October 31, 2016

Josie McKinley
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Re: **Technical Memorandum: CDP Fish Return Discharge Alternatives Analysis**

Dear Josie,

I am pleased to submit HDR's final technical memorandum which constitutes further analysis of the alternative fish return discharge locations for the Carlsbad Desalination Plant. I look forward to discussing our findings with you at your earliest convenience.

Sincerely,
HDR Engineering, Inc.

Timothy M. Hogan

Tim Hogan
Project Manager

Final Technical Memo: CDP Fish Return Discharge Alternatives Analysis

Introduction

Poseidon Water (Poseidon) has developed a conceptual design for the New Screening/Fish-friendly Pumping Structure that will be implemented when the Carlsbad Desalination Plant (CDP) enters long-term, stand-alone operation following decommissioning of the Encina Power Station (EPS). At that point, the CDP will need to comply with the provisions of Chapter III.M of the Water Quality Control Plan, Ocean Waters of California (Desalination Amendment). The long-term, stand-alone CDP will install 1-mm modified (referring to the presence of fish protection features) traveling water screens, designed with a through-screen velocity of 0.5 feet per second (ft/sec) or less, to return collected organisms and debris to Agua Hedionda Lagoon or the Pacific Ocean via the discharge pond.

Modified traveling water screens require fish return systems to safely transport collected organisms from the screen back to the waterbody. The fish return/debris design must minimize, to the extent practical, abrasion, turbulence, shear, and excessive velocity for transported fish. It is critical that the fish return also has sufficient water depth to transport organisms, sufficient velocity to flush organisms towards the discharge point, a means to protect organisms from avian and/or terrestrial predators, and a discharge point that minimizes the risk of recirculating organisms back to the intake.

The initial conceptual design presented in the original Carlsbad Desalination Plant Intake/Discharge Feasibility Assessment (Feasibility Study) dated August 27, 2015 routed the fish return so that organisms would be discharged to Agua Hedionda Lagoon (Lagoon). The CDP Intake/Discharge Feasibility Study Addendum (Addendum) dated August 12, 2016 introduced a second potential fish return discharge location in the EPS discharge pond. A separate technical memo (Comparison of the CDP Fish Return in the Discharge Pond and Agua Hedionda Lagoon, dated August 10) was submitted comparing the two discharge locations in greater detail.

During the September 27, 2016 meeting with staff from the State Water Resources Control Board and the San Diego Regional Water Quality Control Board (the Boards), additional analysis was requested of the two alternative discharge locations. Staff requested additional information that can be used in their effort to reach a determination on the alternative that results in the least intake and mortality of all forms of marine life. Therefore, the objective of this technical memorandum (memo) is to compare the two alternatives to, where possible, quantify the impacts of each alternative fish return discharge location. To do this, the memo is structured to: 1) describe the modified fish return design for the CDP, 2) define each component in a fish return system that has potential to negatively affect organism survival, 3) determine (comparatively for each alternative) the level of impact associated with each component, and 4) discuss the issue of predation at the fish return discharge.

Description of Modified Fish Return System

HDR prepared a technical memo to evaluate the feasibility of re-routing the fish return so that collected organisms and debris are returned to the EPS discharge Pond (Comparison of the CDP Fish Return in the Discharge Pond and Agua Hedionda Lagoon, dated August 10, 2016). After the September 27, 2016 meeting with the Boards, Poseidon implemented a design change to help address the concern over the effluent from the fish return (whether to the Lagoon or Pond).

The previous design included a single combined fish and debris return trough. Fish and debris removed by both the low- and high-pressure spray washes, respectively, would combine into a single pipe before being returned to one of two alternative discharge points. A combined trough would minimize capital and O&M costs, but would result in a combined discharge of debris and organisms. Separate troughs would allow the debris to be separated from the organisms. By separating the debris component from the fish return directed to the lagoon, there would be fewer concerns about debris buildup in the lagoon.

The modified fish return design will utilize two separate troughs, one for debris and one for fish. The Bilfinger Water Technologies (BWT) screens (or similar) are provided with the means to collect fish and debris separately (Figure 1). The fish and debris troughs would transition to separate fish and debris return pipes. The fish pipe could be routed to either the Lagoon or the Pond; whereas, the debris pipe will only be routed to the Pond (Figure 2).

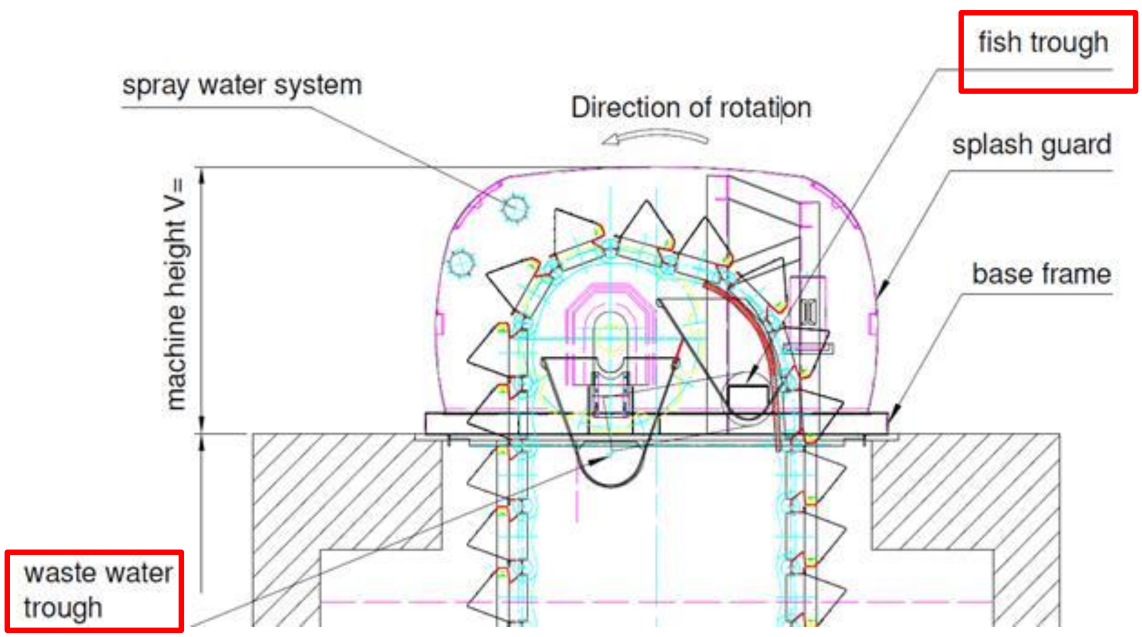

Figure 1. View of the separate fish and debris troughs (in red boxes) integrated into typical traveling water screens (courtesy Bilfinger Water Technologies).

Fish-friendly screens have two stages of spraywash rinsing. First, a low pressure spraywash system is designed to gently rinse fish from the screen face into a fish trough after which a high pressure spraywash system is designed to more powerfully rinse debris into a debris trough. Although the screens and return systems would be designed to separate organisms and debris to the greatest extent possible, it is important to note that some fish are likely to end up in the debris return and some debris is likely to end up in the fish return.

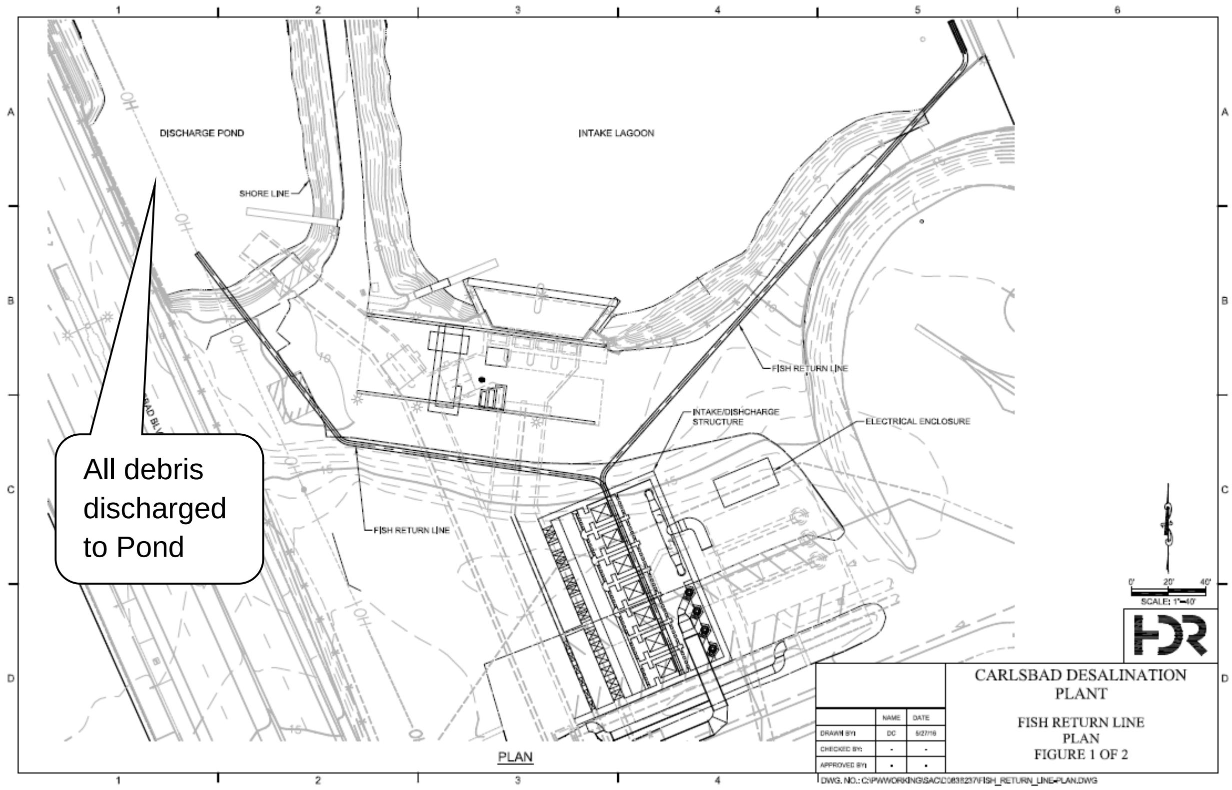

Figure 2. Long-term, stand-alone CDP New Screening/Fish-friendly Pumping Structure showing the routing of the separate fish and debris return systems

Injury and Mortality Factors

Properly designed fish return systems can do an excellent job of safely returning collected fish to the waterbody. However, there are a number of components that require particular attention if the fish return is to operate successfully for the safe handling and return of marine life. Each of the characteristics listed in Table 1 has potential to affect organism survival and should be considered during selection of the least impactful alternative. If properly designed, stress during transport through a fish return system can be greatly minimized. Design criteria from two sources are presented in Table 1. It is important to note that fish return guidelines are sparse; the two used here include one developed by the National Marine Fisheries Service (NMFS 2008) for migratory salmon in the Northwest U.S. and another which is a suggested list of criteria proposed by a National Pollutant Discharge Elimination System (NPDES) permit applicant.

Table 1 provides a comparison between the two fish return discharge alternatives. The components/characteristics evaluated can be grouped generally into those that are inherent to the design of the fish return and those that are related to the receiving water. Thus, the sections below parse the discussion into those two groups.

Table 1. Summary of the fish return design components that can impact survival/mortality, design criteria for those components, and a comparative analysis of which alternative minimizes the risk of intake and mortality of all forms of marine life.

Component	Potential Impact on Collected Organisms	Guideline		Comparison of Alternatives		Alternative with Least Impact
		NMFS Anadromous Salmon Passage Facility Design (NMFS 2008)	Public Service New Hampshire - Merrimack Station	Lagoon Discharge Alternative	Pond Discharge Alternative	
Water depth in conveyance	Can result in abrasion (e.g., scale loss) if flow depth is too shallow	40% of pipe diameter	4-6 inches	Minimum of 4 inches, to be finalized during design	Minimum of 4 inches, to be finalized during design	Equal
Water velocity in conveyance	Can promote fighting of flushing flow if velocity is too low. Fighting discharge current can lead to exhaustion upon discharge	6-12 ft/sec, no lower than 2.0 ft/sec to prevent sedimentation	3-5 ft/sec, slope not to exceed 1/16 ft drop per linear ft	Range between 5-7 ft/sec, to be finalized during design	Range between 5-7 ft/sec, to be finalized during design	Equal
Water velocity at discharge		less than 25 ft/sec impact velocity	NA	Higher than velocity in conveyance due to steeper slope	Higher than velocity in conveyance due to steeper slope	Equal
Water quality in return	Deterioration of water quality (temperature increase/decrease) can stress organisms	NA	NA	Return is longer - approximately 380 ft; however, pipe will be buried and insulated against temperature changes	Return is shorter - approximately 280 ft; however, pipe will be buried and insulated against temperature changes	Equal
Return length	Longer returns result in greater risk of clogging	NA	NA	Greater risk of clogging may create risk of injury to transported organisms	Lower risk of clogging will have comparatively lower risk of injury to transported organisms	Pond

Component	Potential Impact on Collected Organisms	Guideline		Comparison of Alternatives		Alternative with Least Impact
		NMFS Anadromous Salmon Passage Facility Design (NMFS 2008)	Public Service New Hampshire - Merrimack Station	Lagoon Discharge Alternative	Pond Discharge Alternative	
Hydraulic jumps	Hydraulic jumps/pressure changes between open channel and piped flows or free falls within the return trough/pipe can result in physical trauma to transported organism	None allowed in conveyance	NA	Will avoid hydraulic jumps during design	Will avoid hydraulic jumps during design	Equal
Discharge depth	Minimum water depth to minimize risk of impacting the bottom of the receiving water	Must be sufficiently deep to prevent injuries and impact with bottom	Must be slightly below the water level at all times	Target a minimum of 5 ft at MLLW	Target a minimum of 5 ft at MLLW	Equal
Receiving water quality	Discharging collected organisms to poor water quality can negatively health and survival	NA	NA	Quiescent receiving water is the same as the water from which the organism came - no water quality issues	Pond is comparatively turbulent and receiving water is slightly elevated in salinity	Lagoon
Receiving water habitat				Same as the water from which the organism came; but modeling studies indicate that within two days the organisms in outer lagoon will be transported to the	Manmade pond, riprap channel, soft bottom surfzone habitat.	Lagoon

Component	Potential Impact on Collected Organisms	Guideline: NMFS Anadromous Salmon Passage Facility Design (NMFS 2008)	Guideline: Public Service New Hampshire - Merrimack Station	Comparison of Alternatives: Lagoon Discharge Alternative	Comparison of Alternatives: Pond Discharge Alternative	Alternative with Least Impact
				ocean on the outgoing tide.		
Transitions	If not smooth, transition between pipe or trough sections can result in abrasion of fish (e.g., scale loss). Non-smooth transitions can also promote the accumulation of debris in the return system	Must have smooth surfaces to provide conditions that minimize turbulence, the risk of catching debris, and the potential for fish injury	NA	Return flow transitions from open trough in screen house to pipe flow (partially filled) to open tough at the discharge end in lagoon	Return flow transitions from open trough in screen house to pipe flow (partially filled) to open tough at the discharge end in pond	Equal
Bends	Sharp radius bends can increase turbulence and shear in the return flow increasing potential for disorientation upon discharge	Ratio of bypass pipe center-line radius of curvature to pipe diameter (R/D) must be greater than or equal to 5.	No sharp-radius turns, nothing greater than 45 degrees	Other than initial bend after exiting screen house, there is only one additional bend that is under 45 degrees	Other than initial bend after exiting screen house, there is only one additional bend that is under 45 degrees	Equal
Materials	Internal surfaces of return trough or pipe must be smooth to minimize abrasion	NA	NA	Smooth pipe (HDPE, FRP, or coated steel)	Smooth pipe (HDPE, FRP, or coated steel)	Equal

Component	Potential Impact on Collected Organisms	Guideline		Comparison of Alternatives		Alternative with Least Impact
		NMFS Anadromous Salmon Passage Facility Design (NMFS 2008)	Public Service New Hampshire - Merrimack Station	Lagoon Discharge Alternative	Pond Discharge Alternative	
Predation [1]	Terrestrial and aquatic predation can increase indirect mortality associated with the fish return	Must locate discharge to minimize avian and aquatic predation; select locations free of eddies, reverse flow, known predator habitat	Removable cover to prevent avian predation	Greater risk of predation given larger volume of receiving water and presence of greater foraging habitat for predators	Less risk of predation given smaller volume of receiving water and comparatively less foraging habitat; pond is turbulent under typical CDP discharge conditions	Pond
Cleaning	Keeping the return clean minimizes the risk of debris clogging, build-up of biogrowth	Design must facilitate inspection and cleaning	Combination of proper design (e.g., material selection, flow velocity, coatings) and non-toxic physical cleaning with a pig	Combination of proper design (e.g., material selection, flow velocity, coatings) and non-toxic physical cleaning with a pig. Discharge of higher TSS effluent after pigging could impact eelgrass	Combination of proper design (e.g., material selection, flow velocity, coatings) and non-toxic physical cleaning with a pig. Discharge of higher TSS effluent after pigging poses less of a risk to marine life	Pond
Construction method	Construction of the discharge end of the return can impact benthic habitat	NA	NA	Plan to support discharge from existing pier piles; if not possible, will need to support with a piles driven in lagoon.	Plan to support discharge from a piles driven into pond.	Equal

[1] GREATER DETAIL ON PREDATION IS GIVEN BELOW IN THE SECTION TITLED

Literature Review - Predation.

Design-related Factors

There are very few design details that can be used to differentiate which may result in lower intake and mortality for all forms of marine life. Of the engineering details, fish return length and the cleaning of the pipelines are the only two components that stand out as a measurable difference.

Fish return length cannot be designed out of the facility; it is a product of the location of the screening structure, the feasible alignment of the fish return pipe, and the location that has been identified as best for the discharge of collected organisms. The longer length required for Lagoon alternative means that collected organisms would have a longer travel time than for the Pond alternative. That said, since the pipe will be buried, the risk posed by temperature change (heating or cooling) is minimal and would not be expected to be significantly different between the two alternatives.

Fish return cleaning would be approached in a similar manner for both alternatives with the objective being to minimize (by design) the probability of settlement of debris and biofouling organisms. However, to the extent that debris or fouling organisms accumulate in the fish return system, they must be removed. There is, therefore, potential for debris from cleaning to be discharged from the fish/debris return system, although the frequency of cleaning is likely to be low. Each alternative would include pig launching and retrieval stations to provide the capability to physically clean the internal pipe surfaces without the use of chemicals. Pigging is a process used to clean (and inspect) pipelines by creating a pressure differential behind a device referred to as a “pig” to drive it through a pipe. The retrieval system (e.g., screened basket) would be installed at the discharge end of the return pipe (whether to the Lagoon or the Pond) to catch the pig and coarse debris that has been dislodged. The basket mesh would allow water to drain while retaining the debris material. The water would likely be high in total suspended solids. Between the two alternatives, the discharge of effluent from the cleaning process would be more detrimental to the Lagoon since the Lagoon constitutes more valuable habitat than the Pond.

Receiving Water-related Factors

The factors that are not related to the design of the fish return system include receiving water quality, receiving water habitat, and predation. These factors relate to the chemical and physical constituents as well as the ecology of each waterbody.

A comparative assessment of water quality should include a review of each of the water quality parameters with potential to impact organism health. Table 2 below provides a qualitative comparison of the water quality parameters for each of the two alternative discharge locations.

Based on basic water quality parameters, the quality of the water in the Lagoon is better as it reflects ambient water quality; the Pond does not.

Table 2. Comparison of water quality parameters for the two alternative discharge locations.

	Comparison between Alterntives

Water Quality Parameter	Lagoon	Pond
Dissolved Oxygen	Slightly lower DO than Pond due to less turbulence at proposed discharge location in quiescent zone	Slightly higher DO than Lagoon due to flow turbulence and mixing during discharge process
Salinity	Lower salinity than Pond - at ambient of approximately 33.5 ppt	Higher salinity than Lagoon due to brine and backwash constituents from SWRO treatment
Temperature	Lower temperature than Pond - at ambient	Slightly higher temperature than Lagoon due to the SWRO process imparting some heat (e.g., via pumping).
Total Suspended Solids	Lower than Pond during dry weather, higher during wet weather due to existing stormwater outfall near the proposed fish return discharge location	Higher than the lagoon during dry weather due to CDP discharge; lower during wet weather due to minimal stormwater contribution.

A comparative assessment of the receiving water habitat and the predation risk requires consideration of the physical features (e.g. habitat) in each waterbody and the species composition (whether predatory species have been documented there).

To the extent that the physical properties (depth, substrate, velocities, presence of structure/habitat, presence of other food items) of the waterbodies dictate the potential for predation, discharge of organisms to the Lagoon presents a greater comparative risk by nature of the facts that the Lagoon has:

- a greater waterbody volume which could support a greater predator density than the Pond and
- a greater diversity of habitat (e.g., sand, eelgrass) and anthropogenic structure (e.g., rip rap, piers) which could provide more foraging habitat for more predatory species than the Pond.

Impingement sampling conducted by Tenera (2008) documents the presence of a number of species (e.g., sand basses [*Paralabrax maculatofasciatus* and *P. nebulifer*] and white seabass [*Atractoscion nobilis*]) that are either obligate or opportunistic predators of organisms that may be collected and returned via the fish return system. .

Consideration of predation at the fish return discharge location requires a more thorough review of the relevant literature that discusses the issue of predation. During the September 27, 2016 meeting with the Boards, staff asked about the issue of predation ("fish buffet") at the discharge of fish returns. To expand on the topic of predation at fish return discharges, it is important to note that predation refers to both terrestrial (mostly avian [Figure 3], but small mammal predation can occur at some sites) and aquatic predation.

Figure 3. Avian predator perched on fish return system (left) and fish return properly covered to minimize risk of avian predation (right). Note that the image on the right shows the return trough uncovered up to the high water line so that discharge is always free surface regardless of tidal elevation.

Avian predation can easily be avoided along the return alignment by ensuring the fish return is covered (i.e., nets or solid lid) or, as in the case for the proposed CDP system, it is a pipe. Avian predation at the discharge point can be minimized by exposing only as much of the return trough/pipe as necessary to ensure proper operation (Figure 3).

Aquatic predation is prevalent at most fish return discharges. A literature search was conducted to identify existing information on the issue of aquatic predation at fish return discharges. The following summarizes the results of this literature search.

LITERATURE REVIEW - PREDATION

Love, M.S., M. Sandhu, J. Stein, K.T. Herbinson, R.H. Moore, M. Mullin, and J.S. Stephens, Jr. Analysis of Fish Diversion Efficiency and Survivorship in the Fish Return System at San Onofre Nuclear Generating Station. NOAA Technical Report NMFS 76, April 1989.

This paper describes the efficiency of San Onofre Nuclear Generating Station's (SONGS) intake diversion system and the survival of organisms captured by it. The fish return system is unique in that entrapped fish are guided via hydraulic cues provided by a louver system to a quiescent area of the intake. Once congregated there, a fish elevator raises collected fish to a sluiceway where fish are discharged and flushed with auxiliary flow through a fish return pipe that discharges 400 m (1,312 ft) offshore at a depth of 6 m (20 ft). The overall diversion/return efficiency (as measured by comparing the number of fish returned by the total number entrapped) was generally high (95.7% returned in 1984 and 75.1% retuned in 1985), though there was some variability among taxa. Survival (96-hr hold time) of returned organisms was good for most (94 to 100%), with 2 of the 23 species demonstrating poor survival (25 to 54%).

Love et al. (1989) noted that predation occurs at the SONGS fish return discharge. They state that predatory species congregate near the outfall and have associated the structure with a feeding opportunity. The authors note that non-resident schooling predators pose the greatest risk to discharged fish and although they observed the presence of these predatory species during the daytime, they postulate that predators may also be active at other times of the day or night. Predation at SONGS was not quantified, rather, observation was anectdotal.

Consolidated Edison Company of New York, Inc. and New York Power Authority. 1992. Supplement 1: Indian Point Units 2 and 3 Ristroph Screen Return System Prototype Evaluation and Siting Study.

This is a gray literature industry report. It describes a research program designed to: 1) develop the best fish return discharge location (one that minimizes the risk of recirculation and 2) develop the best fish return system design. Hydraulic modeling was used to identify the best return discharge locations, which were then further evaluated in the field with marker/dye studies to understand recirculation potential. Later, live tagged fish were released to confirm the optimal distance from the intake. Testing done at a quarry on the flume and pipe components of the return system concluded that survival was not affected by the pipe diameter (tested 6- and 10-in diameter), pipe length (tested up to 250 ft), flow rates (tested 245 to 1,000 gpm), velocity (tested 2 to 5 ft/sec), presence of debris in the return system, depth of discharge (tested to 35 ft). These results were used to develop the full-scale fish return design for Indian Point.

This study also included an examination of how to minimize the risk of predation at the discharge point. The authors suggest that the use of multiple discharge locations will help reduce the concentration of predators at any one outfall. However, they also note that although conceptually desirable, the practicality of splitting the return flow can create opportunities for debris build-up in the conveyance system.

Morinaka, J., J. DuBois, and M. Horn. 2010. Release Site Predation Study. State of California, California Natural Resources Agency, Department of Water Resources.

This report describes a study conducted by the CA Department of Water Resources in response to concerns over survival of fishes that are collected and returned at the state and federal water diversion facilities in the Bay Delta. The overall study program focused on the far-field survival of returned fish, predation at the discharge point, and the physical factors affecting injury and mortality at the discharge point.

The release site predation study included predator sampling, mark-recapture, high frequency sonar monitoring, hydroacoustic monitoring, and a bioenergetics-based predator risk analysis. The results of the study on predation at the discharge point revealed that:

- the discharge location included various predatory species,
- many predators demonstrated strong fidelity to for the discharge site
- aggregations of fish at the discharge location were highest during summer, fall, late fall, and early spring which coincided with the highest return rate from the fish return system,
- the discharge location did not have substantially greater density of predators when compared to control sites,
- predation mortality at the release sites is dependent upon the season and biomass of returned organisms discharged, and that
- cormorants and gulls were the predominant avian predators

The authors recommend the following to mitigate the risk of predation at the discharge location:

- avoid discharges to know predator habitat,
- time discharges to avoid peak predator activity period (e.g., dawn and dusk),
- install avian deterrent devices where possible,
- periodically remove submerged debris that can be used as cover for predators,
- design for adequate flushing flows to keep predators from waiting near the discharge point

<u>Summary</u>: Existing literature has documented the presence of predation and approaches for minimizing it at fish return discharge locations whether at thermal power plants, hydropower plants, or water diversion structures. The studies acknowledge that predation is a natural phenomenon that occurs in natural systems.

Furthermore, the mortality associated with predation is not a loss to the ecosystem; rather the biomass and energy of one trophic level is being transferred to the next. This is a distinct improvement over the existing EPS intake which still uses conventional traveling water screens for screening their cooling water flows. Any debris or organisms impinged on the screens is rinsed into a debris pit and disposed of as trash. In such a case, the organismal biomass is a loss to the ecosystem.

The New Screening/Fish-friendly Pumping Structure for the stand-alone CDP has been designed to be compliant with the Desalination Amendment. As such, it has been designed to minimize impingement by ensuring that the through-screen velocity is 0.5 ft/sec of less under all operating conditions. With the inclusion of a redundant screen, the through-screen velocity will be even lower because the system is designed to meet the 0.5 ft/sec requirement with only six screens in operation, but under normal operating conditions all seven screens will be in service. Under these design criteria, impingement of healthy juvenile and adult fish is expected to be very low. If impingement is very low, it reasons that the number of collected and returned organisms should also be very low.

The New Screening/Fish-friendly Pumping Structure has also been designed (per the Desalination Amendment) to use 1-mm screening mesh to minimize entrainment. With mesh of this size, some larvae may be collected (though impingement of healthy juveniles or adults is expected to be very low). Poseidon's analysis of intake impacts has made the conservative assumption of 100% mortality for all larval fish entrained into the intake system, including those larvae that would be collected and returned by the screens. Therefore, the loss of these collected and returned organisms has been accounted for in the mitigation project for the CDP.

In identifying all the factors that must be considered in selecting the alternative fish return discharge location for the CDP that creates the least risk of intake and mortality of all forms of marine life, including predation ensures that the review is comprehensive; however, making predation commensurate with other direct impacts may be overstating the impact since there is no net loss of biomass to the ecosystem. Predation as a cause of indirect mortality is common to both discharge locations, although based on the nature of the Lagoon, predation is likely to exert a greater effect on returned organisms there (Table 1).

Technical solutions to predation are very difficult to develop as any interference with wildlife is typically discouraged by resource agencies. A more realistic approach to managing the risk of predation is to make design decisions to reduce the potential for predation. For example, careful consideration of the discharge location and installation of avian deterrent devices can be effective for ensuring that predation is minimized to the greatest extent possible.

References

Consolidated Edison Company of New York, Inc. and New York Power Authority. 1992. Supplement 1: Indian Point Units 2 and 3 Ristroph Screen Return System Prototype Evaluation and Siting Study.

Love, M.S., M. Sandhu, J. Stein, K.T. Herbinson, R.H. Moore, M. Mullin, and J.S. Stephens, Jr. Analysis of Fish Diversion Efficiency and Survivorship in the Fish Return System at San Onofre Nuclear Generating Station. NOAA Technical Report NMFS 76, April 1989.

Morinaka, J., J. DuBois, and M. Horn. 2010. Release Site Predation Study. State of California, California Natural Resources Agency, Department of Water Resources.

National Marine Fisheries Service (NMFS). 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

Tenera Environmental (Tenera). 2008. Clean Water Act Section 316(b) Impingement and Entrainment Characterization Study: Effects on the Biological Resources of Agua Hedionda Lagoon and the Nearshore Ocean Environment.