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Mitigation and Fees for the Intake of Seawater by Desalination and Power Plants

Final report submitted to Dominic Gregorio, Senior Environmental Scientist, Ocean Unit, State Water Resources Control Board (SWRCB) in fulfillment of SWRCB Contract No. 09-052-270-1, Work Order SJSURF-10-11-003

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Background

Raw seawater is used for a variety of purposes, including as source water for desalination plants and to cool coastal power plants. Raw seawater is, however, not just cold and salty but an ecosystem that contains diverse and abundant organisms including the young stages of numerous invertebrates and fishes. Whether impinged (large individuals stuck on screens prior to entering the plant or killed during other plant processes such as heat treatment) or entrained (small individuals carried into the plant with the water) the organisms are killed, essentially eliminating the living production in the water used (review in York and Foster 2005). Considerable research has have been done in California to better estimate losses to this ecosystem by coastal power plant intakes (York and Foster 2005, Steinbeck et al. 2007), and to determine how these losses can be mitigated (Strange et al. 2004).

The information from this research has contributed to State of California policy regulating water used by power plants (policy at http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/docs/policy100110.pdf). The policy now applies only to power plants but the intent to protect marine organisms is also broadly applicable to desalination plants and other users of large volumes of seawater. The State's Once-through Cooling Policy (Policy) states that plants must implement measures to mitigate interim impacts occurring after October 1, 2015, and until the plant comes into full compliance through conversion to closed cycle cooling or by using operational controls and/or structural control technology that results in comparable reductions in impingement and entrainment (IM&E).

The SWRCB is currently developing a policy for addressing desalination plant intakes and discharges which will be instituted through amendments to the Ocean Plan and Enclosed Bays and Estuaries Plan (statewide water quality standards). The California Water Code currently requires new or expanded industrial facilities (e.g., desalination plants) to use the "best available site, design, technology, and mitigation measures feasible" to minimize the intake and mortality of marine life (see the Ocean Plan Triennial Review 2011-2012 Work-plan at http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2011/rs2011

_0013_attach1.pdf). The panel's assumption, based on SWRCB direction, is that the "best site, design and technology" would be employed prior to mitigation measures. Mitigation measures would be applied to compensate for any the residual impacts.

The staff of the SWRCB requested the formation of an expert review panel (chaired by Foster and composed of the authors of this report) to assist in answering questions related to present policy concerning interim mitigation for impacts from power plant intakes and future policy concerning mitigation for impacts caused by the intakes of desalination plants. The issues and questions for the panel to address were:

A. Power Plants: Provide a scientifically defensible basis and unit cost for a fee paid by power plants based on the volume of cooling water used. This fee would be used for mitigation projects to compensate for continued impacts due to IM&E during the interim period after October 1, 1015 and until a plant comes into full compliance with the Policy.

B. Desalination Plants: How should any remaining IM&E be mitigated after the best site, design and technology are determined for a new desalination plant intake?

C. Desalination Plants: Are there desalination intake technologies and designs that can reduce IM&E?

The panel met twice to discuss the questions and possible answers, and panel members Steinbeck and Raimondi prepared three reports as Appendices 1, 2 and 3 to this report. Appendix 1 develops a fee-based approach to questions A. and B. based on the cost of replacing the habitat production lost due to entrainment. Appendix 2 develops a fee-based approach to questions A. and B. based on the loss of adult equivalent fish due to entrainment. Appendix 3 addresses question C. with a review of the efficacy of desalination plant intake technologies and designs in reducing IM&E. The panel recommendations below are based on these reports, discussions and experience from prior assessments and mitigation for power plant intake impacts in California. The panel also held a public meeting on March 1, 2012, presented their recommendations, and received comments, some of which were incorporated into this report.

Alternatives and Recommendations

A. *Interim Mitigation for Power Plants*

1. Given uncertainties about the length of time for interim impacts and amount of water a particular power plant may use while in interim operation, interim mitigation should be fee-based according to the amount of water used ($/Million Gallons (MG)).

2. One alternative is a fee based on Adult Equivalent Loss (AEL), the number of adult fishes eliminated by the entrainment of larval fishes plus fish losses due to impingement (Appendix 2). This fee was estimated for comparison to the APF-based fee (see 3. below) using data and analyses for the Huntington Beach Generating Station (HBGS). The average fee using this estimate and including indirect economic losses is $0.77/MG. This

fee, however, only compensates for economic losses of adult fishes and is, therefore, not recommended.

3. The other alternative is a fee for interim mitigation based on the costs of mitigation already determined for some power plants using Area of Production Foregone (APF; Appendix 1). This fee is based on the cost of creating or restoring habitat that replaces the production of marine organisms killed by entrainment. The APF method is preferred because creation and restoration of coastal habitats compensates for all organisms impacted by entrainment, not just select groups such as fishes. The average fee, based on existing examples of mitigation for power plant entrainment, adjusted for inflation, and assuming a 50 year half- life for the habitat produced, is $2.45/MG (range: $1.66 - $3.28; Appendix 1). The fee is linearly proportional to half-life so, for example, if the half- life of a project was 25 years the fee would double. This fee does not include the cost of management and monitoring after implementation. Management and monitoring costs typically range from 10 - 25% of projects costs (Appendix 1). The fee also does not account for impacts due to impingement. These could be determined using the value (cost/pound) of fishes impinged/MG plus the indirect economic value of the fisheries (see Appendix 2). For example, average annual impingement of fishes from normal operations and heat treatments at HBGS from 2000-2010 was 2,686 lbs. (Appendix 2, Tables 1 and 5). Using the value for fishes estimated from catch totals plus the average indirect economic value (see Appendix 1) yields a total value of ~ $0.80/lb., and an average annual value of fishes impinged of ~ $2,150.00. Divided by the average annual intake flow of 92,345 MG (Appendix 2, Table 5), the average annual mitigation fee for impingement at HBGS during this period would be ~ $0.023/MG.

Creating open coast soft bottom habitat as mitigation for impacts is unreasonable given the ubiquity of such habitat and that other habitat types provide more biodiversity value. In such cases restoration or creation of estuarine or rocky habitat would be more beneficial, and this was done for the HBGS case study used in the above analyses (for further information on this approach see http://www.energy.ca.gov/sitingcases/huntingtonbeach/compliance/2006-07-14_staff_analysis.pdf).

4. An APF-based fee for entrainment could be determined for each plant but the process could be complex and expensive, especially if a suitable entrainment study is not available. Moreover, while the amount of habitat required to be directly compensatory can be estimated for intakes entraining or impinging mainly estuarine or rocky reef species (examples in Appendix 1), impacts to open coast soft bottom species are more difficult to deal with using habitat restoration or creation. Given the relatively small range of fees based on power plants for which the cost of creating habitat equivalent to APF has been determined (see 3. above) the simplest approach for entrainment mitigation would be to use the average fee and apply it to all intakes. Impingement, however, varies greatly among power plants so one fee for all is inappropriate for this impact. The interim mitigation fee for impingement could be determined from ongoing impingement/heat treatment monitoring at each plant, modified as necessary to insure the weight of fishes impinged is determined.

5. The fees, either from individual power plants or groups of power plants, should be used for habitat creation, restoration, protection or other projects that best compensate for the impacts in the region where they occur. In cases where habitat creation or restoration is not feasible, alternatives could include implementation of marine protected areas with limited or no take; such areas may produce healthy, fecund adult populations which, in turn, can produce and provide more offspring to the greater marine environment. Alternatives could also include potentially in-kind but indirect mitigation such as clean-up or abatement of contaminants, and restoration or creation of habitat critical to other marine species (e.g. rocky reef or estuarine) based on habitat-specific larval productivity; for example, mitigation that is viewed as critical to the State's resources such as funding for white abalone restoration. One potential advantage of the fee based approach is that funds could more easily be aggregated if more costly projects are likely to provide the highest mitigation value.

6. Costs associated with the planning and management of mitigation projects should be minimized to achieve maximum compensation for impacts.

B. *Mitigation for Desalination Plants*

7. Ocean intakes at desalination plants can cause IM&E impacts like those of a power plant intake. The primary difference is in magnitude; desalination plants generally use less water than power plants. Therefore, a similar, fee-based approach to mitigation for such desalination plants is appropriate and could use the same fee/MG based on APF (3. and 4. above) for any impacts that remain after the best site, design and technology have been used. The fee should be used as for power plants (5. and 6. above).

C. *Intake Designs and Technologies for Impact Reduction at Desalination Plants*

8. This report does not address biological impacts that may be associated with the variety of subsurface intake technologies, some of which are described in the intake technology review (Appendix 3). However, any biological impacts associated with a properly designed, constructed, and operated subsurface intake should be minimal since the withdrawal velocity through the sediment is very low. Such intakes, however, may not be feasible at some locations and for large plants (Appendix 3). Large beach galleries or seabed filtration systems may have low IM&E impacts but large construction impacts on benthic organisms. Such construction impacts should be thoroughly evaluated for any projects proposing such intakes.

9. Wedge wire screens and a variety of other passive and active devices have been used or proposed for use on surface intakes to reduce IM&E (Appendix 3). Initial pilot studies of wedge wire screens indicate they have little effect on the number of small fish eggs and larvae entrained, but reductions in entrainment of larger larvae may provide some benefit by protecting older larvae that have a greater likelihood of becoming adults (see analyses in Appendix 3). A more thorough assessment of the effectiveness of wedge wire screens is underway in Redondo Beach for the West Basin Municipal Water District,

including observations on impingement and behavior of larvae that encounter the screens but are not entrained, but the results are not yet available. While their effects on entrainment may be small, such screens have potential to eliminate impingement of juvenile and adult fishes if properly designed and located. Other entrainment reduction technologies for surface intakes have not been evaluated in the coastal waters of California.

Some desalination projects are considering deep water surface intakes as a possible way to reduce entrainment. If a deep water intake is proposed, suitable, site-specific studies of shallow versus deep water larval abundance and species composition must be done to determine differences in entrainment.

10. Some desalination projects are considering augmenting their intake of seawater for the sole purpose of diluting the discharged brine to meet toxicity objectives. Entrainment mortality of organisms in the intake water used solely for dilution purposes should be assumed to be 100% (unless suitable studies demonstrate otherwise) and fully mitigated, if allowed. However, this scenario is not recommended as many more organisms may be killed through entrainment and impingement than saved from exposure to high brine concentrations.

Literature Cited

Strange, E., Allen, D., Mills, D., and Raimondi, P. 2004. Research on estimating the environmental benefits of restoration to mitigate or avoid environmental impacts caused by California power plant cooling water intake structures. CEC Report 500-04-092. California Energy Commission, Sacramento

Steinbeck, J., Hedgpeth, J., Raimondi, P., Cailliet, G., and Mayer, D. 2007. Assessing power plant cooling water intake system entrainment impacts. CEC Report 700-2007-010. California Energy Commission, Sacramento.

York, R. and Foster, M.S. 2005. Issues and environmental impacts associated with once-through cooling at California's coastal power plants. CEC Report 700-2005-013 + Appendices (CEC 700-2005-013-AP-A). California Energy Commission, Sacramento

Attachments

Appendix 1. What should be the cost per million gallons for power plant once-through cooling interim mitigation, using entrainment weighted flow and examples of existing mitigation projects? By Peter Raimondi. 4 pages.

Appendix 2. Example of Costing IM&E Losses from Huntington Beach Generating Station. By John Steinbeck. 8 pages + Attachments.

Appendix 3. Desalination Plant Intake Technology Review. By John Steinbeck. 12 pages + Attachments