit can not be predicted.

Exotic Species- Exotic species of fish and various invertebrates have caused many changes in the aquatic fauna in the system, and the rate of accidental introductions has increased in recent decades. The Ecosystem Restoration Program Plan includes actions directed towards reducing the probability of further accidental introductions. These actions should lessen the probability of additional competition and predation caused by exotic species which should benefit all existing species, but no practical options exist for reversing historical changes in aquatic resources.

Harvest Management- The Ecosystem Restoration Program also includes elements designed to reduce illegal harvest and improve harvest management of anadramous fish. That should increase the survival of adult fish making it easier to maintain self sustaining populations. Species likely to benefit include chinook salmon, steelhead, striped bass and white sturgeon.

IMPACTS ASSOCIATED WITH DISTINGUISHING CHARACTERISTICS

Diversion Effects on Fisheries- Diversion effects on fisheries are defined to include only the direct effects on fisheries due to water diversion intakes and associated fish facilities. Such effects associated with diversions from the Delta by the Central Valley Project (CVP) and the State Water Project (SWP) are an integral part of Conveyance Alternatives being considered by the CALFED Program and are reflected in one of the 18 Distinguishing Characteristics selected to evaluate the alternatives. Diversion effects associated with all other diversions from the system are dealt with as part of the Ecosystem Restoration Program and become part of the base against which all three conveyance alternatives are evaluated.

Ecosystem Restoration Program- Targets envisioned by this program include screening all diversions of more than 250 cfs on the Sacramento and San Joaquin Rivers, screening all diversions on tributaries having salmon and steelhead populations, screening small diversions in Suisun Marsh, and developing a long term screening program plan in cooperation with DFG, NMFS, FWS, irrigators and other stakeholders. Substantial progress towards those targets will be made by programs already underway, so it is difficult to decide the degree to which benefits should be included in the No Action Alternative, as opposed to be including them in benefits of the CALFED alternatives. Most such benefits have been attributed to the CALFED alternatives in the following analysis.

In meeting those targets, the Ecosystem Restoration Program will likely screen about 75% of the present cfs of diversions upstream of the Delta, in the Delta and Suisun Marsh. That magnitude of benefits compares with benefits described below associated with improved screening of about 15,000 cfs of diversions from the Delta by the CVP and SWP.

The primary beneficiaries of screening diversions upstream of the Delta will be chinook salmon and steelhead. The primary beneficiaries of screens in the Delta and Suisun Marsh include all of the species in group 1.

For chinook salmon in the Sacramento system and for steelhead, the reduction of diversion effects attributable to the Ecosystem Restoration Program will exceed such benefits attributable to the CALFED alternatives, as will become clear in the discussion of CALFED alternatives.

For chinook salmon in the San Joaquin system and for other species in group 1, potential reductions in diversion effects attributable to CALFED alternatives are greater. Depending on the CALFED alternative selected, they could exceed the benefits attributable to the Ecosystem Restoration Program.

CALFED Alternatives - A description of some physical features of the three CALFED alternatives is necessary as background for analysis of the diversion effects on fisheries. In each of the CALFED alternatives, CVP and SWP fish screens in the south Delta will be consolidated in one state-of-the-art facility at the intake to Clifton Court Forebay. The principal improvements expected are:

- Eliminating predation losses in Clifton Court, which has been shown to cause a mortality of between 75% and 95% of the salmon entering the Forebay.
- Salvaging a greater portion of fish approaching the screens, due to the positive barrier screens (3/32 inch openings), as opposed to the existing behavioral screens (one inch openings).
- Reducing losses attributable to the higher than optimum approach velocities at the present screens, particularly during low tides at the CVP screens.

The situation will still be far from perfect, primarily due to the absence of bypass flows in the vicinity of the screens. That will mean that the present handling and trucking operation for salvaged fish will continue. Mortalities during the salvage operations vary greatly by species, size of fish, and seasonal conditions, primarily water temperature. As examples, for steelhead, which migrate at a large size during cool seasons, mortalities during handling are virtually nil, for chinook salmon smolts mortalities are less than 10%, and for delta smelt mortalities are on the order of 100% even for the adults. Another consideration is the greater screening efficiencies expected due to the positive barrier screens will be primarily for the smaller fish, which will suffer the highest mortality during salvage operations. The result will be less benefit than the improved screen efficiencies would suggest.

In addition to the improvements in CVP and SWP screens in the south Delta, Alternatives 2 and 3 will also have fish screens at Hood on the Sacramento River, where the preponderance of Sacramento River water being exported will be diverted from the Sacramento River. Those screens will have two fundamental advantages in relation to fish screens in the south Delta. Those are:

- Bypass flows will exist in the river, so the screened fish will not have to be handled and trucked.
- Fish using the Delta as a spawning and nursery area will not be exposed to the diversion.

The screens also would be a new risk primarily for salmon from the Sacramento system, in that a larger portion of the population will be exposed to the screens. Also a major portion of the striped bass population and a small fraction of the delta smelt population spawn above the intake. Their young will be too small to be screened, so some brief curtailment of diversions will be required, at least for Alternative 3 in which the diversion would be into an isolated canal. An interagency team of fish facility experts has evaluated the feasibility of installing effective fish screens at this location and concluded that it is feasible.

Two additional aspects of Alternative 2 are:

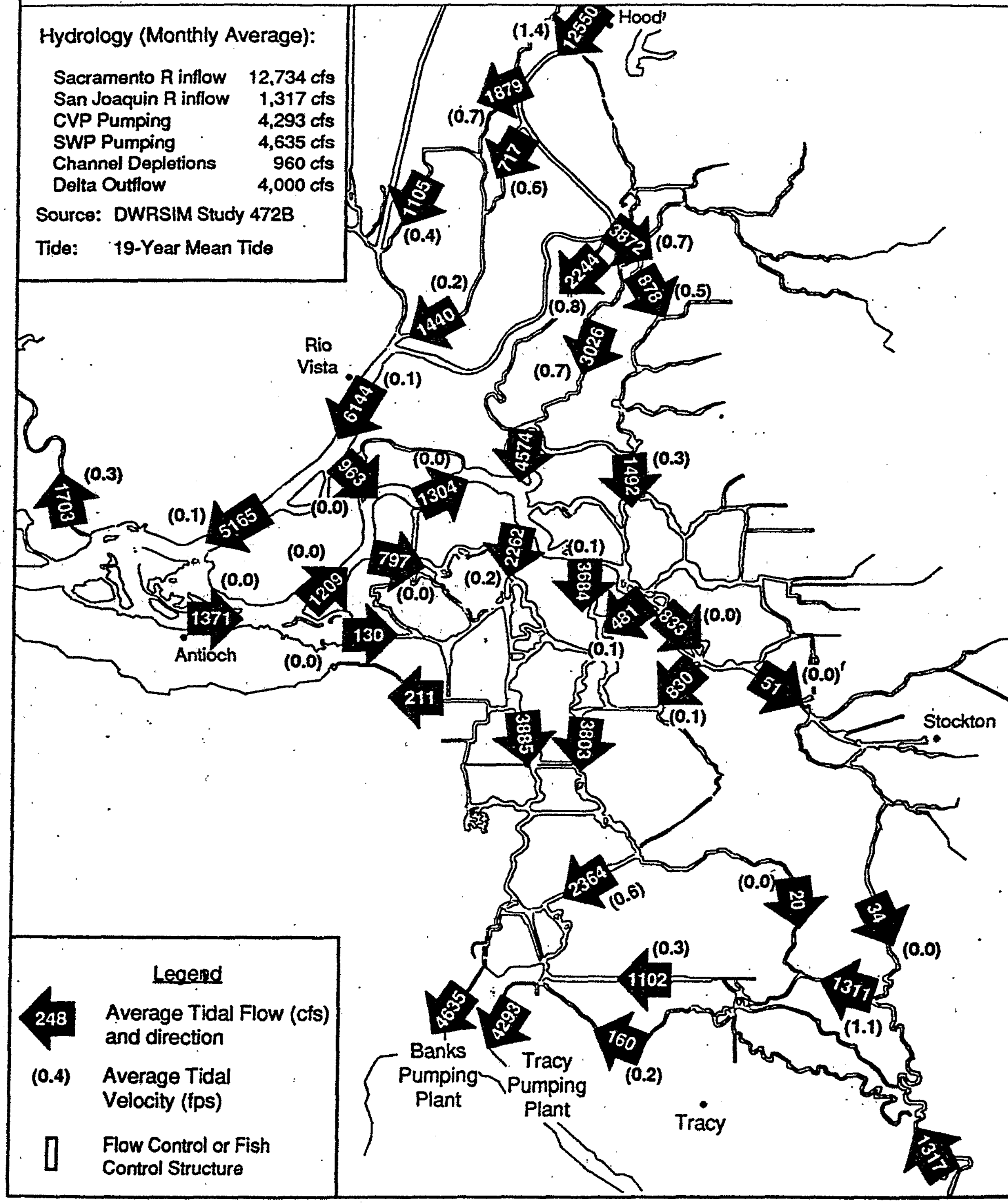
- All water screened at Hood has to be screened again in the south Delta to remove fish entrained as the water passes through the Delta, so the south Delta screens will have to have a capacity of about 15,000 cfs as in Alternative 1.
- Many thousands of adult fish of a variety of species will migrate to the Sacramento system through the new channel into which the water diverted at Hood is discharged. The passage of those fish will be blocked at the pumping plant downstream of the Hood fish screen. Substantial fish passage facilities will be needed to bypass the pumping plant and fish screens and get the upstream migrants into the Sacramento River.

A final consideration to set the stage for impact analysis of diversion effects on fisheries is consideration of interrelationships between flow distribution effects and diversion effects. Each of the CALFED alternatives is characterized by a distinctive flow distribution pattern. For Alternative 1, the direction of net flows during controlled flow periods is towards the pumping plants from the junction of the Sacramento and San Joaquin rivers near Antioch upstream through the Delta (Figure 1). This flow pattern exposes fish to being drafted towards the export pumps from a larger area than either Alternatives 2 or 3. Some question exists as to how significant such net flows are, since they are small in relation to the tidal flows (The magnitude of water sloshing back and forth due to tidal action.). The probability of their being significant in transporting organisms is increased by the fact that many small aquatic animals, including fish, have a general behavior pattern of rising farther off the bottom during flood tide than during ebb tide. That would seem to be an obvious adaptation important to animals being able to maintain their location in estuaries when normal net downstream flows occur. It would be counterproductive when net upstream flows occur. That and the fact that the magnitude of net upstream flows at some locations and under some circumstances with Alternative 1 approximate the net downstream flow from the Delta towards the Bay (Delta outflow) indicate that such net flows likely have ecological significance.

With Alternative 2, sufficient water is diverted at Hood to maintain net downstream flows in the San Joaquin Delta west of the Mokelumne River (Figure 2). Hence fish west of the Mokelumne would no longer be subject to being drafted towards the pumps. Important populations east of that point would still be subject to being drafted towards the pumps.

Finally, with Alternative 3 under operating scenarios being explored by the IDT, about 80% of the water exported from the Delta would pass through the Isolated Facility and 20% would be diverted directly from the south Delta. While net upstream flows might still occur in some areas under some circumstances (Figure 3), approximately an 80% reduction in fish entrainment in the south Delta could be expected in relation to Alternative 1 and a somewhat lesser percentage in relation to Alternative 2.

Average Flows and Velocities
Low Delta Inflows and High Delta Exports (October of water year 1990)
Alternative 1A



Department of Water Resources, Delta Modeling Section

Figure 1

Average Flows and Velocities
Low Delta Inflows and High Delta Exports (October of Water Year 1990)
Alternative 2B

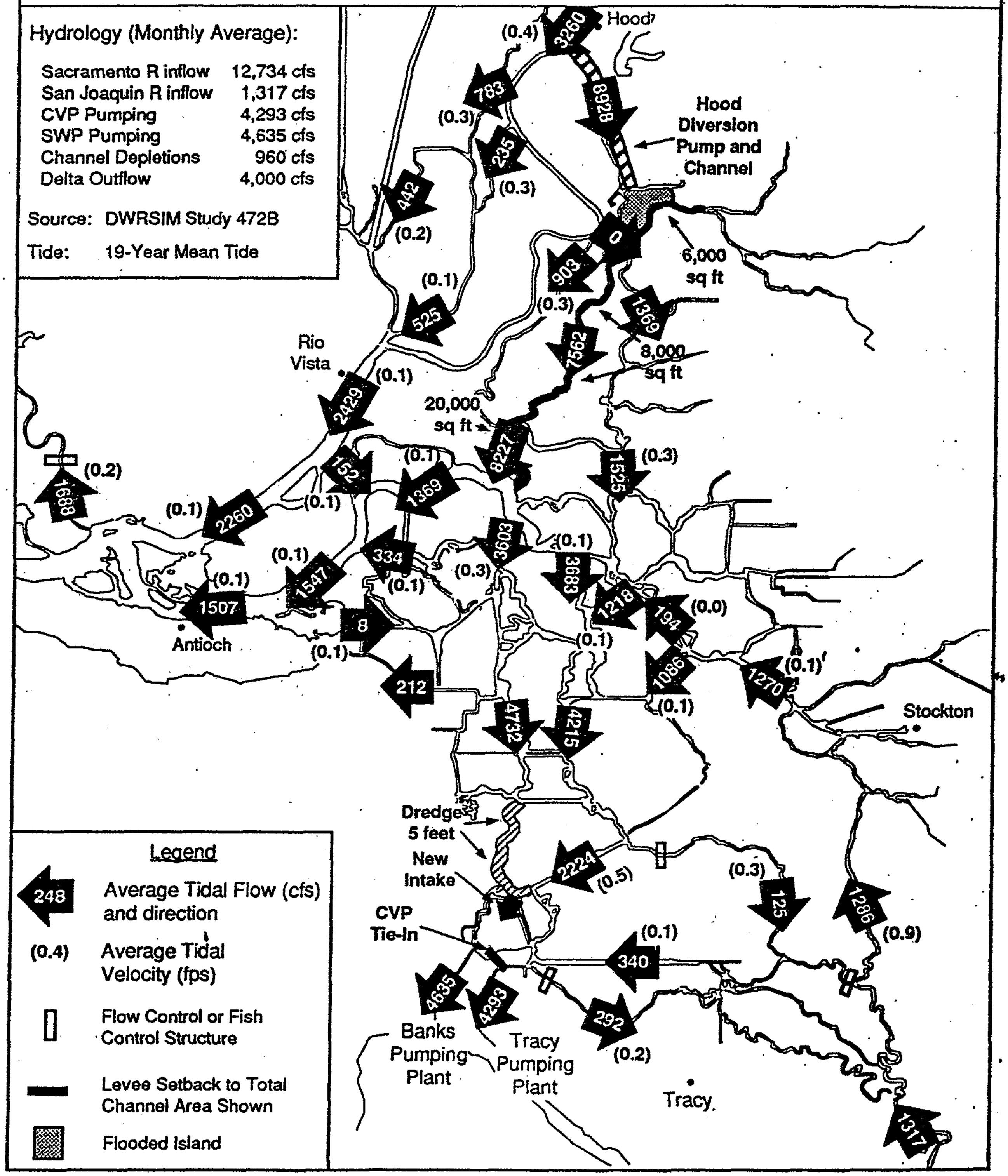


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Figure 2

Average Flows and Velocities
Low Delta Inflows and High Delta Exports (October of Water Year 1990)
Alternative 3E

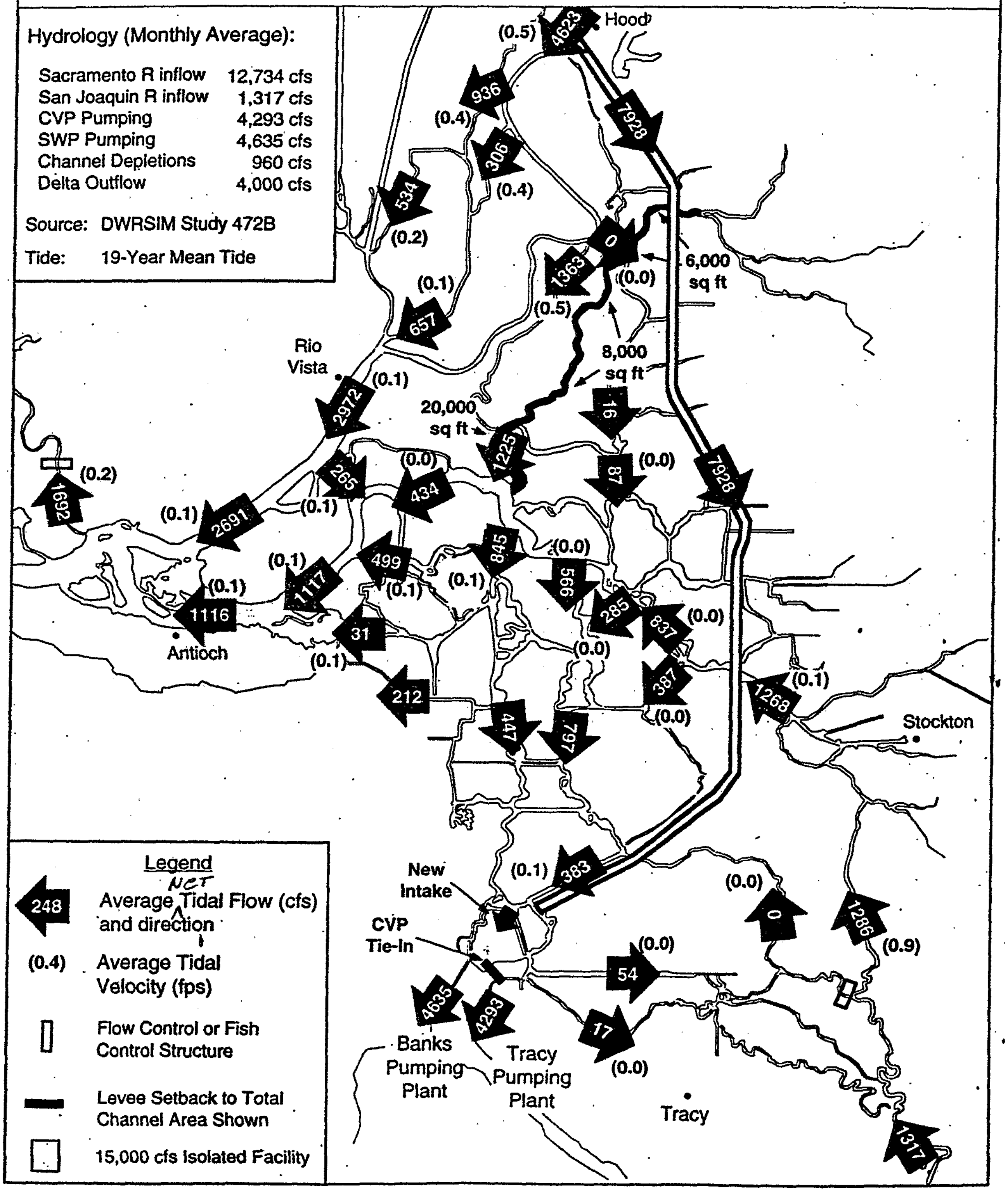

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Figure 3

Given the above conditions, what are the probable magnitudes of diversion effects on fishery resources under the three CALFED Alternatives? First each of the alternatives would include a significant reduction in entrainment due to fish screens included in the Ecosystem Restoration Program. These benefits would be greatest for chinook salmon and steelhead, as they are the primary targets of the program both in geographic scope and screen design. Other species would benefit significantly, but benefits for delta smelt and striped bass would be diminished by the fact that many would be exposed to the screen when they are too small to be screened.

Alternative 1 would tend to increase existing adverse entrainment effects of the CVP and SWP, as operating and physical features of water transport would remain unchanged, and would also include some negative consequences associated with a 9% increase in exports over No- Action Conditions and 14% over Existing Conditions. Alternative 1, however, would realize the benefits of the Ecosystem Restoration Program and have an additional increment of benefit due to the upgraded fish screens at the CVP/SWP south Delta diversions and some shifting of diversions from times of greatest fish abundance to times of lesser abundance. Initial explorations by the IDT of shifting the timing of diversions indicated a limited potential, because there is no time when significant amounts of fish are not present, and cost of allocating water storage to facilitate shifting diversions is high.

Alternative 2 would also include some negative consequences associated with a 9% increase in exports over No- Action Conditions and 14% over Existing Conditions, but would realize additional benefits in relation to Alternative 1. These would result from the positive net flows west of the Mokelumne River limiting the exposure of the young of fishes such as delta smelt and striped bass to the south Delta diversions. Once chinook salmon smolts migrating out of the San Joaquin system reached the Mokelumne, they would receive some benefit from improved net flows, but the overriding consideration for them would be that all water flowing out of the San Joaquin would continue going to the CVP/SWP export pumps under most circumstances, absent continued or greater export curtailments designed to provide some degree of protection. The IDT, however, concluded that those benefits of Alternative 2 would be offset by the risks associated with the upstream passage of adult fish through the channel from Hood to the Mokelumne River. While CALFED's Fish Screen Committee believes measures can be found to provide adequate passage, the IDT is concerned about the magnitude of the task and difficulties which have occurred elsewhere in providing adequate upstream passage.

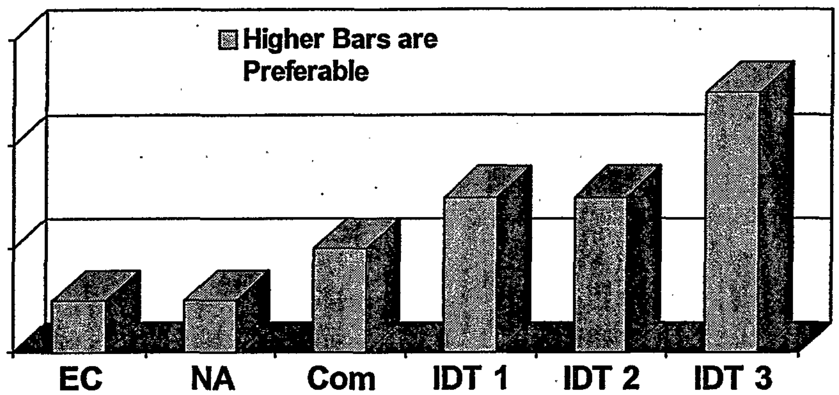
Alternative 3 would also include some negative consequences associated with a 9% increase in exports in relation to No-Action conditions and 14% in relation to Existing Conditions, but would include a large benefit associated with the 80% reduction in exports from the south Delta. While the remaining 20% of exports from the south Delta would continue some adverse impacts, major reductions in conflicts between water exports and the protection of fishes using the San Joaquin Delta as a spawning and nursery area and on chinook salmon smolts migrating from the San Joaquin River would be expected. The species residing in the San Joaquin Delta and receiving major benefit include delta smelt, splittail, striped bass and white catfish.

As mentioned under the description of benefits of the Ecosystem Restoration Program, chinook salmon in the Sacramento system would benefit considerably from improved Delta habitat, but the three CALFED alternatives would affect diversion losses for these salmon only minimally. Presently, salmon smolts diverted from the Sacramento River into the San Joaquin Delta through either the Delta Cross Channel or Georgiana Slough survive at a rate only 1/3 to 1/2 of those remaining in the Sacramento River. A substantial amount of such negative impact is presently avoided by keeping the Delta Cross Channel closed during salmon migrations, except when negative water quality consequences in the San Joaquin are too great and require opening the Cross Channel. That is expected to continue under Alternative 1, although the greater exports under Alternative 1 would increase conflicts with San Joaquin water quality and likely result in the Cross Channel being open more frequently. Under Alternative 1 some salmon would continue to be subject to diversion towards the export pumps through Three Mile and Broad sloughs, but the magnitude and consequences of that have not been measured.

The fish screens at Hood under Alternatives 2 and 3 are essential to prevent diversion effects on salmon in the Sacramento System from increasing, but they will do little to reduce existing diversion impacts. That is probable because some losses at the Hood fish screens and greater diversions of salmon through Georgiana Slough are inevitable consequences of these alternatives. While the salmon diverted through Georgiana Slough would probably survive better than they do now, due to better flow conditions in the San Joaquin Delta, particularly under Alternative 3, diversion effects on salmon smolts migrating from the Sacramento system are likely to be similar to those under Alternative 1.

Overall then, the Ecosystem Restoration program will reduce diversion impacts on fish significantly under all three conveyance alternatives, conveyance alternatives 1 and 2 will cause similar additional reductions, for different reasons, and conveyance alternative 3 will provide the greatest reduction in diversion effects (Figure 4).

Figure 4 - Diversion Effects on Fisheries

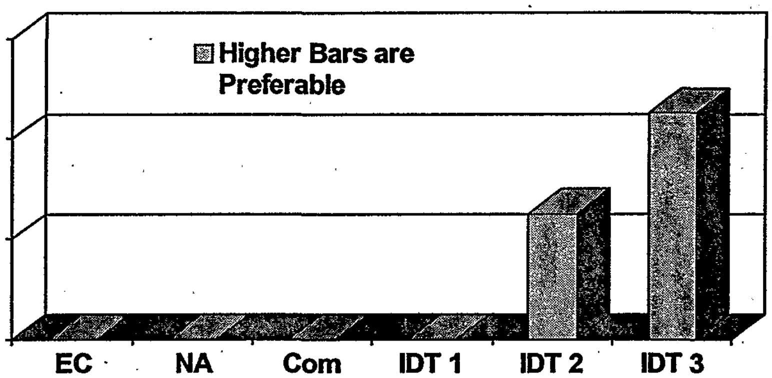


Delta Flow Circulation Effects on Fisheries- This distinguishing characteristic deals with the direct effects of water flow circulation in the Delta on fishery resources. The normal ecological condition in most estuaries is to have water flows alternating between flowing upstream and downstream, due to the action of the tides, but to have the magnitude of flows during ebb tides exceed those during flood tides. The predominance of ebb tide flow is caused by the river flow entering the estuary. The result is a net downstream flow towards the ocean throughout the estuary.

Fishery resources and the aquatic invertebrates, which make up much of their food supply, have adapted to such normal flow patterns in a number of ways. Many fish spawn farther upstream than their prime nursery areas in the expectation that their young will be transported downstream by the currents when they are too small to have much swimming ability. Fishes included in group 1 general have this behavior, with most of them spawning in the spring. Adults depend on the currents either directly or indirectly by transmitting odors from their home streams for important queues guiding their upstream migrations. A more subtle dependence is the strategy of many invertebrates and young fish to rise farther off the bottom during flood tides than ebb tides to help maintain their location in the estuary.

In the Delta, that normal ecological condition has been changed primarily by the CVP/SWP pumps being located in the south Delta and the majority of water exported by them coming from the Sacramento River. The result is that the magnitude of flood tides exceeds the magnitude of ebb tides causing a net upstream flow throughout much of the Delta much of the time, as is illustrated in Figure 1. The result is that many fish and aquatic invertebrates do not have the flow conditions they have evolved to rely on and suffer various adverse consequences.

Figure 5 - Flow Circulation Effects on Fisheries

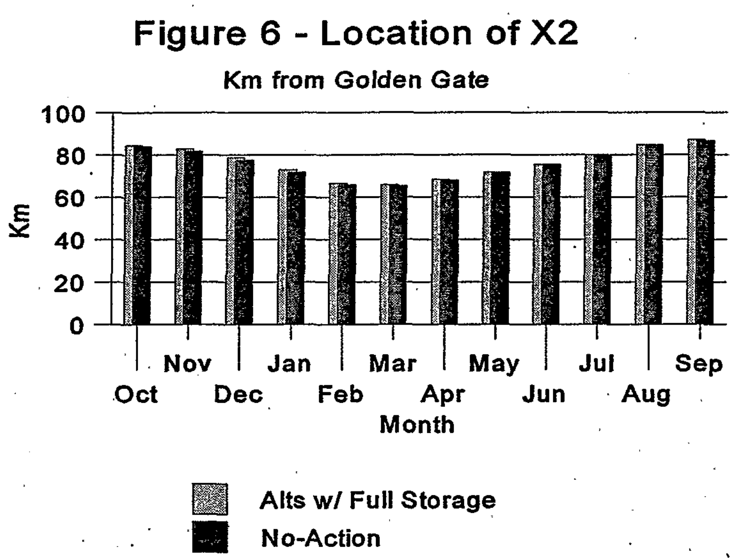


Brackish Water Habitat- This characteristic relates to the location of brackish water habitat in the Western Delta and Suisun Bay. That location of this habitat is a function of the magnitude of Delta outflow. A panel of scientists convened during the development of the Comprehensive Conservation Management Plan (CCMP) by the San Francisco Estuarine Project reached a consensus that the best indicator of the location of this brackish water habitat is the location of 2,000 parts per million total dissolved solids or X2. Hence, X2 is currently used as the primary indicator in managing Delta outflows.

The X2 indicator is used to reflect a variety of biological consequences related to the magnitude of fresh water flowing downstream through the Estuary and the upstream flow of salt water along the bottom in the lower portion of the estuary. It involves both the downstream transport of animals such as delta smelt and striped bass; and the upstream transport of others such as bay shrimp and Dungeness crabs. The abundance of some animals is positively related to the magnitude of downstream flow during the late winter and spring. These animals include bay shrimp, longfin smelt and starry flounder. The evidence of such relationships led to the existing standards concerning X2. Many people believe that this evidence indicates that reduced freshwater flows in the estuary resulting from consumption of water in the basin and exports from the basin have degraded habitat quality for aquatic resources.

Brackish water habitat was identified as a distinguishing characteristic because of concern that the CALFED alternatives would result in further decreases in freshwater flows, with the greatest concern being for flows in the winter and spring. The principal concern is that the degree to which conditions better than that required by the existing X2 standards would be diminished.

Comparison of the No-Action Alternative to the CALFED alternatives with the full new water supply storage being considered by the program indicates very little difference in the average monthly location of X2 between the No-Action and project conditions (Figure 6).



Operations studies for the 1922 through 1992 period indicate the average difference in location of X2 for November through June is about 0.3 km. For dry and critical years, the average difference in location is about 0.2 km. These differences indicate a small incremental decrease in freshwater flow due to the program, but one which is so small that the biological response would not be measurable.

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