CDP # 6-81-330-A
CONCURRENCE WITH ED'S DETERMINATION - BEHAVIORAL BARRIERS

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EXECUTIVE DIRECTOR'S DETERMINATION THAT FISH BEHAVIORAL BARRIERS TESTED AT SONGS ARE INEFFECTIVE

Following is a report on one of the mitigation requirements of Southern California Edison Company's (SCE) coastal development permit for the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 (permit no. 6-81-330-A, formerly 183-73). The purpose of this report is to present to the Commission for discussion and possible action the Executive Director's determination that (1) the fish behavioral barriers installed and tested at the plant were ineffective and unlikely to result in a two metric ton (MT) reduction in fish impingement losses as required by Condition B of the permit, (2) no currently available alternative behavioral barriers are likely to be effective or feasible in reducing fish losses as required by Condition B, and (3) a procedural modification made by SCE in the heat cleaning treatment of the cooling water intake systems of SONGS Units 2 and 3 has reduced fish losses on average by approximately 4.3 MT per year. Based on this determination, the Executive Director has concluded that no further testing of alternative behavioral barriers should be required at this time, provided that Southern California Edison adheres to the operating and monitoring procedures specified in this report to ensure that the annual average reduction in the loss of fish does not increase from current levels.

EXECUTIVE SUMMARY

Background

The Coastal Commission's 1991 SONGS permit conditions (as amended April 1997 and October 1998) require the permittee, Southern California Edison and its partners, to implement a comprehensive mitigation package to address significant marine resource impacts caused by the operation of Units 2 and 3 of the San Onofre Nuclear Generating Station. These mitigation conditions were the result of environmental impact studies conducted by an independent Marine Review Committee. One component of the permit is Condition B: Behavioral Barriers Mitigation. This condition requires SCE to install and maintain behavioral barrier devices, including, but not limited to, mercury lights and sonic devices, in Units 2 and 3 to reduce fish impingement losses.

Between 1983 and 1991 the Marine Review Committee found that annual losses of juvenile and adult fish in the cooling water systems of SONGS Units 2 and 3 under normal operations averaged about 20 metric tons. Although the SONGS permit does not specify any criteria for evaluating the effectiveness of these devices, the recommendation of the Marine Review Committee (Section IV–Proposed Findings and Declarations in the SONGS 1991 permit) was that "the techniques" (behavioral barrier devices) "be tested on an experimental basis, and implemented if they reduce impingement by at least 2 metric tons (MT) per year".

Beginning in 1991, prior to the imposition of Condition B, SCE modified its procedure for its heat cleaning treatment of the cooling water intake systems of Units 2 and 3. This modification (termed the Fish Chase procedure) has reduced in-plant fish losses on average by approximately 4.3 MT per year.

Compliance with Fish Behavioral Barriers Mitigation Condition

To comply with Condition B, SCE installed mercury vapor lights in Units 2 and 3 in September 1992 and tested them for approximately one year. Scientists contracted by the Commission evaluated the results of this experiment in a number of ways. No clear conclusion could be reached concerning the effectiveness of the lights.

In 1994 the staff instructed SCE to conduct a series of laboratory and in-plant experiments to test the behavioral response of fish to lights and sound. (At this time the staff also informed SCE that if the experiments indicated that the installed devices would not decrease fish impingement losses by 2 metric tons per year, then compliance with Condition B would be attained without further testing provided the modified heat cleaning treatment (i.e., Fish Chase procedure) was maintained for the operating life of Units 2 and 3.) Pursuant to this instruction, SCE conducted laboratory studies from 1995 to 1997 on the behavioral response of fish to different intensities of light and different frequencies of sound. Results of these experiments indicated that certain species of fish displayed behavioral responses to incandescent light and sound that could be exploited to reduce impingement in the cooling system. However, the use of sonic devices in the plant was determined not to be feasible due to the logistic difficulty and high cost of reproducing in the plant the frequencies and intensities of sound that were needed to elicit a behavioral response in the laboratory. Staff then instructed SCE to begin in-plant testing using incandescent lights. Installation of the lights in Units 2 and 3 was completed in December 1998 and a three-phased experiment investigating the effect of these lights in reducing fish losses was conducted between February and December 1999. Results from these experiments showed no evidence that using lights in the cooling water systems of Units 2 and 3 would reduce fish impingement losses. Consequently, the Executive Director has determined that the lights and sound devices tested by SCE are not effective as fish behavioral barriers at SONGS.

Although the MRC had recommended testing lights and sound devices as the most promising effective behavioral barriers to reduce fish impingement losses, SCE, in consultation with the Commission's contract scientists, considered other alternatives, including strobe lights, air bubble curtains, pneumatic guns, poppers and electrified nets. Most of these deterrents were inconsistent, either from site to site or from species to species. Some cause adverse effects to marine life and others presented severe installation and maintenance concerns. As a result, the Executive Director also has determined that there are no alternative behavioral barriers that are likely to be effective or feasible at SONGS.

The Executive Director has concluded that no further testing of alternative behavioral barriers should be required at this time. Compliance with the requirements of Condition B will be satisfied provided that SCE (1) continues to implement the modification in its heat cleaning treatment that has resulted in an annual average reduction in the loss of fish of 4.3 MT (i.e., the Fish Chase procedure), and (2) monitors its effectiveness.

Commission Action

No formal Commission action is necessary. If the Commission agrees with the Executive Director's determination, the Executive Director will issue a condition compliance letter to SCE with this report as supporting evidence.

EXECUTIVE DIRECTOR'S DETERMINATION THAT FISH BEHAVIORAL BARRIERS TESTED AT SONGS ARE INEFFECTIVE

A. BACKGROUND

On July 16, 1991, the Coastal Commission found, based on long-term studies by the Marine Review Committee (MRC), that SONGS Units 2 and 3 cause significant adverse impacts to the marine environment and further conditioned the SONGS permit (6-81-330-A, formerly 183-73) to require implementation of a mitigation package. One of the conditions of the package was the installation and maintenance of fish behavioral barriers that reduce fish impingement losses in SONGS Units 2 and 3 (Condition B).

Condition B states:

> The permittee shall install and maintain behavioral barriers including but not limited to mercury lights and sonic devices at SONGS Units 2 and 3 to reduce midwater fish impingement losses. Within six months of the effective date of this permit amendment, the permittee shall submit a plan for installation of behavioral devices to the Executive Director for review and approval. Within 3 months of the Executive Director's approval, the permittee shall install the required devices.
>
> In consultation with the permittee, the Commission staff will monitor the effectiveness of the behavioral devices. If the Executive Director determines that the installed devices are not sufficiently effective to warrant continued use, the Executive Director may require removal and installation of alternative behavioral devices.

While no specific criteria are included in Condition B for evaluating the effectiveness of the devices, the recommendation of the MRC (Section IV–Proposed Findings and Declarations in the SONGS permit) was that:

> ... the techniques [behavioral barrier devices] be tested on an experimental basis, and implemented if they reduce impingement by at least 2 metric tons (MT) per year.

B. REVIEW OF FISH BEHAVIORAL BARRIER MITIGATION

1. Description of Potential Usefulness of Behavioral Barrier Devices

Normal Operations

Cooling water enters each unit at SONGS through a seawater intake system that pumps offshore water to an onshore underground chamber at a velocity of approximately **2** feet per second (see Figure 1). In order to remove material that could block smaller cooling tubes in the plant, all cooling water passes through screens (located in the underground chamber). Each screen array is a series of sections forming a loop that runs from the chamber bottom to top. Attached to each section is a shelf perpendicular to the screen. The array of sections is called a traveling screen because the loop revolves such that the sections facing into the cooling water move up. Material that is caught against the screens or carried up on the shelves is removed to trash receptacles at the top of the screen structure. Units 2 and **3** at SONGS are each equipped with a Fish Return System (FRS). Each FRS is located at the end of the cooling water intake structure, adjacent to the traveling screen array. Those fish making it to the FRS are periodically lifted via an elevator system to a sluice that returns them to the ocean. By design, fish are directed away from traveling screens and into the FRS by large concrete guiding vanes in the underground chamber. Although the FRS diverts a large fraction of the fish taken into the plant back to the ocean, some are impinged against the traveling screens. The goal of Condition B is to implement a device, technique or protocol that would divert additional fish from the traveling screens to the FRS to further reduce fish impingement losses. Two techniques for diverting fish recommended by the MRC were sonic devices and mercury vapor lights. Both devices could be used either to attract fish to the FRS or away from the screens (depending on whether fish were attracted or repelled by the device).

An alternative approach to the use of a behavioral barrier would be to install devices at the intake to preclude fish entering the cooling water system, rather than to divert already entrained fish to the FRS in the screenwell structure. This approach was rejected based on two arguments. First, the cost and effort that would be required to maintain such devices on an intake structure approximately a mile offshore of an unprotected marine coastline was considered to be prohibitive. Second, as noted below, the devices most likely to work in the open water were those that produce loud noises (such as poppers), which were likely to have severe consequences on other marine life, particularly mammals.

Heat Treatment

Biological fouling of intake structures requires that a heat treatment be performed approximately **7** times per unit per year (range 4 to 9). In a heat treatment, flow is reversed such that hot water flows out of the intake structure killing fouling organisms. In 1991 SCE initiated a modification of the heat treatment called the Fish Chase procedure. In the Fish Chase procedure, water temperature is raised slowly (rather than rapidly). The intent is to drive fish from the underground chambers into the FRS before the temperature reaches lethal levels. In the unmodified heat treatment, most if not all fish are killed.

2. Efforts to Comply with Condition B

Review of Behavioral Barrier Alternatives

The basis of SCE's permit requirements is contained in the recommendations of the Marine Review Committee, which were presented in the final "Technical Report to the California Coastal Commission: H. Mitigation" (Ambrose, R.F., February 1990, Marine Review Committee, Inc.). This report recommended testing mercury lights and sonic devices to reduce fish impingement losses. SCE, in consultation with the Commission's contract scientific staff, also took into consideration many studies conducted throughout the United States by the Electric Power Research Institute (EPRI). The EPRI studies also evaluated strobe lights, bubble curtains, pneumatic guns, poppers and electrified nets. Most of the deterrents proved to be either inconsistent from site to site or from species to species. Some of the more promising deterrents appeared to have major flaws. For instance, sonic devices would have to operate at intensities high enough that they could possibly endanger marine life, such as affecting the hearing of marine mammals or damaging planktonic eggs and larvae. This was of particular concern for operations that would have occurred at the intake, rather than in the screenwells. They also presented severe installation and maintenance concerns. In addition, it was found that strobe lights might repel some fish but attract others. Use of these technologies would jeopardize the effectiveness of the existing Fish Return System, which as described below is highly effective. On the other hand, it was found that attractants, such as light, had more consistent results. It was therefore decided to concentrate efforts on guiding fish more effectively through the FRS, along with developing an effective pre-heat treatment "fish chase" procedure.

The Electric Power Research Institute is continuously researching and testing new fish protection devices. In 1999 studies[1] EPRI reviewed behavioral barriers with the following results.

Strobe lights. Strobe lights have effectively repelled several different fish species in laboratory and field experiments. Recent studies have demonstrated that various lacustrine, riverine, and anadromous species avoid strobe light. Conversely, some studies have indicated that certain species from similar environments or with similar life history strategies or phylogeny will not respond to strobe lights in a laboratory setting or under field conditions.

> *SCE studies showed inconsistent results for northern anchovy and apparent attraction for Pacific sardines. Strobe lights were therefore eliminated from consideration due to the probability that they would increase fish impingement at SONGS.*

Air bubble curtains. These curtains generally have been ineffective in blocking or diverting fish in a variety of field applications. Air bubble curtains have been evaluated at a number of sites on the Great Lakes with a variety of species. All air bubble curtains at these sites have been removed from service.

Sound. The focus of recent fish protection studies involving underwater sound technologies has been on the use of new types of low- and high-frequency acoustic systems that have not

[1] 1999: E.P. Taft. Fish protection technologies: a status report. In Power Generation Impacts on Aquatic Resources Conference. Atlanta, Georgia, April 12-15, 1999, EPRI and U.S. Department of Energy.

previously been available for commercial use. High-frequency (120 kHz) sound has been shown to effectively and repeatedly repel members of the Genus Alosa (American shad, alewife and blueback herring) at sites throughout the U.S. Other studies have not shown sound to be consistently effective in repelling species such as largemouth bass, smallmouth bass, yellow perch, walleye, rainbow trout, gizzard shad, Atlantic herring, and bay anchovy.

Given the species specific responses to different frequencies that have been evaluated and the variable results that often have been produced, additional research is warranted at any sites where there is little or no data to indicate that the species of concern may respond to sound.

> *SCE's laboratory studies of local species found no effect from the high-frequency sound.*

Infrasound. In the nearfield, fish response to "sound" is probably more related to particle motion than acoustic pressure. Particle motion occurs through the agitation of molecules in the nearfield, whereas acoustic pressure refers to the action of sound waves on tissues or membranes. Particle motion is very pronounced in the nearfield of a sound source and is a major component of what fish most likely sense from infrasound (frequencies less than 50 Hz). In the first practical application of infrasound for repelling fish, Knudsen and colleagues[2] found a piston-type particle motion generator operating at 10 Hz to be effective in repelling Atlantic salmon smolts in a tank and in a small diversion channel.

Following the success of Knudsen and colleagues, there was a general belief in the scientific community that infrasound could represent an effective fish repellent since there was a physiological basis for understanding the response of fish to particle motion. The potential for currently available infrasound sources to effectively repel fish has been brought into question by the results of more recent studies[3]. Given these results, it appears that infrasound sources need to be further developed and evaluated before they can be considered an available technology for application at cooling water intake systems.

> *SCE Behavioral Barrier Studies found low frequency sound elicited an avoidance response from some species but installation of the devices on the SONGS intake was not possible due to technological limitations of the sonic devices and concern about adverse environmental impacts (mainly to marine mammals, but also to fish) from the sonic devices.*

Mercury light. Response to mercury light has been shown to be species specific; some fish species are attracted, others repelled, and others have demonstrated no obvious response. Therefore, careful consideration must be given for any application of mercury lights to avoid increasing impingement of some species while reducing impingement of others.

> *Mercury lights were the ftrst lights to be tested at SONGS and had no detectable effect (see below). Subsequent light tests were conducted using*

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[2] 1992: F.R.. Knudsen, P.S. Enger and O. Sand. Awareness reactions and avoidance responses to sound in juvenile Atlantic Salmon. Journal of Fish Biology 40: 523-534; 1994: F.R. Knudsen, P.S. Enger, and O. Sand. Avoidance to low frequency sound in downstream migrating Atlantic Salmon. Journal of Fish Biology 45: 227-233.
[3] *Ibid.*, E.P. Taft, 1999.

incandescent light. The light spectrum used was tested for penetration through the water column and species sensitivity based on retinal absorption data from fish commonly occurring at SONGS.

Electric screens. Electric barriers have been shown to effectively prevent the upstream passage of fish. However, a number of attempts to divert or deter the downstream movement of fish have met with limited success. Consequently, past evaluations have not lead to permanent applications. Given their past ineffectiveness and hazard potential, electric screens are not considered a viable technology for application at cooling water intake systems.

SCE's Compliance Process

Table 1 documents the chronology of events by SCE and CCC to comply with the Behavioral Barrier condition. **A** brief summary follows.

In 1992 SCE submitted a plan that was approved by the Executive Director for the installation and testing of Mercury Vapor Lights (MVLs), which were expected to attract fish into the FRS. SCE installed the lights and tested them for approximately one year.

The results of this experiment were evaluated in a number of ways by contract scientists working for the CCC. There was no clear indication that the lights were effective. There was considerable day to day and unit to unit variation in impingement rates that made detection of any effect due to the lights impossible. Thus if there was a light effect it was very small.

In a September 14, 1994 letter, the Commission staff laid out its determination of the provisions under which SCE could attain compliance with Condition B (see attached letter), as follows:

The Study Plan for Behavioral Barriers should be revised to incorporate these elements.

1) *The Fish Chase procedure should be continued (see #6b below).*

2) *SCE should continue with small-scale experimentation to assess the potential effectiveness of light and sound devices for implementation in-plant.*

3) *The CCC should evaluate the RFPs, protocols and results for small-scale experimentation.*

4) *At the end of the small-scale experiments, the CCC and SCE should meet and decide whether to implement devices in-plant (The decision is the responsibility of the CCC, however, we expect to interact extensively with SCE).*

5a) *If devices are implemented in plant, a preliminary sampling program will be set up to determine the effort needed to fully assess the effectiveness of the devices.*

   i) *The cost of the full-scale monitoringprogram will be evaluated relative to its benefit to the mitigation program.*

ii) *The full-scale monitoringprogram will continue only until the effectiveness of the device(s) is assessed or until some predetermined level of sampling effort has been reached. The level will be set based upon cost and benefit analysis.*

iii) *If the devices are not effective then the CCC and SCE will evaluate the cost and benefit of implementation of alternative in-plant or offshore devices (including the cost of assessing their potential effectiveness using small-scale experiments).*

5b) *If devices are not implemented then the CCC and SCE will evaluate the cost and benefit of implementation of alternative in-plant or offshore devices (including the cost of assessing their potential effectiveness using small-scale experiments.*

6) *Compliance will be attained if:*

a) *The behavioral barrier devices are implemented in-plant and yield a demonstrated (by monitoring) increase in live fish return of at least 2 metric tons per year.*

b) *If behavioral barrier devices are not implemented or do not yield a demonstrated increase in fish survival of 2 metric tons per year compliance will be attained if the Fish Chase procedure is kept in place and continues to operate for the life of the plant.*

At the time the findings for the SONGS permit were adopted in 1991, total impingement losses were estimated at about 20 MT per year. Staff expected the absolute effectiveness of the devices (in MT) to be very difficult to estimate because of the high temporal variability in impingement. Therefore a relative standard was put forth and incorporated into the implementation standard such that full implementation would occur if the devices would be expected (based on an experimental phase) to reduce annual impingement by at least 10 percent. The value 10% is equal to the reduction threshold (2 MT) divided by the estimated annual impingement (20 MT).

Since receipt of the 1994 letter, there has been substantial ongoing dialogue between SCE and CCC contract scientists and SCE has followed all pertinent advice offered by the CCC contract scientists. Experiments were conducted to evaluate the utility of both sonic and light devices (see Table 1 for details). In a joint decision, the CCC and SCE agreed that the use of sonic devices was technically infeasible and unlikely to be effective. In addition, there was an agreement to test lights as a behavioral barrier device. CCC and SCE scientists jointly designed the testing phase (Phase I light study). Results from Phase I study were evaluated by CCC contract scientists in April 1999. Based upon the analysis, a Phase II light study was designed and conducted at SONGS, from June to July 1999. CCC scientists evaluated results of Phase II and together with SCE designed the Phase III light study, which was run from September to November 1999.

3. Description and Evaluation of In-plant Light Studies

General Description of Methods

A general protocol was followed for all three phases of the in-plant light studies. Impingement was sampled once a day by a team of biologists who identified fish species, and counted and weighed all fish that were caught on the travelling screens. Diversion was estimated by biologists as follows. Once per day the elevator in the FRS was raised and individuals were removed from 30% of the area of the elevator (based on a grid system in the elevator). The species, number of individuals, length and biomass were visually estimated for these fish. These fish were then returned to the ocean (via the FRS) and the elevator lowered back to the receiving chamber in the FRS. The elevator was raised at least three times during each sampling event and fish species, abundance, length and biomass were determined as described above until very few individuals were found.

In each of the three studies there were two experimental treatments. In Phases I and II the conditions were lights-on or lights-off. In Phase III the treatments were total darkness or ambient light. For a given day the two units were exposed to different treatments (e.g., lights-on at Unit 2 and lights-off at Unit 3). The following sample day, the treatment would swap between Units. The intent of this design feature was to help ensure that any effects of the treatments on fish losses would be detectable above that resulting from day to day variation. Data were collected in two ways. First, counts and biomass of impinged fish (by species) were collected from the traveling screens before they were removed to the trash. These variables measure the loss of fish numbers and biomass due to impingement. Second, the number and biomass of fish (by species) were measured in the FRS–these were individuals that were alive and being returned to the ocean. The clearest indication that a treatment (e.g., lights-on) would likely further reduce fish impingement losses would be a decrease in impingement biomass coupled with an increase in biomass in the FRS.

Phase I Study

Phase I was carried out between February and March 1999. The type of lights and intensity used in Phase I was based on results from small-scale experiments done at SCE's laboratory facility in Redondo Beach. The two experimental treatments were lights-on or lights-off in the underground chambers. Lights were positioned in the chambers so as to divert fish to the FRS. The data were analyzed using factorial Analysis of Variance (ANOVA) that examined the effects of Unit (i.e., Unit 2 vs. 3), day, and treatment (lights-on vs. lights-off). As noted above, the inclusion of Unit and Day in the statistical model was to estimate and eliminate extraneous sources of variability and increase the chances of detecting any effect of lights. The results of the Phase I experiment are shown in Figure 2. There was no difference in impingement between lights-on and lights-off treatments, but return rates were much greater for the lights-off treatment. This suggested that lights did not affect impingement and that they unexpectedly caused a decrease in the return of fish via the FRS. Clearly there was no evidence that lights worked as an effective behavioral barrier device.

Phase II Study

Observations made during the Phase 1 study indicated that fish were lingering near the screenwells (the area in the underground chamber in front of the traveling screens) during the lights-on treatment possibly because light was "spilling" out from its intended location. In an effort to control the location of light and more clearly direct fish to the FRS, light intensity was reduced to 70% of that used in Phase 1 and the experiment was repeated. Observations were made from June to July 1999 and the main results are shown in Figure 2. Results of this experiment showed no significant effects of treatment; however, there was a trend for the lights-off condition to reduce impingement and increase fish return via the FRS.

Phase III Study

The results of Phase I and II experiments suggested that not only was artificial lighting ineffective at reducing fish impingement losses, but that it might actually have caused greater losses. CCC and SCE scientists recognized that ambient light entered the screenwells during the lights-off condition. CCC and SCE scientists concluded that even very low levels of light (ambient light spilling in from outside the screenwells) might have caused fish to linger and avoid being directed to the FRS. CCC and SCE scientists speculated that the guiding vanes in the plant might be most effective at directing fish away from the screens and into the FRS under conditions of complete darkness. To test this idea a third phase was carried out between September and November 1999 in which the two treatments were ambient light and darkness (ambient light was excluded by covering the overhead walkways). The results of this phase are shown in Figure 3. Here impingement was increased in the dark condition (compared to ambient light) and there was no difference in fish return under the two conditions. Also shown is the daily impingement and return to give an indication of the temporal variability in both variables.

4. Studies Demonstrating Effectiveness of Fish Return System and the Fish Chase Procedure

As part of its permit requirement SCE has been monitoring impingement since 1983. These data are shown in Figure 4 and can be used as a benchmark to judge the effectiveness of the Fish Return System (FRS) and Fish Chase procedure. Fish impingement losses have been variable, averaging about 23 metric tons per year during the period 1983-1999.

Since its inception, the FRS has been remarkably effective. On average, during normal operations, 80% of fish entering the intake system are returned alive to the ocean (see Figure 5 for a representative sequence of the FRS). The savings in fish biomass resulting from the FRS are unknown, as these data are not routinely collected.

The Fish Chase procedure added in 1991 to the Heat Treatment procedure at SONGS has exceeded the expectations of the amended permit conditions that 2 or more MT of fish, equivalent to a 10% decrease in impingement, be returned to the ocean (see Figure 6). As a result of the Fish Chase procedure, an average of 4,300 kg (4.3 metric tons) of fish that would have been killed and impinged during heat treatment is returned to the ocean alive via the FRS every year. These are fish not counted in the FRS during normal (i.e., non-heat treatment) operations. Put another way, impingement has declined by an average of about 13% per year since implementing the Fish Chase procedure (based on data collected during 1992-1999; Figure 6).

C. CONCLUSIONS AND PROVISIONS FOR COMPLIANCE WITH CONDITION B

The only pattern that emerged from the three in-plant light experiments was that there was no clear benefit from the use of light (as tested) as a behavioral device to further reduce fish impingement losses. However, both the Fish Return System and the Fish Chase procedure have been shown to be highly effective. The FRS was a design feature of the intake structure and was never intended to be considered as a "new" behavioral barrier device as required by Condition B of the permit. However, the procedural change implemented during heat treatment further reduces fish losses by altering fish behavior during the heat treatment, and its continuing effectiveness is noteworthy. Through 1999 the Fish Chase procedure has reduced impingement by an average of 4.3 metric tons per year, well above the 2 metric ton recommendation. Indeed, if one considers the combination of the FRS and modified Fish Chase procedure as a behavioral barrier device, it would likely be the most effective one in use today (for any power generating station having a cooling system with a long intake tunnel). In its September 1994 letter, the Commission staff accepted the idea that the Fish Chase procedure could be considered as a new behavioral device if a good faith effort to implement other devices was shown to be ineffective.

Based on the results of SCE's behavioral barrier studies and experiments, and other evidence provided in this staff report, the Executive Director has made the following determination:

1) SCE has met its obligations pertaining to items 1-5 of the staff's September 14, 1994 letter.

2) The lights and sonic devices tested are unlikely to decrease fish losses by 2 or more metric tons per year (item 6b of the September 14, 1994 letter), and are therefore ineffective as fish behavioral barriers at SONGS.

3) In accordance with item 6b of the September 14, 1994 letter, and acknowledging that SCE has made a good faith effort to satisfy Condition B of the SONGS operating permit, compliance with the requirements of Condition B of the SONGS permit will be satisfied at this time provided that SCE (1) continues to implement the Fish Chase procedure for the operating life of SONGS Units 2 and 3 and (2) utilizes the following monitoring requirements:

    a) During the Fish Chase procedure, SCE shall determine by the same methods used previously[4] the numbers, type, biomass and condition of (1) fish diverted to the FRS and (2) fish impinged.

    b) SCE shall deliver to the Executive Director of the Commission a written report of each Fish Chase procedure by July of the following year. In addition to the data described in (a) above, this section of the report shall contain other pertinent information needed to evaluate the effectiveness of the Fish Chase procedure (e.g., the date of the heat treatment, the rate at which temperature was increased, how the FRS elevator was used).

    c) If unusual events occur, such as higher than normal mortality[5] during heat treatments, SCE will provide to the Executive Director a report including the details noted in (a) and (b) above, and an explanation for the event.

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[4] SCE environmental procedure: S023-5-121 "Methodology for conducting Fish Chase prior to Heat Treatment."

[5] Mortality rate is defined here as the biomass of fish killed during a heat treatment divided by the biomass of fish entrained (fish impinged plus fish returned alive via the FRS). Higher than normal mortality is defined as (1) a sequence of three or more heat treatments where the mortality rate exceeds 50%, (2) more than 50% of heat treatments in a given year have more than a 50% mortality rate, or (3) mortality rate for the year exceeds 50%.

4) If in the future new technologies or techniques for fish protection are developed which either (1) become accepted industry standards or (2) are required by the Commission in other power plant regulatory actions and which, if implemented at SONGS, would meet the permit goals for reducing impingement losses, SCE shall make every effort to test, and if found feasible, install such devices at SONGS Units **2** and **3.** SCE should continue its leadership to facilitate the reduction of fish losses throughout the industry.

Next Steps

If the Commission agrees with the Executive Director's determination, the Executive Director will issue a condition compliance letter to SCE with this report as supporting evidence.

TABLE 1. Fish Behavioral Barrier Studies

(Condition B of SONGS Unite 2 & 3 Coastal Permit)

DATE	EVENT	NOTES
Mar. 12, 1992	Behavioral Barrier Study Plan submitted to CCC	This original study plan detailed the testing of mercury vapor lights and reviewed the history of lights and sonic devices tested at other utilities.
Sep. 2, 1992 - Apr. 23, 1993	SCE begins testing of Mercury Vapor lights	Analytical test of lights using ON/OFF comparisons of fish loss is begun at SONGS Units 2 & 3.
Jan. 1, 1993	CCC requests SCE to revise behavioral barrier study plan and re-analyze data	The CCC staff did not comment on SCE's study plan until the arrival of Dr. McGowan, who requested changes to the plan.
May 13, 1993	SCE discussion with Dr. McGowan (CCC contract scientist) regarding changes to Behavioral Barrier study plan	Dr. McGowan emphasized requirement for sonic studies, and use of additional analytical techniques to assess light effects.
Jun. 29, 1993	Draft revised study plan, data disks, and tables sent to Dr. McGowan for review	Dr. McGowan requested data to determine optimal analytical techniques for SONGS data.
Jul. 12, 1993	CCC contract scientist suggests new analytical procedures to be used for Behavioral Barrier study	Dr. McGowan made a number of suggestions regarding analytical techniques in this Internet message.

Aug. 3, 1993	CCC contract scientist requests additional analyses be made	Dr. McGowan asked for some specific analyses including Kolmogorov-Smirnov two sample test, ANOVA, etc. in this Internet message.
Apr. 29, 1994	SCE submits Revised Study Plan to CCC	Following an extensive re-analysis of data as requested by Dr. McGowan and incorporation of many of the CCC staff suggestions; the Revised Plan was completed and submitted.
Jul. 1, 1994	CCC comments on Revised Study Plan	CCC staff comments to SCE included some areas of disagreement including credit for "Fish Chase" and a tangible "performance criteria."
Jul. 26, 1994	Meeting with CCC staff and contract scientists	An open discussion of mutual concerns regarding the project helped clarify goals.
Aug. 2, 1994	SCE submits response to CCC comments on Revised Study Plan	SCE addressed continuing concerns regarding CCC letter dated 7/1194.
Sep. 14, 1994	CCC staff response to SCE concerns	Agreement was reached on all major issues.
Oct. 20, 1994	Scope of Work developed for light and sonic tests	Input was solicited from CCC technical staff and included in Scope of Work.
Dec. 27, 1994	Request for Proposals issued for testing of light and sonic devices	RFPs due 1/26/95 to be reviewed by SCE and CCC staff and contractor(s) selected.
Jan. 27, 1995	Proposals received for light and sonic device testing	Responses to RFP for light and sonic testing received for review and selection of contractors.
Feb. 3, 1995	Proposals for light and sonic testing sent to CCC staff for review	CCC contract scientists given proposals to review and make recommendations for selection of contractors.

Feb. 16, 1995	Meeting with CCC staff and contract scientists	SCE and CCC staff and contract scientists met to discuss selection of contractors to conduct light and sonic tests.
Mar. 24, 1995	Purchase Orders issued to begin light and sonic testing	Entrix contracted to conduct light studies; Sonalysts to do sonic studies, in agreement with CCC contract scientists.
Apr. 10, 1995	CCC staff invited to review studies in progress	CCC staff and contract scientists toured the Redondo Laboratory facility and observed light and sonic studies in progress.
Jul. 25, 1995	Sonic device laboratory studies completed	Sonalysts complete data collection using sonic devices at Redondo Laboratory.
Nov. 15, 1995	Draft Final Report on sonic devices completed	Sonalysts submits draft report for review.
Dec. 12, 1995	Preliminary light studies completed	Entrix completes collection of light data.
Dec. 22, 1995	Draft Final Report on light devices completed	Entrix submits draft report for review.
Feb. 20, 1996	Determination to extend light studies	Review of light studies reveals need to clarify effects of light on some species.
Apr. 1, 1996	Draft design determined for follow-up light study	Entrix and SCE determine best sample design for completing light studies.
May 1, 1996	Suitable study apparatus constructed at Redondo Laboratory for light study	Tanks and plumbing constructed in newly completed lab facility.
May 3, 1996	Copies of light and sonic studies sent to CCC staff for review and comment	CCC contract scientists to review light and sonic studies. Additional light data to be forwarded when available.

Jul. 10, 1996	Phase II light studies completed by Entrix	Positive reactions of fish to simulated fish return apparatus suggests similar light at SONGS would reduce fish loss.
Sep. 1, 1996	Mercury light data re-analyzed at request of CCC staff	Eco-Analysis contracted to analyze fish return data collected during monitoring of mercury lights in fish return system.
Dec. 16, 1996	Final report on impacts of a lighting system on fish at SONGS completed	New analysis concludes that 19% of fish species entrained at SONGS have increased survival due to lights.
Jul. 10, 1997	New installation plan for behavioral barriers completed for internal review	New installation plan designed around study results from Redondo Laboratory.
Aug. 18, 1997	Installation plan reviewed and approved by SONGS engineering for installation	Installation of lights deemed feasible by SONGS engineers.
Oct. 21, 1997	Revised installation plan sent to CCC for approval	New plan recommends use of lights to guide fish into fish return system.
Dec. 11, 1997	Meeting with CCC contract scientists	Meeting with CCC contract scientists at Redondo Lab to discuss installation plan.
Dec. 22, 1997	CCC Deputy Director makes recommendations for changes to the installation plan and requires additional light studies	CCC staff recommends detailed light analyses to assure light in lab study is duplicated at SONGS.
Mar. 4, 1998	Purchase Order awarded to ENTRIX to conduct studies required by CCC	ENTRIX (Dr. Jahn) begins work on sampling design, light characteristics and turbidity studies as required by CCC.
May 11, 1998	Light measuring device ordered to comply with light measurements required by CCC	Construction of custom radiometer required to comply with need for precise underwater light measurements.

Jun. 23, 1998	Light measuring device completed and sent to SCE	International Light Research Radiometer with SHUD003 illuminance probe to respond to light visible to fish.
Jul. 7, 1998	Light measurement begun at Redondo lab	Light values found at Redondo will be transferred to SONGS.
Jul. 14, 1998	SONGS designers and engineers instructed to begin installation design for lights in SONGS intake screenwell	Lights to be designed to replicate optimum light values found in Redondo studies.
Aug. 8, 1998	Redondo light tests with sardines completed	Studies show positive attraction of sardines to lighted area.
Aug. 12, 1998	Work Order issued to SONGS for design and installation of lights in screenwell	Estimated cost of installation is $35,000.
Dec. 30, 1998	Light installation in SONGS intake screenwell completed	Light array uses 5 halogen lights placed to illuminate back of screenwell to keep fish away from screens.
Feb. 1, 1999	CCC contract scientists inspect light installation at SONGS	Mutual agreement is reached between SCE and CCC staff to proceed with testing of lights.
Feb. 22 – Mar. 27, 1999	Phase I light study at SONGS	Light intensities found optimal in Redondo lab studies are tested at SONGS. Observations indicate fish are attracted to light but "linger" in screenwell.
Apr. 1999	Phase I light study data sent to CCC staff for analysis	Analysis indicates an increase in fish impingement with lights on.

Jun. 8 – Jul. 16, 1999	Phase II light study at SONGS using reduced light level (70% of Phase I)	Light intensity reduced to 70% in attempt to reduce "lingering" of fish in screenwell.
Aug. 13, 1999	Phase II light study data sent to CCC staff for analysis	Analysis still shows increased impingement with light on, but less impingement than with full light intensity tested in Phase I.
Sep. 20 – Nov. 24, 1999	Phase III light study at SONGS using covers to achieve maximum darkness	Since impingement decreased slightly with a decrease in light intensity, the study is modified to measure the effect of maximum darkness on fish guidance in the fish return system.
Dec. 30, 1999	Phase III data sent to CCC staff for analysis	Preliminary analysis indicates maximum darkness also increases fish impingement, indicating "no treatment" may provide optimum survival of fish.

Figure 1

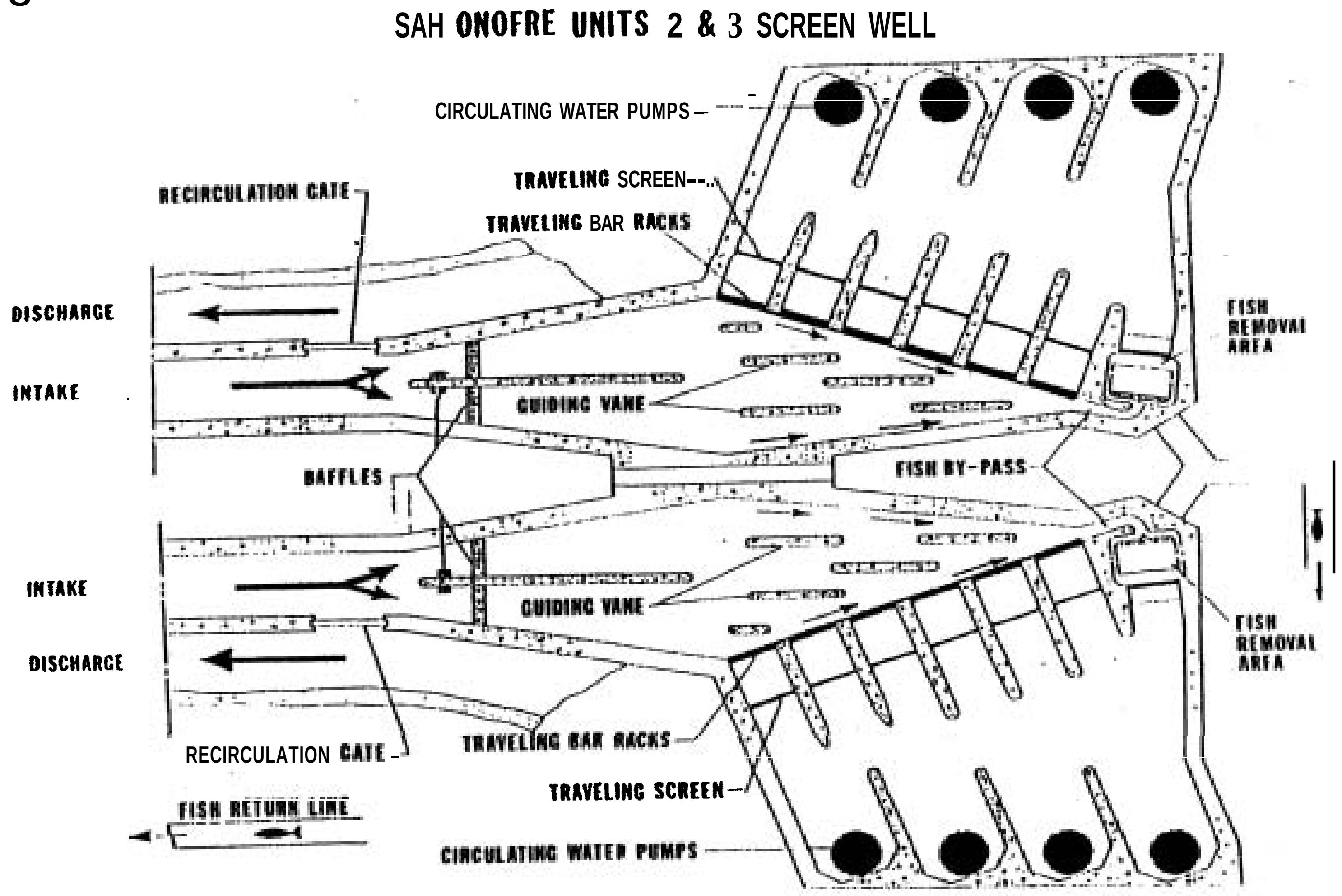
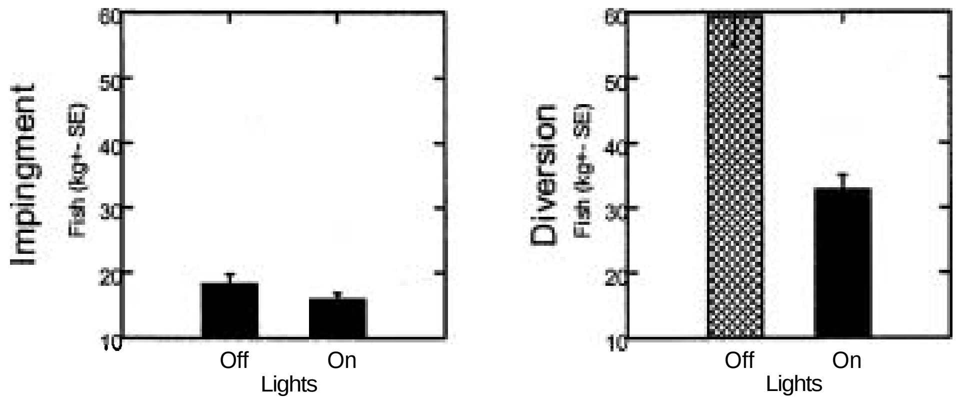
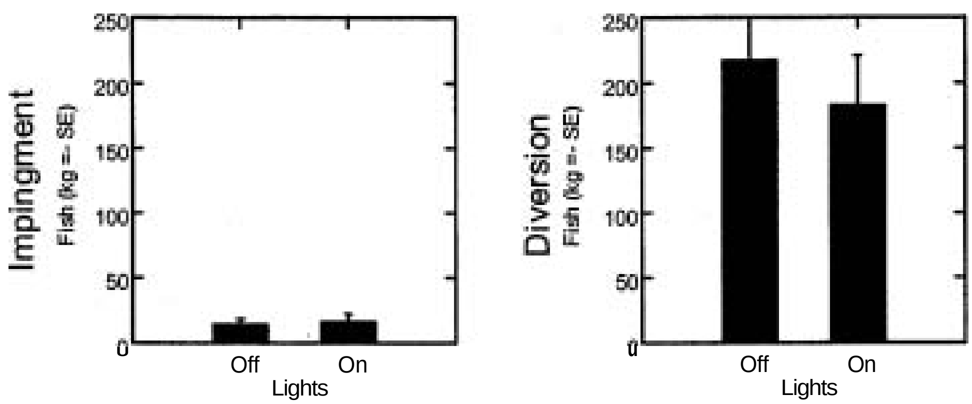

SAH ONOFRE UNITS 2 & 3 SCREEN WELL
CIRCULATING WATER PUMPS
TRAVELING SCREEN
TRAVELING BAR RACKS
RECIRCULATION GATE
DISCHARGE
INTAKE
GUIDING VANE
BAFFLES
FISH BY-PASS
FISH REMOVAL AREA
INTAKE
GUIDING VANE
DISCHARGE
FISH REMOVAL ARFA
TRAVELING BAR RACKS
RECIRCULATION GATE
TRAVELING SCREEN
FISH RETURN LINE
CIRCULATING WATER PUMPS

Figure 2

Phase 1: Feb - March 1999



Phase 2: June - July 1999, similar to phase 1 experiment but with light reduced to 70% in 'on' treatment



Experiments 1 & 2: Evaluation of the effects of lights on impingement and on diversion to fish return system during normal operations. Bars having different patterns are significantly different ($p<0.05$)

Figure 3

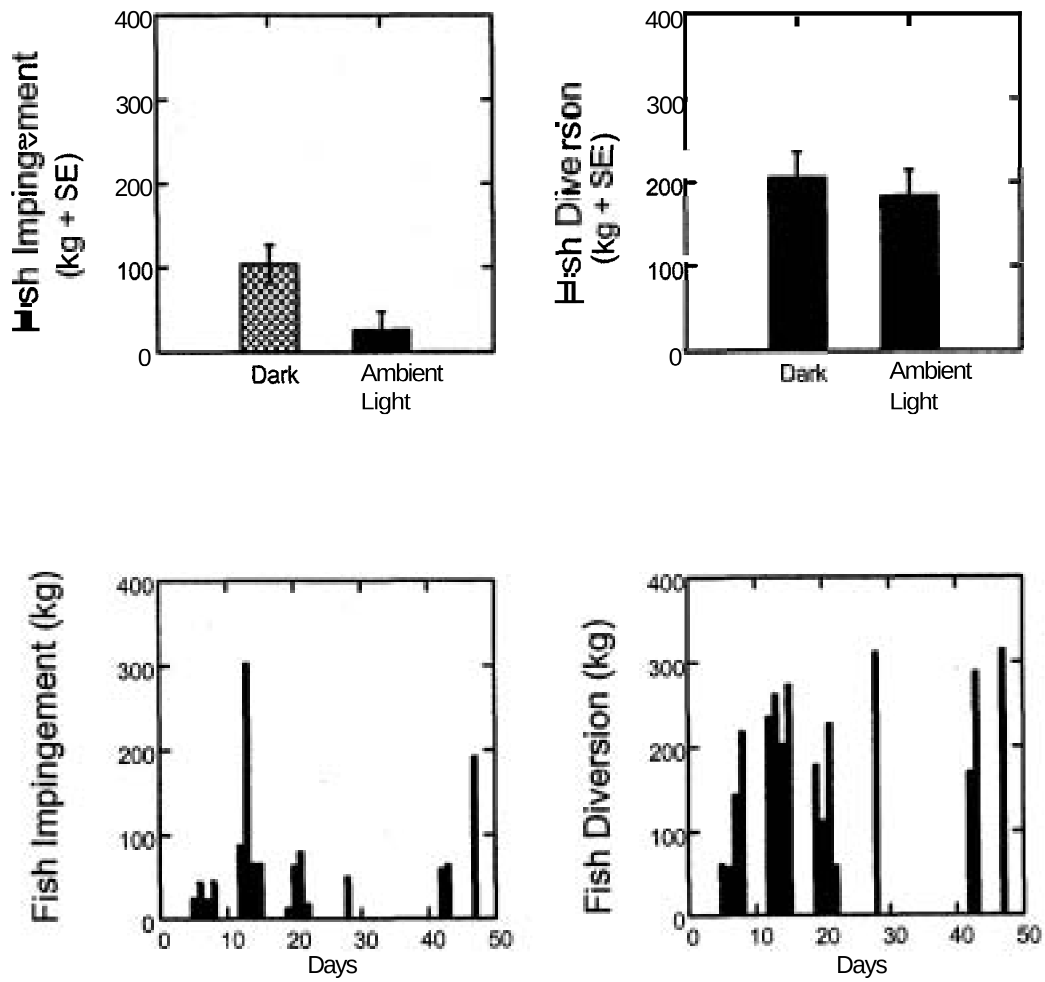


Figure 3: Evaluation of the idea that total darkness would decrease impingement and increase diversion to fish return system during normal operations. Also shown is daily varibility in impingement and diversion. Bars having different patterns are significantly different ($p<0.05$)

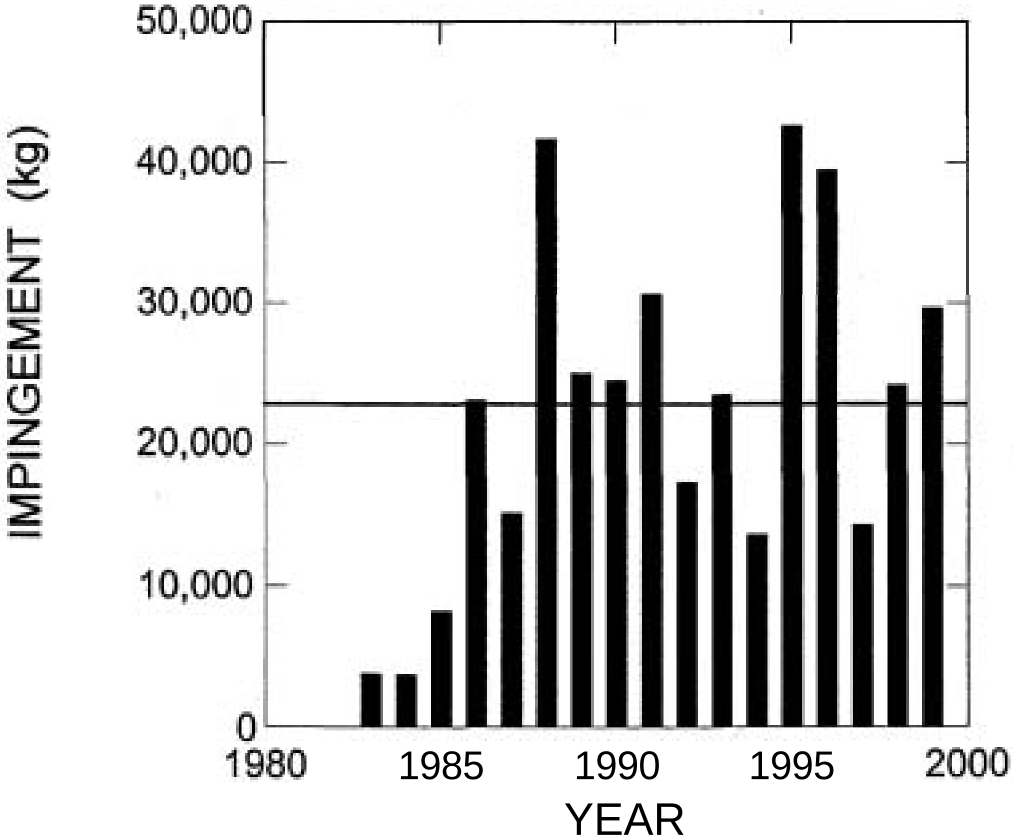


Figure 4: Fish impingement losses at SONGS Units 2 and 3. Horizontal line represents long-term mean.

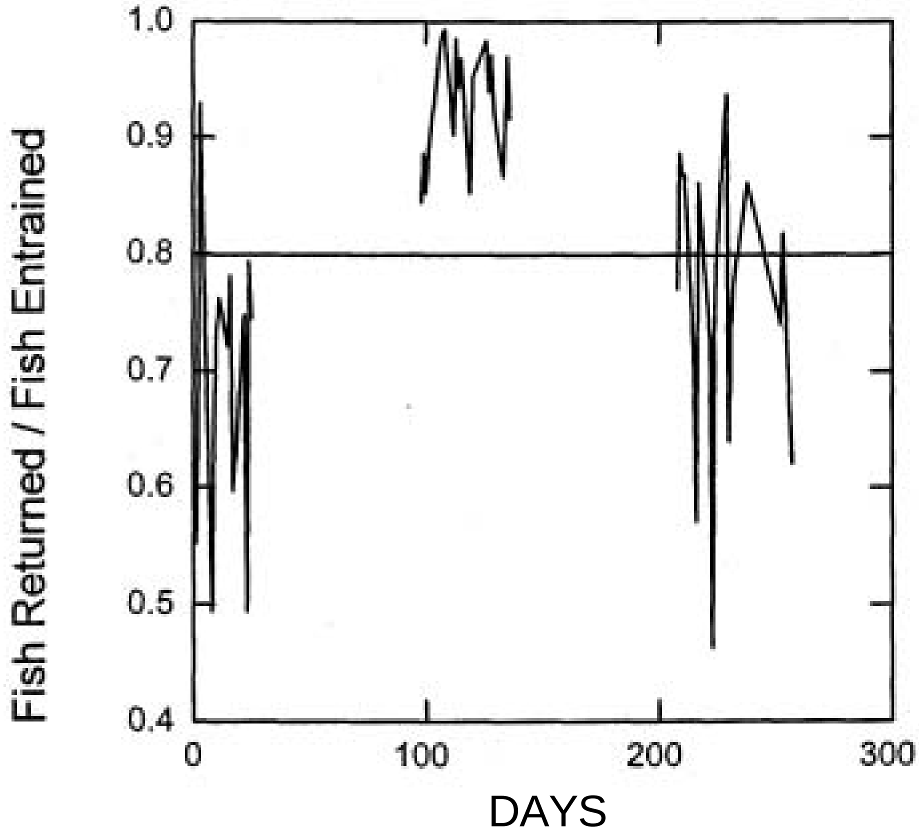


Figure 5: Efficiency of SONGS Units 2 and 3 Fish Return System (FRS) for 1999. Values represent the number of fish returned alive via the FRS / total number of juvenile and adult fish entrained. (Number entrained = impinged losses + fish returned). Horizontal line represents the mean.

ATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

CALIFORNIA COASTAL COMMISSION
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ATTACHMENT
SONGS **Behavioral**
Barriers **Report**

September 14, 1994

Frank Melone
Southern California Edison Company
P.O. Box 800
Rosemead, California

Subject: CCC Staffs Recommended Revisions to SCE's Behavioral Barrier Mitigation Plan

Dear Mr. Melone;

Thank you for your timely response to our comments on the Revised Study Plan. This letter responds to several issues raised in your letter of August 2,1994. In addition, if SCE implements the recommendations described below, we believe that the CCC executive director will be able to approve the plan, pursuant to the requirement in Condition B.

1) Performance Goals. The permit condition states: "In ***consultation with the permitee, the Commission staff will monitor the effectiveness of the behavioral barrier devices. If the Executive Director determines that the installed devices are not sufficiently effective to warrant continued use, the Executive Director** may **require removal and installation of alternative behavioral barrier devices".*** The intent of this condition is to require SCE to make a good faith effort to save fish Hence, if the executive director **requires** removal of one type of device because it is not effective in saving fish, installation of another may be required, unless the-cost is prohibitive. Clearly then, SCE's goal should be to make every effort to succeed so as to avoid **having** to install alternative devices.

At issue is what is "not sufficiently effective", as it is this criterion that potentially triggers removal and installation of alternative devices. The Commission staff's position is that a behavioral barrier device will be considered sufficiently effective if it reduces impingement of fish by at **least** an estimated **2 metric** tons **per year** (this is consistent with recommendations by the MRC). We believe that this is a reasonable, attainable standard. At current levels this represents approximately a 10% decrease in annual fish impingement. It should be noted that (I) it is the hope of the CCC that there will be substantially more than a 10% decrease in impingement and, (2) that **monitoring** required to assess the effectiveness of the devices **decreases** with increasing effectiveness of the devices.

It is important that assessment of the effectiveness of the behavioral barrier devices be powerful. statistically, because, as described above, failure to meet the permit standard may result in a requirement to install alternative devices. Therefore the goal of the CCC is to design a monitoring program with power = 0.7 (at $\alpha = 0.10$) to detect a 2 metric ton decrease in fish impingement.

In the Revised Study Plan (April 29,1994), SCE contends that such a monitoring program is impracticable because of the sampling effort involved. SCE suggests that an alternative to sampling in the plant is to assess potential effectiveness using small scale experiments and assume that implementation in-plant will have a similar degree of success. The Commission staff does not agree with that suggestion for two reasons. First, while CCC staff believes that small scale experiments will be valuable for assessing the potential for success of behavioral barrier devices, such experiments are most useful for determining what sorts of devices or configurations of devices are likely to be not effective. If they don't work in small scale experiments they are unlikely to work in-plant. Kowever, the in-plant success of devices shown to work in small scale experiments is less predictable because of the problems associated with implementation of devices in the plant. For example, lights may not be seen and sound *may* bounce from wall to wall in the screenwells.

Second the contention that in-plant monitoring is impracticable is based on the high variability in annual fish impingement. We think there may be ways to reduce the variability. First, inclusion of data from years affected by the 1983-1984 "El Niño" may artificially inflate variability (CV drops from 0.64 to 0.35 if data from 1983-1985 are not included). Second, as SCE has shown (Table A-2, Revised Study Plan), fish impingement *can* be measured as the proportion impinged, and this parameter is much less variable than annual impingement. As an example, the CV for proportion of fish not impinged (proportion of fish saved by weight) after accounting for the variance explained by differences in units and sample periods (see SCE Table A-2; Revised Study Plan) was 0.112. Further reduction in variability may result by assessing species separately; we did not have those data.

We calculated the number of samples that would be required to have Power = 0.7 at Alpha = 0.10 to detect increases in fish saved from impingement ranging from 10 to 50% (Figure 1). Approximately 25% of fish taken into the plant are impinged (not returned in the elevator return system per SCE data), and a 10% reduction in impingement corresponds to an overall increase in the rate of fish saved from impingement of 2.5%, from 75% to 77.5%. As annual fish impingement is about 20 metric tons (1983-1992) or 25 metric tons [for years not affected by the 1983-1984 "El Niño" (1986-1992)], a 10% increase in fish saved from impingement would represent an estimated reduction in impingement of between 2 and 2.5 metric tom of fish. As noted above, the performance standard has been set at a low level, 2 metric tons/year; however, the goal is to save as many fish as possible and clearly the effort required to detect success of the behavioral barriers decreases with increases in fish saved from impingement. Five curves are shown; each represents a different level in variability of data: 1X = the current level of variability, 2X is twice the current level, .5X is half the variability, etc. The replicate number decreases with decreases in variability. We strongly suspect that variability in the proportion of fish saved from impingement will decrease if behavioral barrier devices are effective and are implemented effectively in the plant; the degree to which variance decreases would depend on how strongly the devices affected behavior. (We think that the mercury light experiment was not implemented in a way that was effective. Thus "lights on" treatment was no different from the "lights off' treatment and nothing informative can be said about likely levels of variability when behavioral barriers are implemented). At half the current level of variability, 50 replicates would be needed to detect a 10% increase in fish saved, and only 15 replicates would be needed to detect a 20% increase. These are reasonable levels of effort.

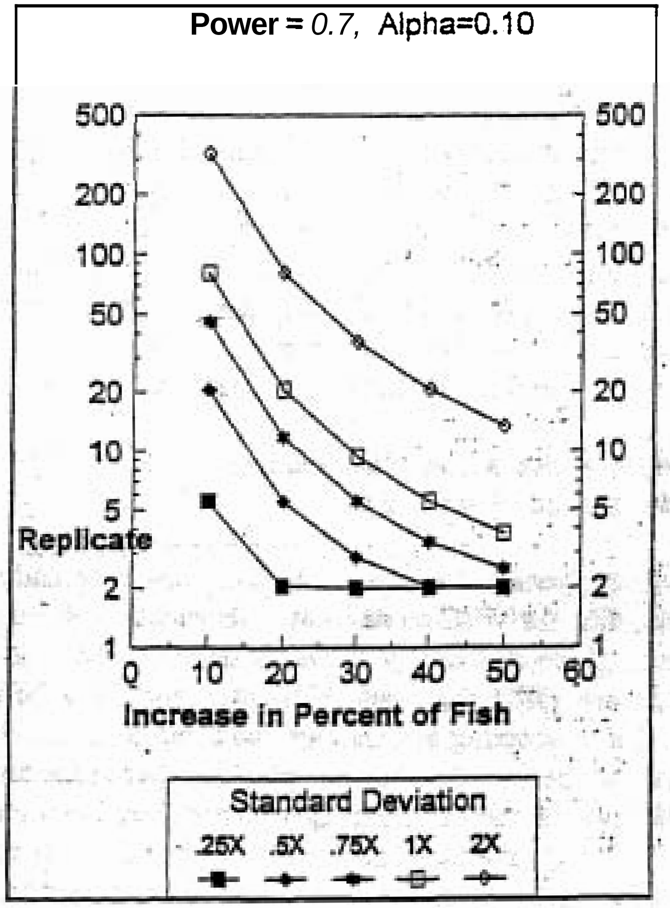

Figure 1

At this time, the Commission staff believes that evaluation of behavioral barrier devices in the plant is feasible.' We suggest that following installation of *devices,* a sampling procedure, designed and under the control of the CCC, be established. A preliminary set of data will be collected over a short period of time to determine variability and to estimate the sampling effort required to fully evaluate the effectiveness of the installed devices. In consultation with SCE, we will then determine if the cost of the full evaluation is warranted. Note, that the idea behind the preliminary sampling effort is to evaluate the cost-effectiveness of full scale monitoring. Note also, that if full scale monitoring is initiated it will be discontinued as soon as the devices are shown to be either effective or ineffective - the CCC does not intend to require long term monitoring.

2) Fish Chase Procedure. SCE has taken the position that the Fish Chase procedure should count as a behavioral bamer device. We do not agree for two reasons. First, Section III-C-4 of Permit 183-73 (February 1974) states:

"4. Entrainment and mortality of fish during heat treatments. Every 5 or 6 weeks, the applicant proposes to heat the water in the cooling system to 125°F to remove marine organisms growing in within the system. These elevated temperatures will kill virtually everything entrained within the system. It is expected that between 11,000 and 28,000 lbs. of fish may be killed per year in this manner. The procedure does not comply with the general standards established by the State's Thermal Plan and an exemption from those standards was requested by the applicants. An exemption was granted, but with the condition that studies be conducted over the next three years to determine whether the heat treatment proposed is the least environmentally destructive method of controlling marine growth within the cooling system, or whether the system should be redesigned to permit lower-temperature or less-frequent treatment. Until these studies are completed, no finding can be made as to the least destructive method."

We believe that the fish chase is a less "environmentally destructive method" of heat treatment provided for in the 1974 permit.

Second, SCE says that experimentation with the fish chase procedure did not begin in a systematic way until after the MRC made its recommendations for mitigating fish losses, and therefore because of the chronology of events, the procedure should qualify as a behavioral barrier for mitigation purposes. More important than the chronology of experimentation is that in adopting the findings and conditions of the Permit (1991), the Commission considered the fish chase to be part of the operations procedures for SONGS and intended that behavioral barriers for mitigation purposes be other procedures. Nevertheless, the CCC may give SCE credit for the fish chase procedure, if SCE follows the process outlined in this letter, makes a good faith effort at using other behavioral barrier devices to save fish, and that effort fails.

3) Cost of Mitigation. The CCC believes it is important to control costs for the SONGS mitigation program, and to evaluate the cost-effectiveness of all procedures. To that end we would like to discuss with SCE ways of controlling the costs of mitigation. For such a discussion to be effective both SCE and the CCC would have to willing to provide accounting of costs directly associated with particular projects (e.g. what the cost of sampling has been for the behavioral barriers experiments).

3) Specific comments to SCE's responses

Item 1. The **CCC** looks forward to reviewing draft RFP's for experimental work to be done on the behavioral barrier devices. SCE states that installation will not proceed if no significant benefit will be gained by their installation. The implementation and selection of type of device is left largely to SCE; however it must be noted that for Permit requirements, the effectiveness of devices is to be evaluated by the CCC after installation. If SCE intends to use the results of small scale experiments to argue against installation of devices in plant, it is critical that the CCC be co dent that both the experiments and analyses of results were done correctly. Therefore, the CCC should review all experimental protocols and independently evaluate results from the small scale experiments.

Item 2. See section 1 (Performance Goals).

Item 3. CCC staff believes that it is critical to evaluate behavioral barrier devices during both normal operation and heat treatments so as to be able to determine the most effective way of implementing the devices. For **example,** should lights be on all the time or perhaps only during heat treatments?

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Item 4. See section 1 (Performance Goals).

Item 5. CCC staff agrees with the approach to do small scale experiments prior to installation at SONGS. However, as described above (section 1: Performance Goals), CCC staff believes that evaluation of behavioral barrier devices after installation at SONGS is both required under conditions of **the** Permit and **logistically feasible.**

Item 8. CCC staff agrees that offshore behavioral **deterrents** should **only** be implemented if they are cost-effective. **Note that** "cost-effectiveness" **as a** basis for not meeting Permit requirements will be evaluated by the CCC. We **also note, again, that** CCC staff does not consider the fish chase procedure to be a behavioral **barrier for mitigation** purposes.

Item 9. See section **2** (Fish Chase Procedure).

RECOMMENDATIONS

The CCC staff recommends the following course of *action* for attaining compliance for the behavioral barrier mitigation program. The Study Plan for Behavioral Barriers should be revised to incorporate these elements.

1) The fish chase procedure should be continued (see #6b below).

2) SCE should continue with small scale experimentation to assess the potential effectiveness of light and sound devices for implementation in plant.

3) The CCC should evaluate the RFP's, protocols and results for small scale experimentation.

4) At the end of the small scale experiments, the CCC and SCE should meet and decide whether to implement devices in plant (The decision is the responsibility of the CCC, however, we expect to interact extensively with SCE).

5a) If devices are implemented in plant, a preliminary sampling program will be set up to determine the effort needed to fully assess the effectiveness of the devices-

1) The cost of the full scale monitoring program will be evaluated relative to its benefit to the mitigation program.

2) The full scale monitoring program will continue only until the effectiveness of the device(s) is assessed or until some predetermined level of sampling effort has been reached. The level will be set based upon cost and benefit analysis.

3) If the devices are not effective then the CCC and SCE will evaluate the cost and benefit of implementation of alternative in plant or offshore devices (including the cost of assessing their potential effectiveness using small scale experiments).

5b) If devices are not implemented, then the CCC and SCE will evaluate the cost and benefit of implementation of alternative in plant or offshore devices (including the cost of assessing their potential effectiveness using small scale experiments).

6) Compliance will be attained if:

a) The behavioral barrier devices are implemented in plant and yield a demonstrated increase in live fish return of at least 2 metric tons per year.

b) If behavioral barrier devices are not implemented or do not yield a demonstrated increase in fish survival of 2 metric tons per year, compliance will be attained if the Fish Chase procedure was kept in place and continues to operate for the life of the plant.

Thank you for your cooperation. Please call me, Chris Parry, Pete Raimondi, or Dan Reed if you have any questions. We look forward to your response to the approach to condition compliance that we have described in this letter.

Sincerely,

Susan M. Hansch

Susan M. Hansch
Manager, Energy, Ocean Resources and
Technical Services Division

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