Cooling Water System
Findings Regarding Clean Water Act Section 316(b)
Diablo Canyon Power Plant
NPDES Permit Order RB3-2003-0009

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I served on the technical workgroup that was formed to oversee the 1995-1999 Diablo Canyon Power Plant (DCPP) 316B study. Between 1995 and 1999 I represented the League for Coastal Protection. I now serve as an independent consultant to the Regional Board. I am providing testimony independent of that offered by any other party. My testimony will address the following areas.

1) Technical merit of the 316B study
2) Entrainment losses
3) PGE's valuation approach
4) Trends in local populations
5) The benefits of marine reserves mechanism as a potential mechanism for compensation
6) The benefits of conservation easements as a potential mechanism for compensation

Technical merit of the 316B study

The 316B study was designed to evaluate the losses due to entrainment and impingement of marine organisms. I will restrict my comments to issues associated with entrainment (only because estimation of impacts due to impingement has not been considered to be problematic). Entrainment sampling at DCPP was designed largely around the idea that estimation of impact would best be accomplished using an empirical transport model (ETM). The details of the modeling introduce considerable complexity, but the essence of the model is simple. The idea is to determine the number of organisms that are entrained and compare that value to the number at risk of entrainment (the source population). The ratio of those two numbers (Pm value) then represents the proportion expected to be lost as a function of entrainment. Entrainment sampling was done weekly for over two years, Source water sampling was done monthly over the same period. The details of sampling are presented in the RWQCB document. A number of assumptions had to made to estimate Pm. I believe all of the assumptions are reasonable. The assumptions include:

1) all organisms entrained are killed
2) estimation of a suite but not all species would provide a realistic approximation of the level of impact
    a. only larval forms were used – no holoplankton
    b. mostly fish larvae were used, crab larvae were also sampled, no algal propagules

    c. those species sampled represent a range in life histories that allow understanding of the likely impacts to other (unsampled) species
3) Entrainment sampling was sufficient and unbiased
4) Grid sampling (the basis of estimation of source water populations) was sufficient and unbiased
5) Extrapolation from the grid to the source water population was realistic
    a. Use of larval sizes to approximate age was appropriate
    b. Use of mean and maximum larval duration yielded realistic values for source water populations and therefore Pm
    c. Estimates of currents were sufficient and unbiased
    d. Larval behavior did not modify estimation of source water body
6) The two years of sampling was sufficient to capture the variability in Pm values

As one can see there are a great number of assumptions (and an even larger ones as you start addressing the details of the approach). However, each of these assumptions together with the overall approach was thoroughly discussed by the technical working group (TWG) prior to adoption. In my opinion the work done at DCPP was the finest entrainment sampling ever done for a power plant permit in the state of California and likely in the world.

ENTRAINMENT LOSSES

Entrainment losses are relatively easy to calculate, but the impact of such losses are much more difficult to understand. It is in the interpretation of the losses that I have had substantial differences in opinion with PGE and their contractors. These differences in opinion are of the sort that commonly arise in complex analyses and I want to be clear that I have great respect for the scientists at Tenera, who have done the analyses. Table 1 will aid in understanding both the problems in interpreting entrainment losses and also some approaches we taken.

Table 1 list species for which we were able to estimate larval impacts. Three approaches were used. Fecundity Hindcast (FH) and Adult Equivalent Loss (AEL) are both based on the idea of conversion of larval losses to adult losses. Both of these approaches have been used in other entrainment studies, but both rely on assumptions of larval survivorship that often can only be loosely met or not met at all, particularly for the species entrained at DCPP. I can talk about these more, but the TWG agreed early in the process that we would rely on the empirical transport model (ETM) and the estimates of proportional larval losses (Pm) that arose from the model. These are presented in the ETM columns. The difference between the ETM columns reflects the range in estimates of Pm. The first ETM column represents the proportional larval loss assuming that the population at risk is best represented by the average larval age entrained. Recall that the spatial extent of the population at risk (source water body) is arrived at by multiplying the age of a larvae entrained by average current velocity for that period. Hence a 4 day old fish that was entrained during a period when the current averaged 1 kilometer to the south per hour, could have come from as far away as (4 X 24 X 1 =) 96 kilometers to the north. What is needed is an estimate coming form all entrained individuals of a particular species. The mean ETM calculation uses a source water body that is based on the average age of entrainment, the Maximum ETM calculation is based on the statistical maximum age of an entrained larvae (outliers were not used in this calculation). It is my opinion that the maximum value best represents the impact because it uses as the source water body the area over which a larvae could have come from, rather the area over which the average aged larvae came from. Note, this is a point of disagreement with PGE. The population at risk is calculated by multiplying the area at risk by the density of fish per unit area. In the end ones arrives at Pm estimates that are given in the two columns. These represent the likelihood of loss through entrainment for the population at risk. Typically the estimate for mean larval duration is less than that for the maximum larval duration. In the next two columns are estimates for the spatial extent of the population at risk (source water body). These were calculated in two ways. For very nearshore taxa the source water body is represented by an alongshore distance (distance from which the larvae could have come). For the other taxa, an area is given (the area over which the larvae could have come from). The difference in spatial estimates (distance vs area) is caused by differences in the distributions of larvae. I produced the last two columns because I don't think either the Pm or source water estimates are the correct currency for interpreting loss (another point of disagreement). For example the table indicates that based on the maximum larval duration of individuals entrained in 1998-1999, 17.9 % of the black eyed Goby population at risk was entrained. By contrast in 1997-1998 only 0.91% of the Painted Greenling population at risk was entrained. Without more information one might guess that the problem was about 18 times worse for Black eyed Goby. Now move to the column labeled Alongshore area (for maximum duration). Here you will find that the source water bodies for the two species are 134 and 2738 square kilometers, respectively. With this information one might conclude that the effect was much more severe for Painted Greenling. The last two columns are the product of the two values (Pm and source water body) – I will call this the Area of Production Foregone (APF). This value represents the area or distance over that would have to be added to the source water body to compensate for the effects of entrainment. I believe this to be the best currency to interpret entrainment loss from a biological standpoint. Note that the APF value (24 square kilometers) is essentially the same for the Black Eyed Goby and Painted Greenling. Another way to think about this is that if the loss were concentrated it would represent all the larval production over a 24 sq kilometer area of suitable habitat.

The next step in my opinion is to come to a single value that represents the best estimate of impact due to entrainment. Recall that we did not estimate Pm for all species, but that we assumed that the ones evaluated were representative of those that were not evaluated. Given this assumption, then the best estimate of impact is the average APF value. Here we have to separate the near shore species from the others because the APF values are in different units (distance vs area). It is also helpful to separate crabs from fish. These values are shown below.

Source	Average APF based on mean larval duration	Average APF based on maximum larval duration
Near shore fish	9.42 kilometers of coastline	30.98 kilometers of coastline
Subtidal and Pelagic Fish	5.76 square kilometers of suitable habitat	11.54 square kilometers of suitable habitat
Crabs	Not done	14.52 square kilometers of suitable habitat

PGE'S VALUATION APPROACH

I am not a research economist and therefore will limit my comments to the biological portions of the model used. My major concern is over the inability to assign value to species not sampled or for those where no Pm calculations were done. In addition, I had concerns about valuation for the non-commercial species. This is problematic for a system like ours where by the rules laid out most of the benefits would be of the Nonuse type (because the species affected are mainly those without commercial value). By its very nature nonuse estimation is imprecise (sometimes extremely so) and is affected by a myriad of inputs. My guess is that it has never been applied to a case of this magnitude for a coastal CA impact.

TRENDS IN LOCAL POPULATIONS

Typically it is asked if there is any evidence for a decline in species abundances as that could be used to support (or reject) the notion that entrainment is causing an impact to **adult populations.** It is my opinion that this is not a valuable question to ask. Marine species that are entrained larval phases that can last from weeks to months. The estimated source water areas for the species entrained 63 to 16,000 square kilometers. The area over which the impact could be spread is likely to be similarly large. An argument is usually raised that if such losses are spread over such large areas then the impact is small. This is simply wrong thinking. Coastal ecosystems around the world have been ravaged as a result of the implicit assumption that diffusion of impact is the solution. Thinly spread impact add up and it is one of the most insidious traits of such impacts that they can rarely be demonstrated. This is because the spatial scale of the impact (to adult populations) is large (while the effect at any local scale is small), and most monitoring efforts are constrained to the local scale. Trying to detect impacts at relevant scales or small impacts at the local scale is possible but would be extraordinarily expensive. In addition it would typically require that data be collected prior to the onset of impact at both (true) control and impact sites. These data are not available in this case. Hence any trends in abundance are confounded by life history (the larval life history of marine species) and design – the lack of a true control site.

The issues mentioned above in no way affect my ability to conclude that there has been an impact due to entrainment. Quite simply, there has been and it is in my opinion substantial but not catastrophic.

THE BENEFITS OF MARINE RESERVES MECHANISM AS A POTENTIAL MECHANISM FOR COMPENSATION

Entrainment losses are almost exclusively driven by losses of planktonic forms (larval and holoplankton), gametes and spores. Direct compensation for such losses in diverse coastal systems is problematic. As an example, single species nurseries are inadequate because of the variety of species entrained. Typically the methods that have been used end up being a sort of out-of kind compensation. One possible compensatory approach would be to facilitate the creation and/or maintenance and enforcement of coastal marine reserves. Marine reserves are not a panacea for all that ails the ocean but there is evidence that they may be useful in increasing larval production of many harvested species (fish and invertebrates). Hence, while not providing direct compensation for all species entrained, marine reserve areas could provide a measure of direct compensation for a suite of species. Additional benefits would also be obtained that while not directly compensatory would add considerable value the area. I am including a link to a booklet produced by a group that part of (as a Principal Investigator). It is called the "Science of Marine Reserves" and was produced by the Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO).

http://www.piscoweb.org/outreach/pubs/reserves/booklet_final.pdf

THE BENEFITS OF CONSERVATION EASEMENTS AS A POTENTIAL MECHANISM FOR COMPENSATION

I have commented on this earlier and have included a copy of a letter sent to the Regional Board.

> The value of habitat protection for intertidal zones (tidepools).
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> I have been studying intertidal zone (tidepool) areas along the west coast of the United States for over 20 years. Currently I direct the largest intertidal monitoring program ever conducted: the Shoreline Inventory. This is a program funded largely by the Packard Foundation and the US Department of the Interior (with some funding form the State of CA and the Counties of Santa Barbara and San Luis Obispo).   As of today the Inventory comprises over 80 sites and ranges from Canada through Baja California. In San Luis Obispo County we sample six sites (Shell Beach, Hazards, Cayucos, Cambria, Piedras Blancas and Pt. Sierra Nevada), and in the adjoining counties (Santa Barbara and Monterey) we sample an additional 14 sites. I note this information to indicate our level of understanding of the nearshore ecological communities in the vicinity of DCPP.
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> The coastal areas of San Luis Obispo County are experiencing a fundamental change in the level of public awareness, exploration and exploitation. Twenty years ago it was rare to find anyone on the

rocky shores of the county outside of a few places with easy access. This is not true today for the following (major) reasons.

1) The California Coastal Commission – the CCC has emphasized increasing access to coastal areas
2) A Shift in culture and education – children start going to tidepools early and often and parents soon follow.
3) A shift in fishing effort – a lot of harvesting is done in the rocky intertidal zone.
4) Economic changes – there has been and will be a major shift of ownership of the coastal properties – mainly from ranches to the State or Conservation groups. This has dramatically increased access.
5) Population growth – large increases, particularly near to the coast.

In our surveys along the coast we can characterize each site by the level of access afforded the public. Based on this characterization we have come to the following conclusions.

1) Ecological communities with limited access (primarily those associated with ranches or military bases are very different from those with considerable access.
2) The most degraded ecological communities are often found in State Parks, even when collecting is prohibited.
3) The change in ecological communities in areas of high access shows up in a series of major categories:
    a. Large Seastars are rare
    b. Abalone are largely absent – even in disease free areas
    c. Large grazers (particularly the giant Limpet) are rare
    d. Mussels are less common and smaller
    e. The algal community is less complex and more dominated by coralline algae (resistant to trampling)
    f. Generally the ecological communities are less diverse and composed of smaller individuals
    g. Birds and mammal diversity is lower
4) These changes are the result of:
    a. Collection
    b. Exploration – turning rocks over, picking up fragile organisms
    c. Trampling – areas can be trampled down to bare rock or algal "pavement"
    d. Activity – Birds and Mammals particularly are affected by human activity.

In my opinion, one of the worst things you can do to a tidepool community (with respect to the ecological state of the community) is to allow open access to it. Clearly there are major benefits to the public associated with access, and in fact I believe that increased access to the coastal areas has dramatically increased public awareness and sensitivity to these areas. However it is my firm belief that protection from access for certain areas provides major benefits to both the public and to the environment. These areas act as a conservation refuges that protect intact and pristine ecological communities, while at the same time providing a source of new individuals that can replace the lost ones in areas of high access (this is a feature of marine systems where many of the babies of most species are exported away from their birthplace.

The rocky intertidal in the vicinity of DCPP is (with the exception of the impact area) one of the most pristine areas in SLO county. It is spectacular in its geology and also in its biology. The biological attributes of the area are due in large part to its isolation from public access. It is my opinion that there should continued conservation of this area and that such protection will be of immense (in many ways immeasurable) value to both the public and to the environment.

This letter was written as a comment about the value of habitat protection as proposed in the proposed settlement in the DCPP. It is not an indication of whether I view the settlement as sufficient for the impacts caused by the operation of the plant.

CONCLUDING THOUGHTS

One subject not yet commented on is the adequacy of the settlement, which I speculate was supposed to compensate for impacts due to the operation of DCPP (thermal effects and Entrainment and Impingement). The settlement was arrived before we had done finalized an analysis of the impacts of entrainment and impingement. Hence the Technical Working Group never came to a consensus on level of impact. This being said it is my opinion the settlement will not compensate for the sum of the impacts to the marine environment resulting from the operation of DCPP.

Table 1

Taxon	FH Method (annual adult females lost)	AEL Method (annual adults lost)	Period	ETM Estimated Percentage Reduction due to Entrainment		Alongshore Distance (km) or Area (km^2) Calculated based on Mean Larval Duration	Alongshore Distance (km) or Area (km^2) Calculated based on Maximum Larval Duration	Units	production foregone: distince or area based on mean larval duration	production foregone: distance or area based on maximum larval duration
				Mean Larval Duration	Maximum Larval Duration					
Nearshore taxa - source water body calculated using alongshore distance										
smoothead sculpin	no calc	no calc	1997-98	10.50%	15.30%	49.28	127.58	km	5.17	19.52
			1998-99	14.60%	19.80%	51.91	142.78	km	7.58	28.27
monkeyface prickleback	no calc	no calc	1997-98	16.20%	23.20%	51.98	120.29	km	8.42	27.91
			1998-99	10.80%	11.30%	41.53	138.58	km	4.49	15.66
clinid kelpfishes	no calc	no calc	1997-98	31.80%	41.00%	53.57	126.12	km	17.04	51.71
			1998-99	29.40%	39.50%	47.11	108.36	km	13.85	42.80
Subtidal and pelagic taxa - source water body calculated as area										
painted greenling	no calc	no calc	1997-98	0.88%	0.91%	856.24	2,738.23	km^2	7.51	24.92
			1998-99	1.14%	0.44%	517.98	2,642.98	km^2	5.91	11.73
snubnose sculpin	no calc	no calc	1997-98	3.61%	2.31%	263.00	1,168.57	km^2	9.49	26.99
			1998-99	12.06%	2.10%	115.49	810.28	km^2	13.93	17.02
cabezon	no calc	no calc	1997-98	0.68%	0.57%	295.42	614.46	km^2	2.02	3.50
			1998-99	0.84%	0.92%	141.78	326.19	km^2	1.18	3.00
blackeye goby	no calc	no calc	1997-98	13.10%	7.87%	111.14	359.47	km^2	14.56	28.29
			1998-99	16.30%	17.90%	63.71	134.50	km^2	10.38	24.07
Pacific sardine	3,170 - 8,460	2,600 - 7,000	1997-98	0.03%	0.01%	981.92	16,562.96	km^2	0.28	1.11
			1998-99	not calculated						
northern anchovy	16,000 - 45,000	43,000 - 120,000	1997-98	0.06%	0.01%	641.06	7,174.45	km^2	0.37	0.56
			1998-99	0.21%	0.02%	360.35	7,319.59	km^2	0.74	1.47
white croaker	5,100 - 7,400	14,700 - 64,100	1997-98	0.26%	0.13%	518.87	2,157.13	km^2	1.32	2.87
			1998-99	2.11%	0.70%	217.06	1,468.66	km^2	4.58	10.34
blue rockfish	18 - 43	160-350	1997-98	0.10%	0.05%	415.20	998.77	km^2	0.40	0.46
			1998-99	2.11%	0.36%	199.92	1,065.08	km^2	4.22	3.79
KGB rockfish	500 - 620	900 - 1,100	1997-98	1.46%	0.96%	300.38	1,110.19	km^2	4.39	10.68
			1998-99	2.18%	0.48%	232.15	1,493.59	km^2	5.06	7.11
sanddabs	90 - 430	510 - 1,450	1997-98	0.49%	0.41%	502.77	805.78	km^2	2.48	3.33
			1998-99	4.59%	1.06%	158.46	487.61	km^2	7.27	5.17
California halibut	no calc	no calc	1997-98	0.08%	0.08%	477.47	1,858.94	km^2	0.40	1.42
			1998-99	12.30%	5.25%	199.22	1,257.20	km^2	24.50	66.00
brown rock crab	91,000 - 117,000	180,000 - 230,000	1997-98		0.002%		6,318.46	km^2		0.12
			1998-99		0.01%		4,423.45	km^2		0.65
slender crab	8,950 - 27,300	17,900 - 55,000	1997-98		1.07%		5,065.07	km^2		54.20
			1998-99		0.08%		3,991.97	km^2		3.13