

# Resource Agency Views of Technology Employed to Prevent Fish Mortality at Cooling Water Intakes

Presented by:

**Richard L. Wantuck**

**NOAA Fisheries  
Southwest Region**



**Cooling Water Intake Symposium**

**Arlington, VA**

**May 6-7, 2003**



# Overview

- **Nature and scope of the problem**
- **Federal-state regulations**
- **Legal matters**
- **Some emphasis on West Coast perspective**
- **Considerate of the national “big-picture”**
  
- **General Considerations for Resource Protection Priorities**
  
- **Historical and Existing Standards for Fish Protection**
  
- **Guidelines for fish protection system**
  - **NMFS fish protection standards (west),**
  - **AFS Bioengineering**
  
- **Current CWIS projects in California**
  
- **Where do we go from here?**

# Why are we here?

## **Cooling Water Intake Structures - CWA Sec. 316(b)**

EPA is developing regulations under section §316(b) of the Clean Water Act. **Section §316(b) requires that the... *location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.***

**More than 1,500 industrial intakes use large volumes of cooling water from lakes, rivers, estuaries or oceans** to cool their plants, including steam electric power plants, pulp and paper makers, chemical manufacturers, petroleum refiners, and manufacturers of primary metals like iron and steel and aluminum.

**Cooling water intake structures cause adverse environmental impact** by pulling large numbers of fish and shellfish or their eggs into a power plant's or factory's cooling system. **There, the organisms may be killed or injured by heat, physical stress, or by chemicals** used to clean the cooling system. Larger organisms may be killed or injured when they are **trapped against screens** at the front of an intake structure.

**Source:** <http://www.epa.gov/waterscience/316b/>

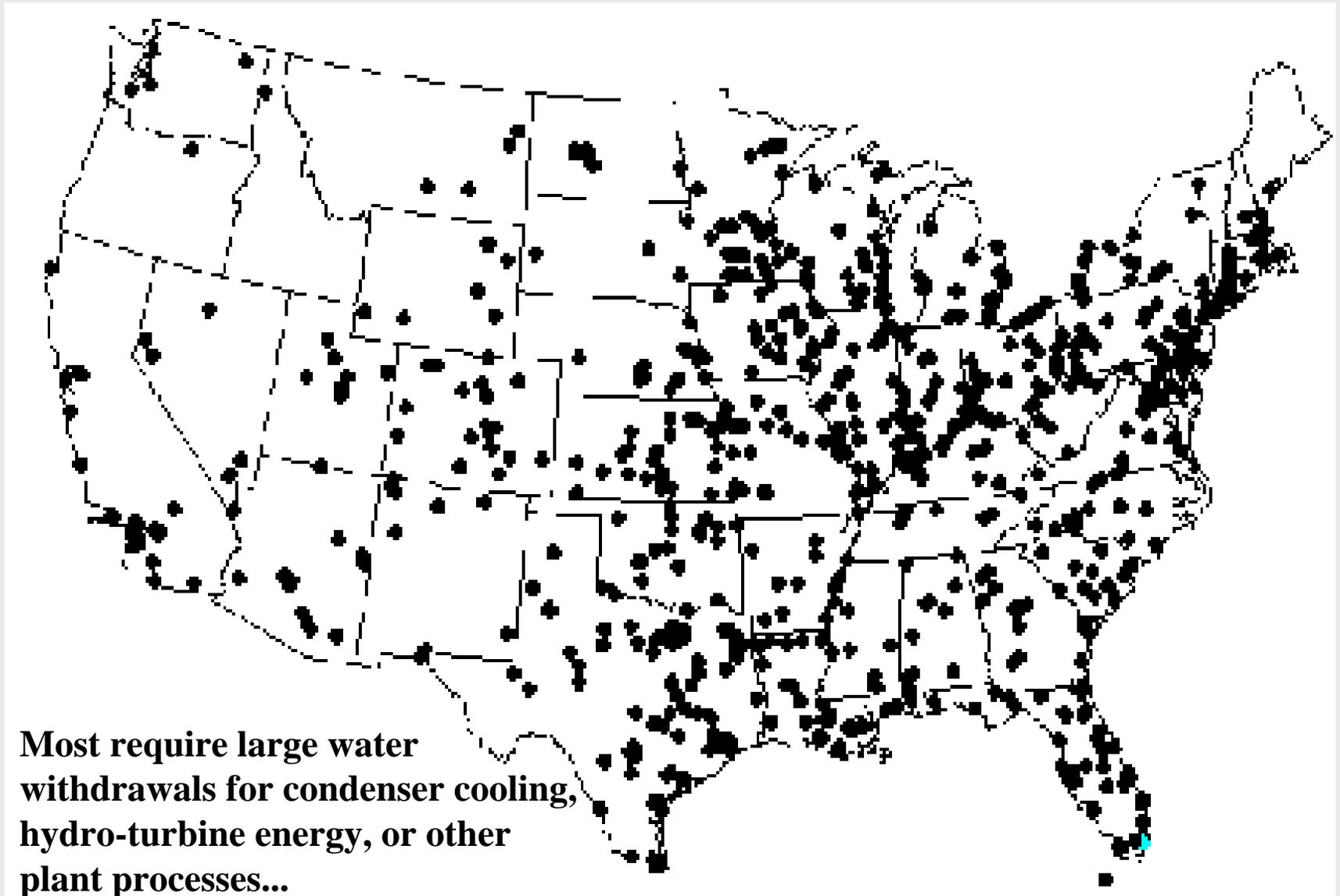
In January 2002, **Hudson Riverkeeper led a coalition of environmental groups** in a legal challenge to EPA's Phase I rule in the Second Circuit, U.S. Court of Appeals in New York City. **...a decision from the Court is expected in in 2003**

The **new regulation is clearly superior to the...1976 regulation**, and is a vast improvement over the 25-year period during which there were no federal regulations in this area. In particular, **it acknowledges the technology-based nature of Section 316(b) regulations and mandates closed-cycle cooling as "best technology available."** That alone can protect billions of aquatic organisms at each new power plant that uses closed-cycle cooling rather than once-through cooling. The regulation is also an improvement over the draft Phase I rule which would have allowed once-through cooling for offshore intakes in oceans, lakes and non-tidal rivers...

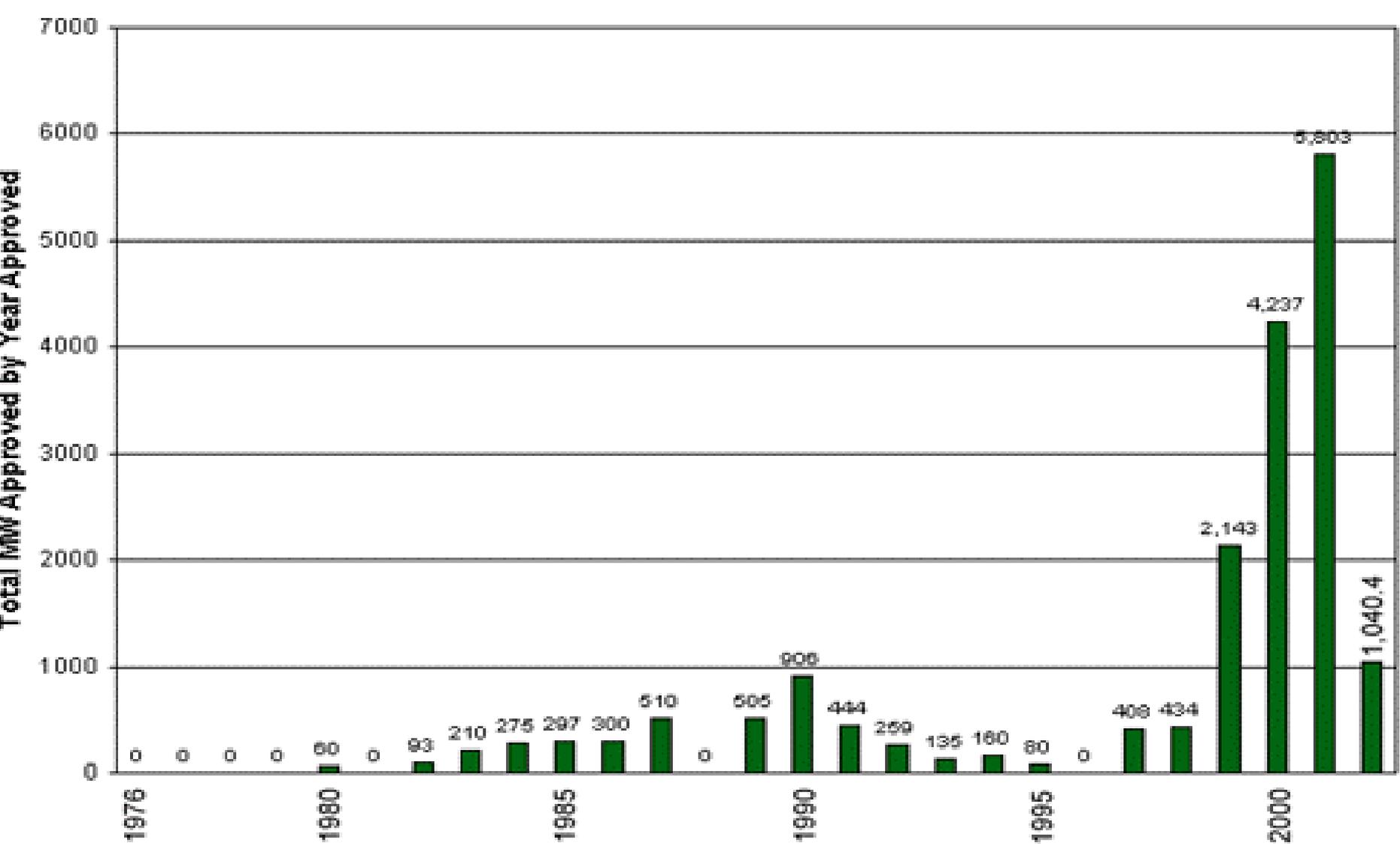
While it [is] a drastic improvement, **the new regulation also contains "serious loopholes."**

*...applicants willing to conduct additional studies may be permitted to use once-through cooling either alone or in conjunction with other technologies...if they can demonstrate that these technologies will be 90% as effective as closed-cycle cooling...*

# U.S. Power Plants



**Most require large water withdrawals for condenser cooling, hydro-turbine energy, or other plant processes...**



## Megawatts Approved by Year in California

source: California Energy Commission

## **Approaching the Problem**

***Fish Protection and Technology Standards for Water Intakes at U.S. Power Plants and Industries Must Be Viewed in the Context of:***

- 1) National, Regional, and State Overall Priorities**
- 2) National, Regional, and State Natural Resource Conservation Priorities**
- 3) National, Regional, and State statutes, codes, and regulations**
- 4) Social and Economic Factors**
- 5) An Understanding of Existing Standards and Historical Norms\***
- 6) Technological Capabilities and Results-Oriented Development\***

# Historical and Existing Standards for Fish Protection

## ....Evolution from....

- **Trashracks...**

trash and debris- equipment concerns, structure may provide some fish deterrence, but poor hydraulics generally leads to entrainment /impingement

- **Louvers...**

early 20th century behavioral technology, hydraulic behavioral guidance mechanism

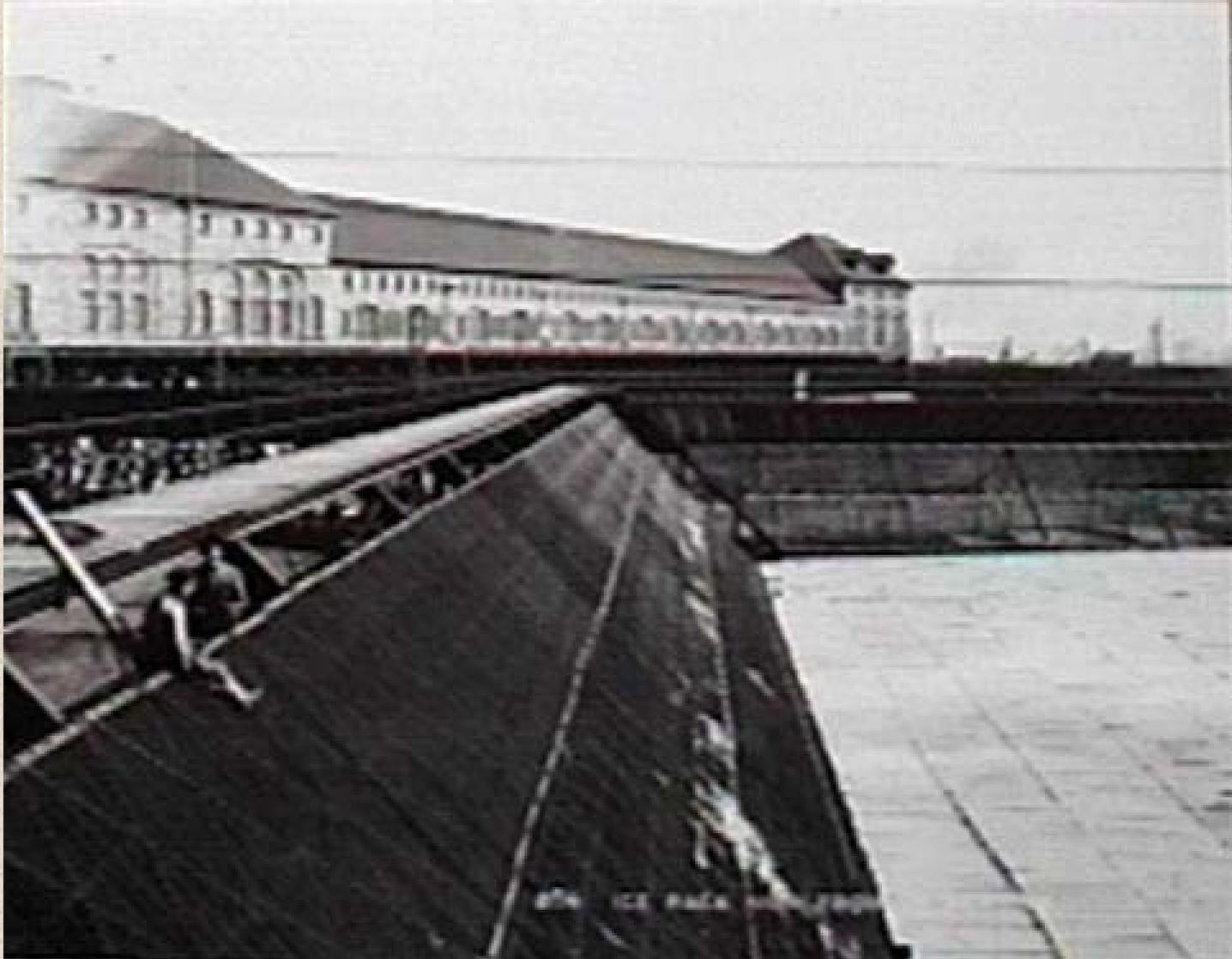
- **Positive Barrier Fish Screens....**

current west coast standard for Pacific salmon protection

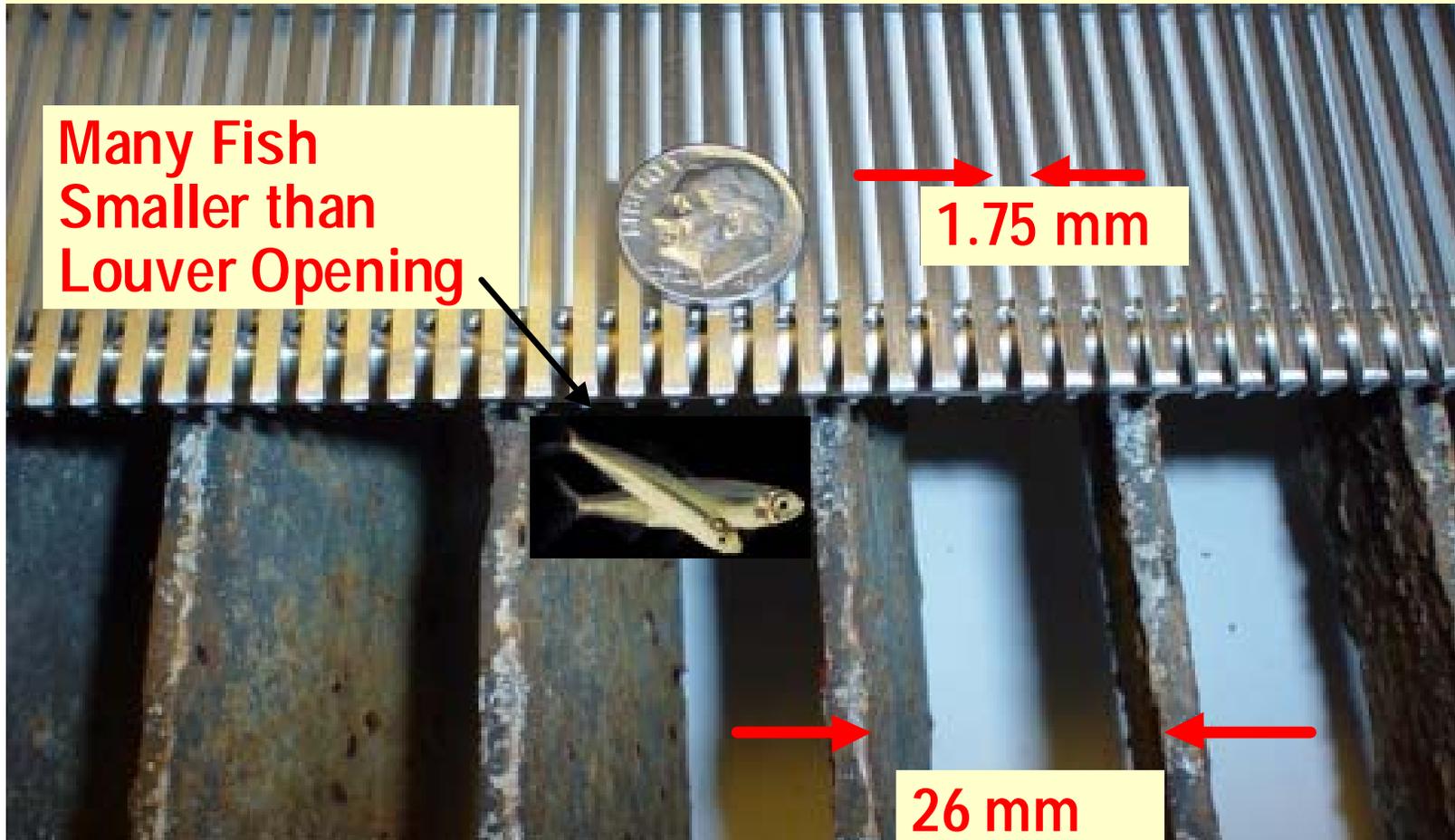
- **Behavioral Fish Guidance Devices**

“walls of light,” infrasound, underwater electric fields, chains, and “bubble curtains”

# TRASHRACKS



# *Proposed Screen Opening will be 14 Times Smaller than Louvers!*



## *Transition from Louvers to Positive Barrier Fish Screens*

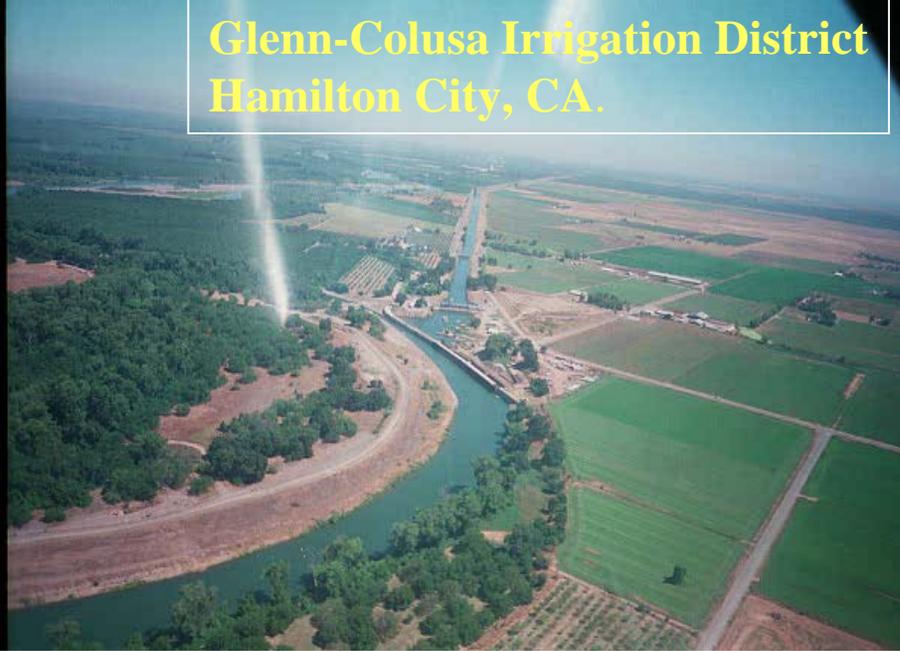
Slide courtesy of Darryl Hayes, CH2MHill Sacramento, CA



Preventing fish entrainment with state-of-the-art fish screens

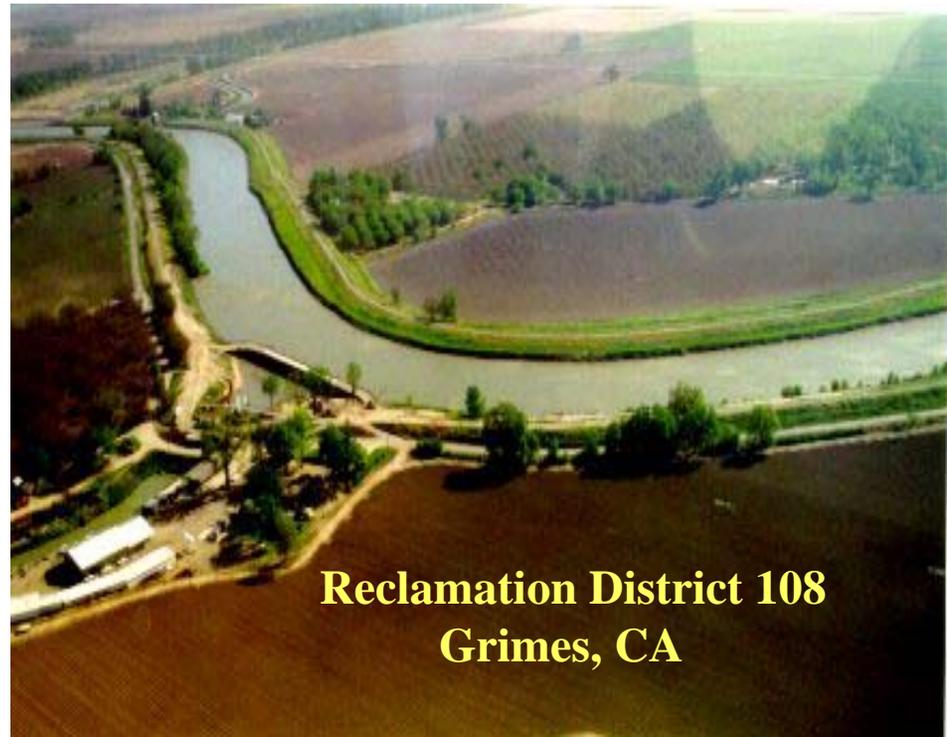
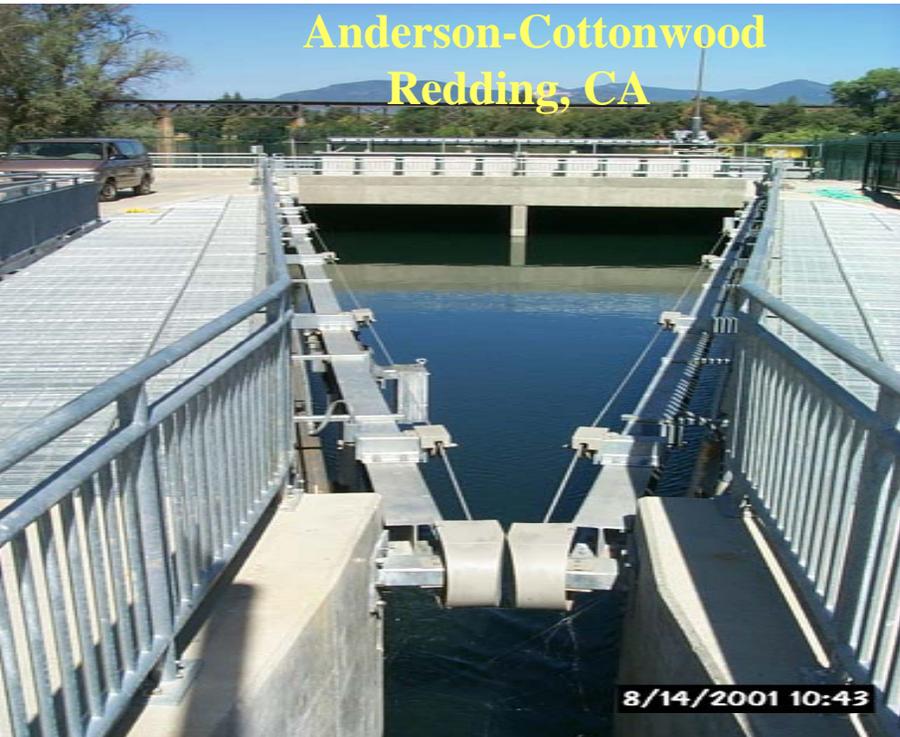


**Glenn-Colusa Irrigation District  
Hamilton City, CA.**

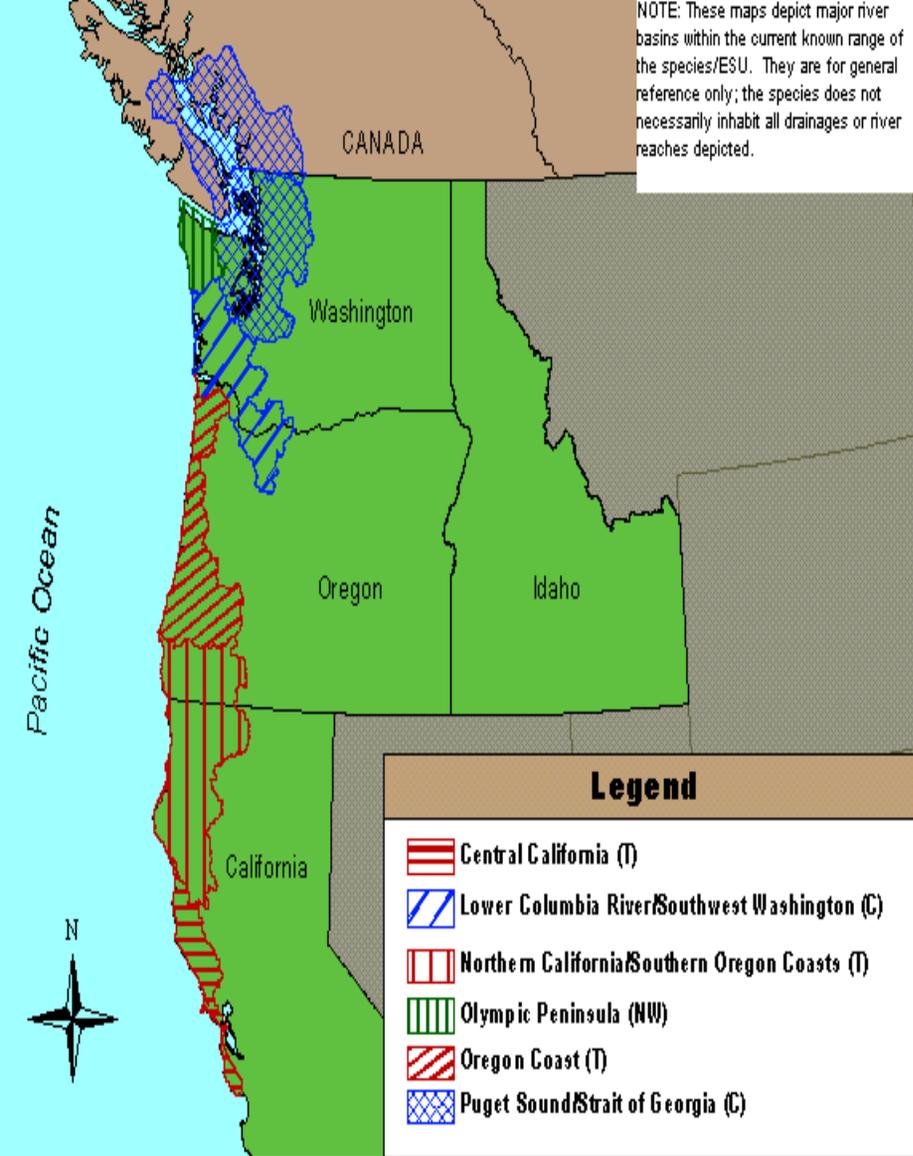


**City of  
Sacramento, CA**

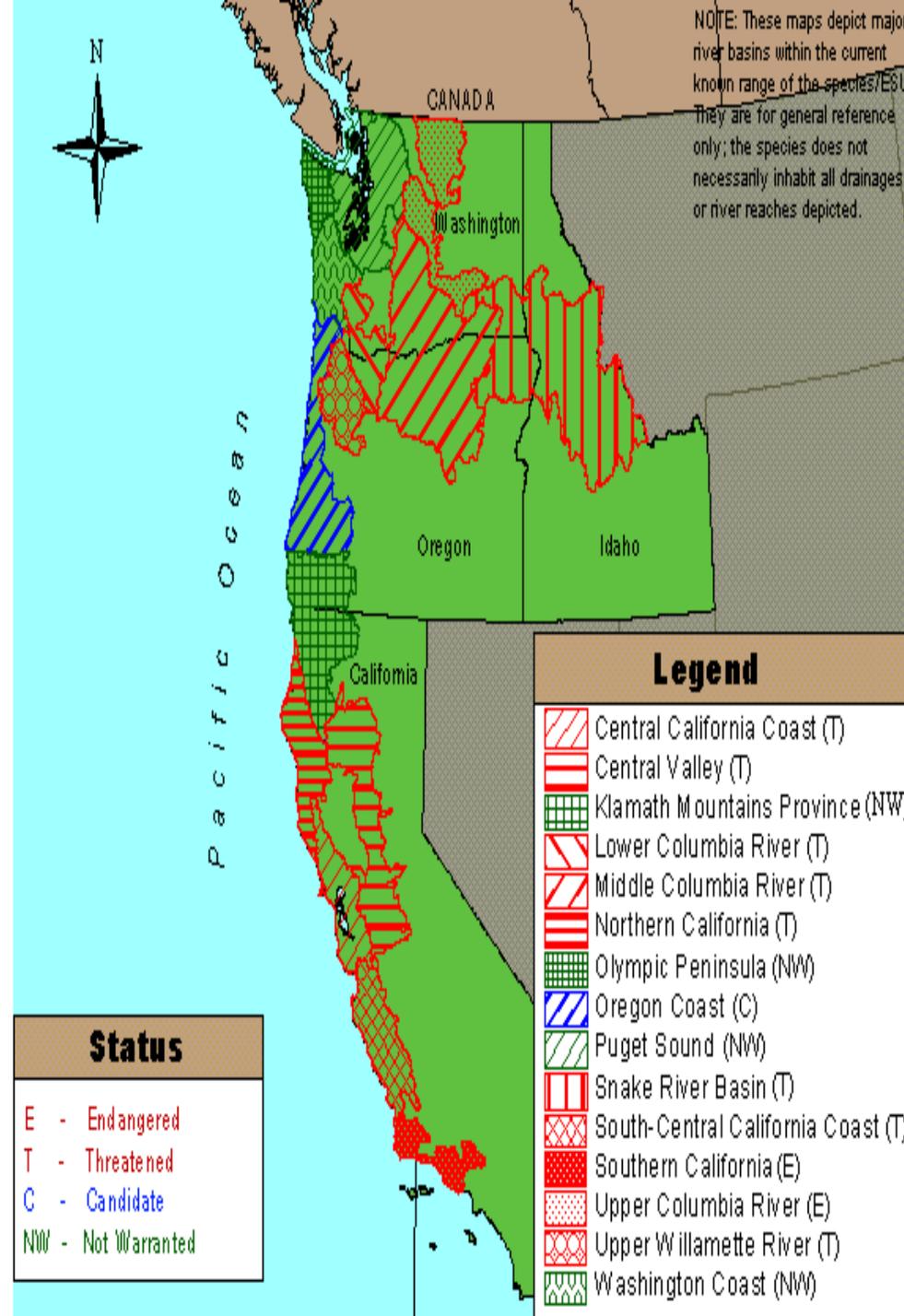
**Anderson-Cottonwood  
Redding, CA**



**Reclamation District 108  
Grimes, CA**



..some regions require different biological standards of effectiveness..



# Approach to Assessing Technological Capabilities

## Why?

### 1) Government Regulatory Responsibilities

- Clean Water Act
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Federal Power Act
- State Fish and Game codes
- NEPA, and other regulations

### 2) Industry Stewardship Responsibilities

- EPRI Initiatives, AFS Bioengineering Section, Industry sponsored research

### 3) Promote Scientific Advancement:

- Academic research
- Promote Effective Technology Development using scientific methods
- ***Combined, cooperative efforts*** of government, industry, academia, entrepreneurs, and fisheries professionals toward a ***well-articulated common goal*** will yield fastest, most effective results

# Experimental Fish Guidance Devices (1994)

<http://swr.nmfs.noaa.gov/habitat.htm>

- **NOAA Fisheries Southwest Region position statement on Experimental Technology for Managing Downstream Salmonid Passage**
- ***a tiered process...for studying, reviewing, and implementing future fish protection measures***
- **concerned with *effectively preventing or minimizing* the three main causes of delay, injury or mortality at water intakes: *entrainment, impingement, predation***
- **NOAA Fisheries (west) currently considers *Positive Barrier Screens* as *Best Available Technology* for protection of juvenile salmonids and other marine species of fish *regardless of the classification of water diversion...***
  - ...i.e.- municipal, industrial, , hydro- and non-hydro power generation, and agricultural water diversions are treated the same**

# Experimental Fish Guidance Devices (1994)

<http://swr.nmfs.noaa.gov/habitat.htm>

The “tiered-procedure” for study, testing, and evaluation is:

- 1) **Consider Earlier Research**
- 2) **Study Plan**
- 3) **Laboratory Research**
- 4) **Prototype Units**
- 5) **Study Results**

# Experimental Fish Guidance Devices (1994)

<http://swr.nmfs.noaa.gov/habitat.htm>

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## Behavioral Fish Guidance Devices:

### *“Pros”*

- Generally, *far less costly* than conventional positive barrier screens
- *Readily adaptable* as technology progresses
- Scientific research, technology innovations, and evaluations of field prototypes indicate *improved results* in recent years...  
*...in some cases*
- Useful in many situations as *interim improvements* or *long term enhancements* to existing fish protection technologies already in place....

# **Experimental Fish Guidance Devices (1994)**

<http://swr.nmfs.noaa.gov/habitat.htm>

## **Behavioral Fish Guidance Devices:**

### **“Cons”**

- **Requires a volitional taxis by fish to avoid entrainment... [resulting from a “startle” or avoidance response to a stimulus]**
- **in strong/accelerating water velocity field, the lack of swimming ability, or swimming fatigue, in a small fish may prevent it from responding to stimulus even if it attempts to do so**
- **providing a “safe hydraulic environment” for fish often requires physical structure. If behavioral devices require structural additions to modify hydraulics, the cost advantage may be substantially diminished**
- **other environmental conditions & cues [e.g.- predator/prey behavior, turbidity, etc.] may cause fish to be confused or ignore the signal.  
(competing stimulus theory)**

# Experimental Fish Guidance Devices (1994)

<http://swr.nmfs.noaa.gov/habitat.htm>

## Criticisms of the policy:

- **Too rigid, inflexible**
- **No well-defined system to determine where a technology is in the process and how it can move to the next step with general acceptance by government regulators**
- **Takes too long to move serially from one step to another**
- **Regulators often are not up-to-date on technological progress as it happens as a result of simultaneous, and geographically, distant lab experiments and field prototype tests**
- **Stifles innovation by creating unreasonable “barriers to entry”**

**On the other hand...using this approach, the NOAA Fisheries Southwest has seen the following results from experimental behavioral barriers field testing-**

***1993-1996 - Reclamation District 108***

***Sacramento River, Agricultural Irrigation - 582 MGD or 900 cfs***

Field experiments failed to show efficacy using **acoustics and electricity as barriers**; first consultant's report used incorrect and misleading statistical methods, i.e. - "pseudo-replication"  
Second consultant improved the legitimacy of the science, but the results remained ***inconsistent*** and ***ultimately unsatisfactory*** for the protection of endangered winter-run chinook salmon fry.

***1994-1996 - Reclamation District 1004***

***Sacramento River, Agricultural Irrigation - 388 MGD or 600 cfs***

Field experiments failed to show efficacy using acoustic barrier.  
In addition, the installation was plagued by mechanical anchoring problems.

***1997 - Georgiana Slough Acoustic Guidance Experiment,***

***Sacramento River, water conveyance- 5000 cfs or 3232 MGD (estimate)***

Field experiments failed to show efficacy of acoustic barrier in guiding fish away from a channel which leads to California's Delta Water Export Pumping Plants. In addition, the installation was plagued by mechanical anchoring problems.

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## Recent History and Evolution of Technology Guidelines and Development:

- 1994- NOAA Fisheries Southwest Region develops Regional Guidelines to discourage proliferation of ineffective “black box fish protection systems” Northwest Region soon adopts a similar policy.
- 1993-97- NOAA Fisheries and California Dept.of Fish and Game evaluate unsuccessful field trials of acoustic and electric barriers
- 1995- *Fish Passage Technologies*- published by Congressional Office of Technology Assessment
- *Using Sound to Modify Fish Behavior...*Portland State workshop (see: Bonneville Power Administration Final Report)
- 1997- NOAA Fisheries Southwest Region modifies: “*Fish Screening Criteria for Anadromous Salmonids*” to include provisions for a “*Variance Procedure*” on a project-specific basis
- 1997 - *EPRI Fish Passage Workshop* in Milwaukee, WI
- 1998 - NOAA Fisheries Southwest Region promotes a proposal for an applied “Technology Development Facility” at the U.S. Bureau of Reclamation’s fish salvage facility at Tracy, CA.
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## Recent History and Evolution of Technology, Guidelines, and Developments

- 1999 - *Innovations in Fish Passage Technology* - Odeh et al.  
American Fisheries Society
- 2000- *Guidelines for Evaluating Fish Passage Technologies-*  
American Fisheries Society Bioengineering Section
- 2000 - *Advances in Fish Passage Technology* - Odeh et al.  
American Fisheries Society Bioengineering Section
- 2001 - EPA initiates CWA 316(b) rules for “Cooling Water Intakes”**
- 2001 - *Behavioral Technologies for Fish Guidance* - Coutant et al.  
American Fisheries Society
- 2002- NOAA Fisheries Sacramento area office accepts field prototype(s) and 5 year monitored test of **“Aquatic Filter Barrier”** at Mirant Corp’s Pittsburg and Contra Costa Power Plants under ESA Section 7 consultation
- 2003- NOAA Fisheries Sacramento area office *considers a proposal* for **“combined behavioral technology”** (acoustics+bubble curtain) prototype experiment as a potential means to collect juvenile salmon above Oroville Dam on California’s Feather River
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**American Fisheries Society Bioengineering Section**  
***Guidelines for Evaluating Fish Passage Technologies (2000)***

[http://www.afsbioengineering.org/fish\\_pass\\_comm.htm](http://www.afsbioengineering.org/fish_pass_comm.htm)

- 1) Recognizes the **conflict between peer-reviewed science standards and timelines faced by industry** through regulatory processes
- 2) Acknowledges that **many field tests have proved equivocal, or not sufficiently scientific...and that vendors of technology have inherent financial interests and may occasionally be biased in claiming product effectiveness.**
- 3) Asserts that **some promising behavioral technology studies have been negatively received due to inadequate experimental design, lack of experienced personnel, and improper applications of specific technologies**
- 4) Acknowledges that lack of peer-reviewed science relegates test results to **“gray literature”** status in the minds of many scientists and regulators. Proposes to establish a **“peer-review system” via AFS Bioengineering Section** to help expedite evaluations of technology field trial performance

**American Fisheries Society Bioengineering Section**  
**Guidelines for Evaluating Fish Passage Technologies (2000)**

[http://www.afsbioengineering.org/fish\\_pass\\_comm.htm](http://www.afsbioengineering.org/fish_pass_comm.htm)

- 4) Clear need: **improving evaluating process [of fish protection technologies]**  
providing... **greater consistency in experimental design...**  
... **scientific and objective evaluation process**
  
- 5) Replace: **Trial and Error Process**  
with: **improved experimental design, better communication,**  
leading to: **general consensus on biological effectiveness (or ineffectiveness)**
  
- 6) **...Tool for bringing new technologies into practical application**
  
- 7) offers... **standardized procedures** for development, evaluation, and application of technologies **using “sound science,”** but remaining **sufficiently flexible.**

**American Fisheries Society Bioengineering Section**  
***Guidelines for Evaluating Fish Passage Technologies (2000)***

[http://www.afsbioengineering.org/fish\\_pass\\_comm.htm](http://www.afsbioengineering.org/fish_pass_comm.htm)

**Effectiveness requirements may vary by jurisdiction due to:**

**\* species distribution,**

**\* regional histories of specific technologies**

**\* robustness of local stocks,**

**\* laws and statutes,**

**\* fish management strategies,**

**\* regional societal values...**

**American Fisheries Society Bioengineering Section**  
***Guidelines for Evaluating Fish Passage Technologies (2000)***

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**Technologies Defined:**

**Existing Technologies-**

**e.g.- positive barrier screens, fish ladders, other conventional hydro-mechanical systems... are subject to existing formal design and performance criteria in the western states NMFS, USFWS, state departments of Fish & Game**

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**Experimental Technologies-**

**Devices or systems ... which have demonstrated some potential for protecting or passing fish, but .. adequate scientific evidence has not been collected to verify effectiveness...gain agency acceptance or ... considered for general application. Behavioral fish protection devices such as louvers, strobe lights and sound systems are considered experimental by some resource agencies (NMFS 1994), but are accepted by others (Odeh and Orvis 1997).**

# *Guidelines for Evaluating Fish Passage Technologies (2000)*

American Fisheries Society Bioengineering Section

[http://www.afsbioengineering.org/fish\\_pass\\_comm.htm](http://www.afsbioengineering.org/fish_pass_comm.htm)

## **Guideline Implementation... another step-wise process**

### **Phase I- Conceptual Development**

...establish an “Expert Review Panel” and study plan

### **Phase II- Laboratory Evaluation**

...controlled operational and environmental conditions

### **Phase III- Prototype Evaluation**

...large scale field evaluation in “real world conditions”

### **Phase IV- Application and Evaluation**

...Expert Review Panel verifies effectiveness  
stating any conditions, limitations, or exceptions

**Current “CWIS”  
Evaluation and Certification Processes  
in  
California**

# **POWER FACILITY LICENSING CASES CURRENTLY BEFORE THE COMMISSION**

## **Projects Greater Than 300 Megawatts(4)**

Avenal Energy Project (01-AFC-20) Project Suspended until May 2003

1.Blythe Energy Project Phase II (02-AFC-1, 6 or 12-month AFC)

2.East Altamont Energy Center (01-AFC-4)

3.El Segundo Modernization Project (00-AFC-14)

4.Inland Empire Energy Center (01-AFC-17)

5.Morro Bay Power Plant Project (00-AFC-12)

6.Palomar Energy Project (01-AFC-24)

7.Potrero Power Plant Project (00-AFC-4)

8.San Joaquin Valley Energy Center (01-AFC-22, 6-month AFC)

9.SMUD Cosumnes Power Plant Project (01-AFC-19)

10.Tesla Power Plant Project (01-AFC-21)

United Golden Gate Power Plant, Phase II Project (01-AFC-3, 6-month AFC) - Project On Hold

## **Projects Less Than 300 Megawatts**

11.City of Vernon Malburg Combined Cycle (01-AFC-25, 6-month AFC)

Los Banos Voltage Support Facility (01-AFC-23, 6-month AFC) - Project Suspended, 5/15/02

12.Modesto Irrigation District Electric Generating Station - Ripon

(03-SPPE-1, Small Power Plant Exemption)

13.Pico Power Project (02-AFC-3)

14.Salton Sea Geothermal Power Project (02-AFC-2, 12-month AFC)

15.Turlock Irrigation District Walnut Energy Center (02-AFC-4, 12-month AFC)

## **Notable California Power Plants currently in consultations under:**

- California Energy Commission certification procedures,**
- California Fish and Game Codes**
- CWA 316(b) regulations,**
- Endangered Species Act, and/or**
- Essential Fish Habitat Consultations**

**→ Pittsburg-Contra Costa Power Plants (2)- Mirant Corp.**

**→ Portrero Power Plant- Mirant Corp.**

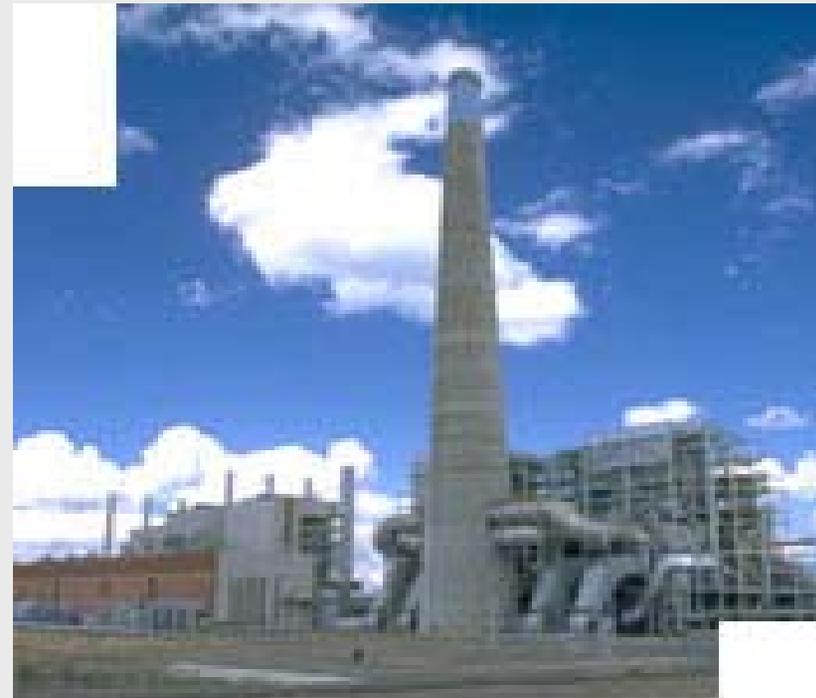
**→ Morro Bay- Duke Energy**

**→ Moss Landing- Duke Energy**

## Contra Costa Power Plant

Mirant Corporation

Total Output: 6,7, and 8 = 1,210 MW  
“once-through cooling system”  
water source- Sacramento River



Contra Costa Generating Plant

## Pittsburg Power Plant

Mirant Corporation

Total Output = 1,906 MW  
“once-through cooling system”  
water source- Sacramento River

### NMFS Biological Opinion 2002:

- **Pittsburg-**
  - 5-year field test of “AFB”
  - **Formal monitoring and evaluation**
  - Habitat enhancement measures
  - Off-site mitigation
- **Contra Costa-**
  - cooling water conservation program
  - variable speed drive pumping (VSD)
- Habitat enhancement measures
- Off-site mitigation

# Potrero Power Plant

Mirant Corporation

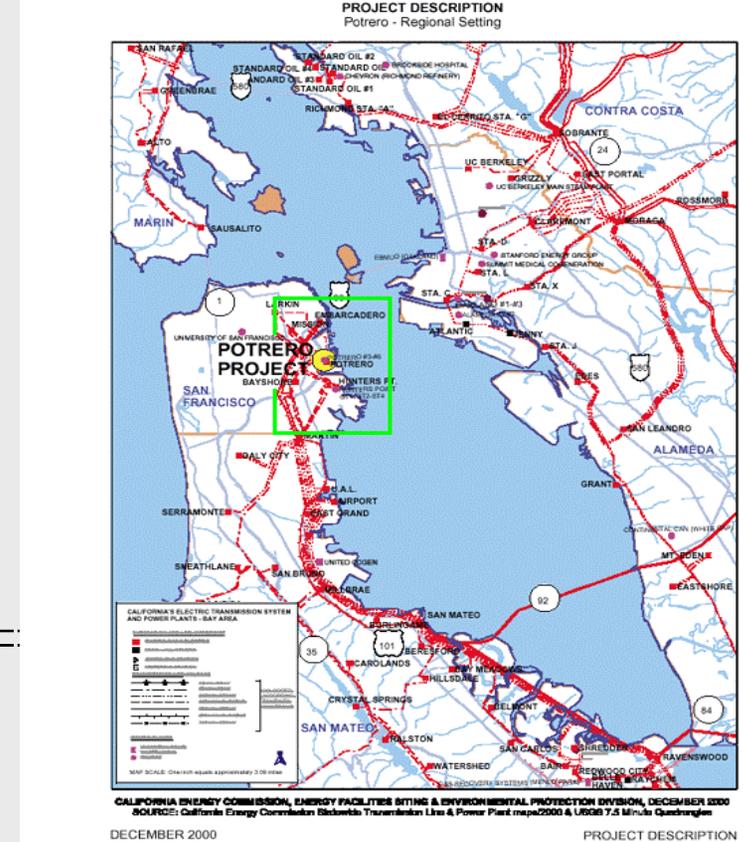
Proposed Total Power Output = 540 MW  
(units 4-7)

“once-through cooling system” = 228 MGD  
water source = San Francisco Bay

NOAA Fisheries consultations in progress:

ESA § 7 - considering conventional screening of intake, along with Habitat Enhancement and off-site mitigation

EFH - recommending consideration of Dry Cooling as best means of minimizing adverse impact to NOAA trust resources in SF Bay



Other agencies forums and regulatory proceedings are simultaneously in progress

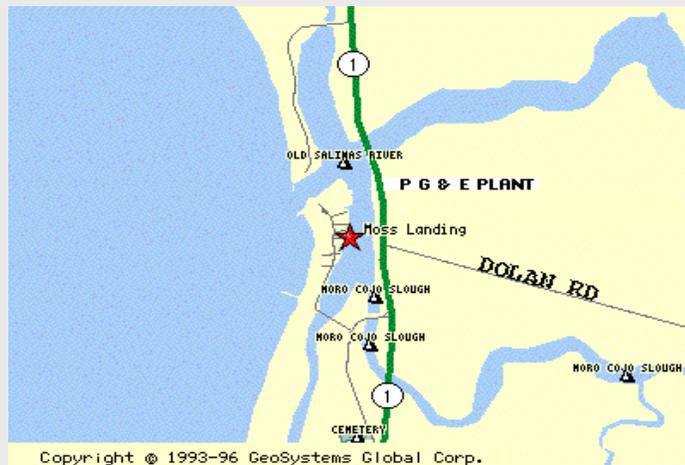


# Moss Landing Power Plant told to review use of water for cooling

...a Monterey County judge has ruled that **more expensive cooling methods must be studied** for **Duke Energy's** huge power plant in **Elkhorn Slough** at **Moss Landing**.

Superior Court Judge O'Farrell's **decision** *won't interrupt the flow of 2,550 megawatts of power* -- about 5 percent of California's total electricity use on a hot summer day. [but ...*it will force the Regional Water Quality Control Board to review its permit to make sure that the ``best technology available'' is being used to protect marine life*, as required by the Clean Water Act....

San Jose Mercury News 10/03/02



**Aquatic Filter Barrier proposed for this site to prevent entrainment**



# Morro Bay Power Plant

Duke Energy

Total Upgraded Output = 1,202 MW  
(enough to serve 1 million households)

applicant proposes to use existing  
**“once-through cooling system,”**  
but modernized plant **will use 38% less cooling water**



## Proposed Habitat Enhancement Measures

- 1) Offset and minimize effects of entrainment with *modernized* plant
- 2) Improve quality and quantity of aquatic habitat in Morro Bay
- 3) Reduce sediment transport into Morro Bay
- 4) Complement on-going Bay protection programs
- 5) Conduct **“Aquatic Filter Barrier”** feasibility study

**April 10, 2002...Letter from Duke Energy to CA. Regional Water Quality Control Board:**  
citing independent review:

*Entrainment Mortality and the Morro Bay Power Plant Modernization Project:  
Technical Comments and Ecological Context ...*      **Dr. James Cowan, Jr.**

Selected and Paraphrased Excerpts:

- ...mortality estimates should **include all major taxa** of entrained species
- ...known “**mechanisms of compensatory mortality**” effectively operate to maintain population levels commensurate with the carrying capacities of their respective habitats
- ...Dr. Cowan used a **life history [model] to predict magnitude of compensation** and to describe the first-order potential for compensation in Morro bay fish species
- “...each of the species should be capable of either compensating for losses of early life stages, or to persist in the face of very high mortality rates of eggs and larvae
- ...losses of larvae do not translate *directly* into losses of adults if entrainment occurs before compensation...[and] **arguments that infer that removal of larvae [from Morro Bay] at any level results in an equivalent decline in ecosystem productivity are not founded in sound ecological and fisheries theory.**

## **EPA 316(b) Legal Process:**

### **A New Standard for Protection of Aquatic Organisms?**

Traditionally, NOAA Fisheries-west has been concerned with preventing entrainment of fry-size salmonids (20-30mm FL) with positive barrier fish screens

With current fish screen mesh sizes (1.75mm) and good hydraulic characteristics, high-efficiency exclusion of organisms as small as 4 mm has been observed.

However,

at least two major court cases are pending where environmentalists challenge the entrainment, impingement, and predation effects on **zooplankton and phytoplankton** communities- sometimes referring to large water intakes as “**giant filter-feeders**” which adversely impact the aquatic ecosystem’s food web.

Other scientists counter that these small organisms reproduce rapidly and prolifically; and there is a “**density-dependent**” phenomena at work which allows populations to sustain themselves.

# NOAA Fisheries-SWR Engineering Perspective of a Prospective “*Phytoplankton Standard*”

## Questions

- What percentage of phytoplankton and zooplankton survive transport in “once-through cooling systems?”
- What is the biological cause(s) of mortality for organisms that die?
- Can small biota be salvaged and returned to the environment?
- Can plant cooling systems be re-engineered or retrofitted to maximize survival of very small aquatic species?



# NOAA Fisheries-SWR Engineering Perspective of a Prospective “*Phytoplankton Standard*”

- **“Micromesh fabrics”**

such as the Gunderboom Aquatic Filter Barrier are considered experimental technology and are undergoing analysis of laboratory research and field prototype testing. There is no guarantee that this is a long term solution until sufficient performance evaluations have been conducted in enough situations.

**Durability, structural integrity** in hydraulic environments, and **maintenance** questions remain to be evaluated.

- **Non-physical Behavioral Guidance Systems**

(e.g.- sound, light, electricity, bubbles, etc)

**virtually no physical or biological effect on entrainment of extremely small organisms** (poor swimming or non-swimming), nor is there a hydraulic or biological rationale that would support a different expectation

# NOAA Fisheries-SWR Engineering Perspective of a Prospective “*Phytoplankton Standard*”

- Physical entrainment barriers using **micron size mesh** may present a **tremendous challenge to maintain the barrier material clean and undamaged on a consistent basis**, particularly in winter, or during stormy weather and spring freshets- where incipient **debris loading rate** can be very high in many locations
- If “**phytoplankton standard**” is upheld in courts for cooling water intakes, what does it mean for our existing, multi-billion dollar, national fish protection infrastructure (ie.- positive barrier fish screens and louver systems) at hydro-, agricultural, municipal, and other industrial water intakes across the country ?
- Is **hybrid Wet** or **Dry-Cooling** the only acceptable answer, or is there room for compromise based on biological and economic priorities? What about other sectors where water withdrawal cannot be avoided, e.g.- agricultural irrigation or municipal water supply?

## **Where do we go from here?**

- Courts will likely decide how stringent or flexible technology standards can be for Cooling Water Intakes under EPA 316(b)**
- There may be other laws and standards in effect, e.g.- Endangered Species Act listings in regional areas.**
- NMFS-west generally defers to another standard if it requires a higher level of fish protection efficiency under an existing state, federal, or local laws**

## In the meantime,

from a federal, regulatory point-of-view...

- continue working on ways to improve *effective fish protection* for the lowest possible cost
- support continued technological innovation for fish protection, but make sure it is based on good science
- support use of: *NMFS Experimental Fish Guidance Devices (1994)*  
*AFS Guidelines for Evaluating Fish Passage Technologies (2000)*  
as appropriate to the protection goals and standards of particular regions
- consider more streamlined, efficient evaluation and approval processes to allow more widespread testing of field prototypes...
- ...so long as there is a sufficient amount validity and integrity to the process of demonstrating “fish protection results” accurately and scientifically.

**THE END**

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