SANITATION DISTRICTS OF LOS ANGELES COUNTY

Occurrence and Effects of Contaminants of Emerging Concern (CECs) in the Southern California Bight (SBC) Coastal Ecosystem

Joe Gully

Ocean Monitoring and Research Group

Los Angeles County Sanitation Districts

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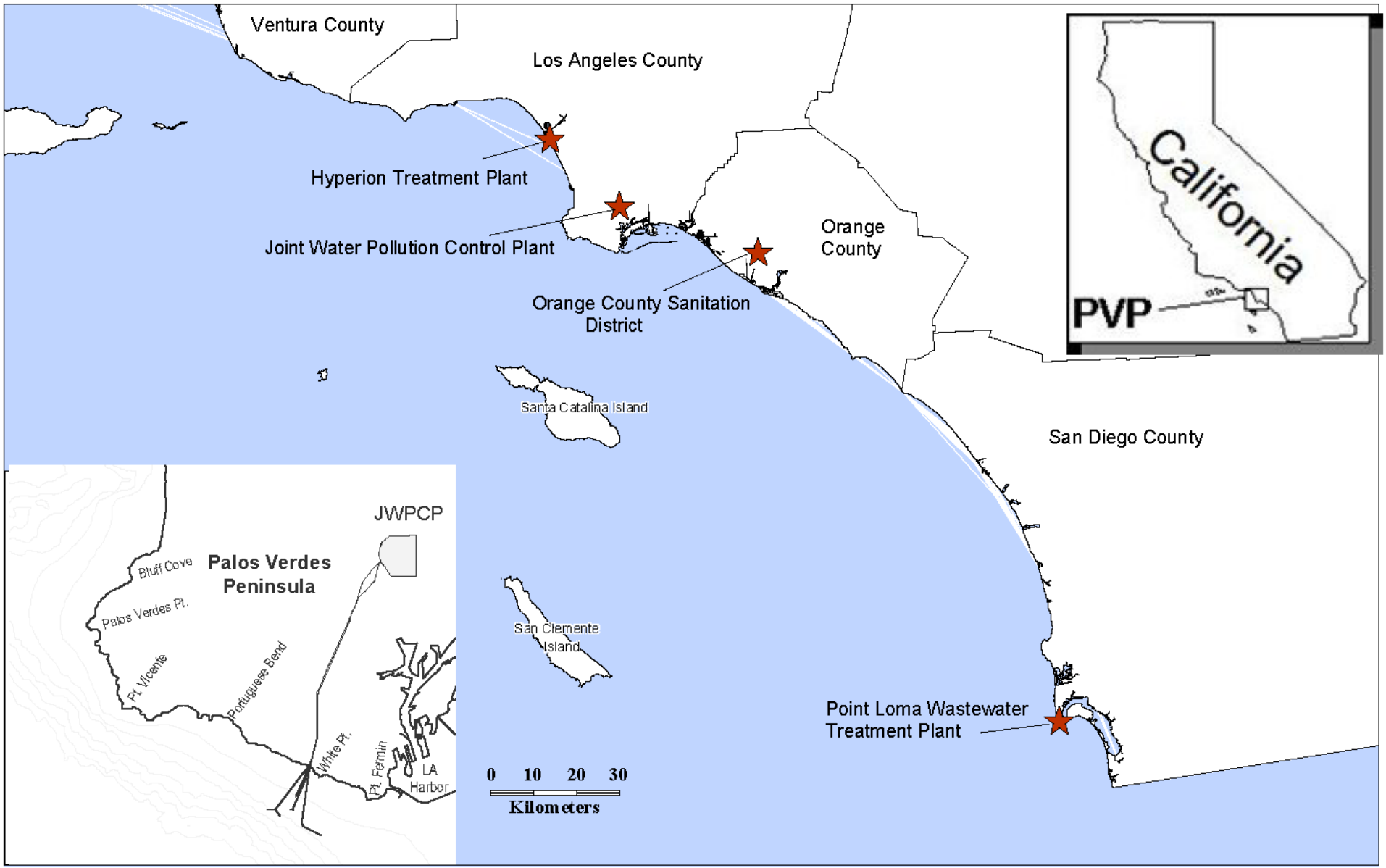
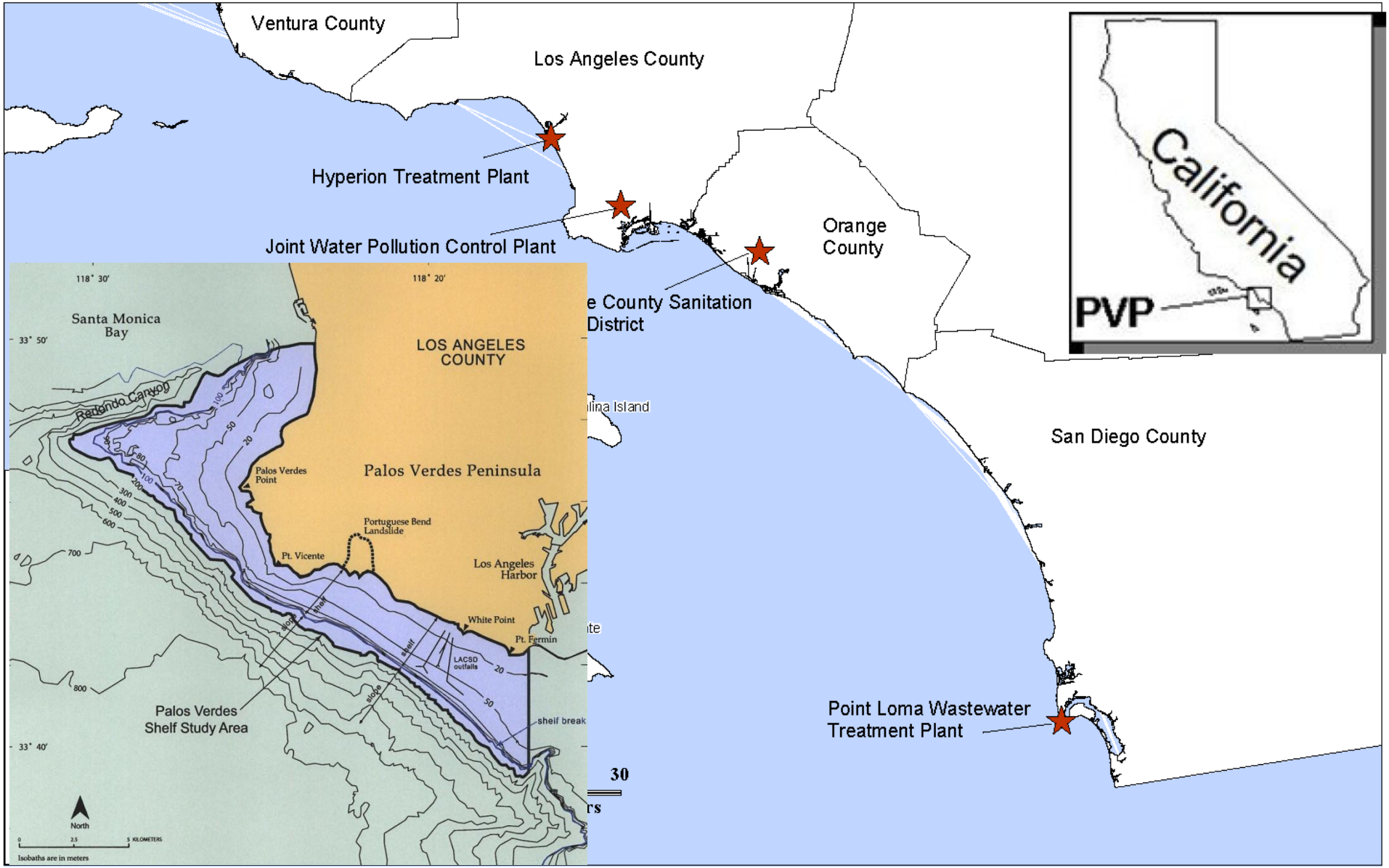
- LACSD: Dave Montagne, field crew
- OCSD: Jeff Armstrong, field crew
- CLAEM: Curtis Cash, field crew
- CSD: Tim Stebbins, field crew
- ABC Labs: Scott Johnson, field crew
- EPL: Marilyn and Jeff Wolf
- SNWA: Shane Snyder; Brett Vanderford, Janie Zeigler
- MSCL: Kevin Armburst; Kang Xia
- Ocean Institute: Rick Baker, Julianne Steers

Why Study the SCB?



Why Study the SCB?



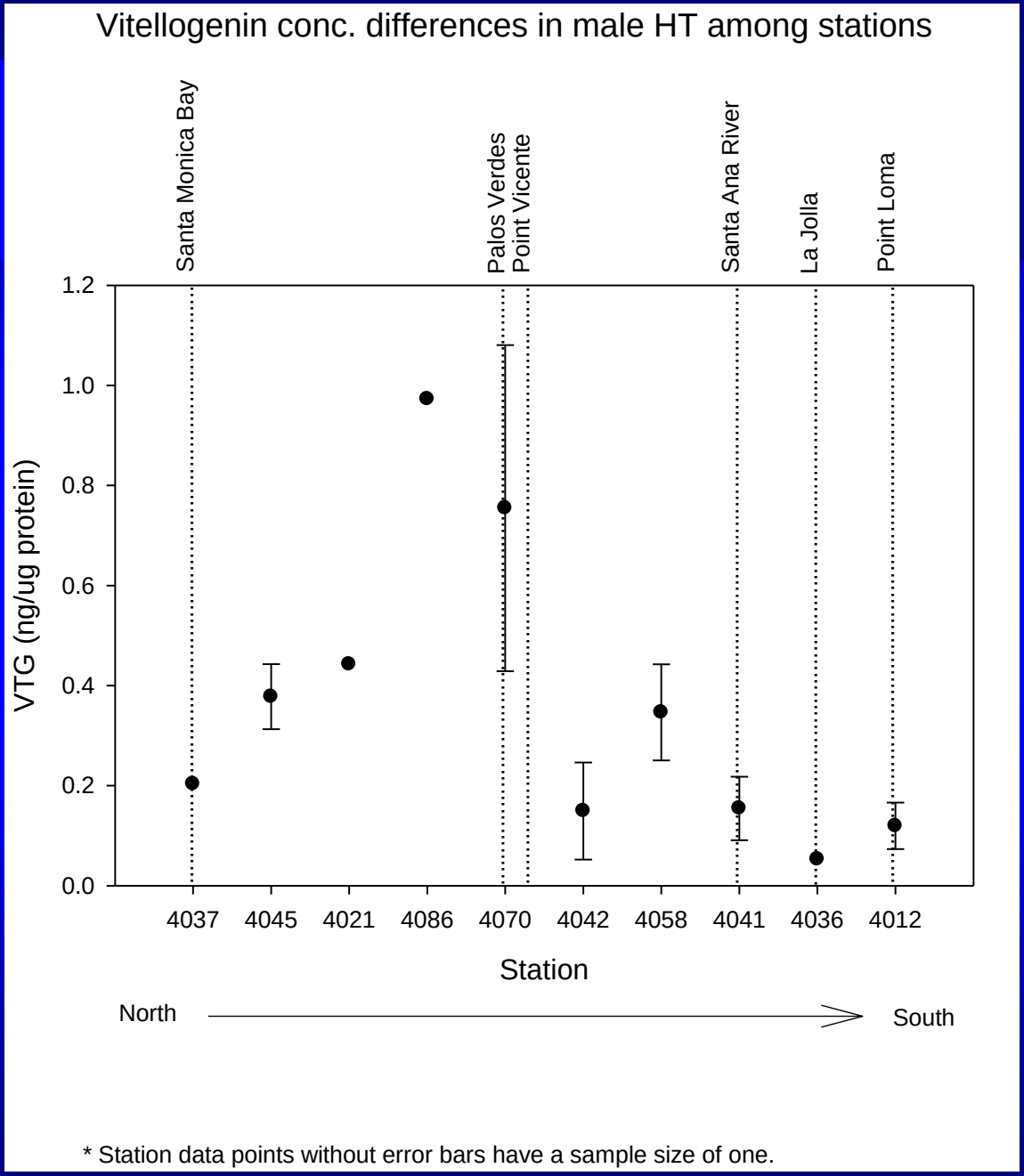
Prior CEC/EDC Research in the SCB

- NOAA/EPA
  - 1980s-1990s
  - Effects of DDT and PCBs
- Schlenk et al./OCSD
  - 1990s-2000s
  - Vitellogenin, reproductive metrics, stressor ID
- Kelly et al./OCSD
  - 2000s
  - Fish stress response
- SCCWRP/Bight'03
  - 2003
  - Flatfish condition

Bight'03 Pilot Study Design

Bight'03 Pilot Study Findings

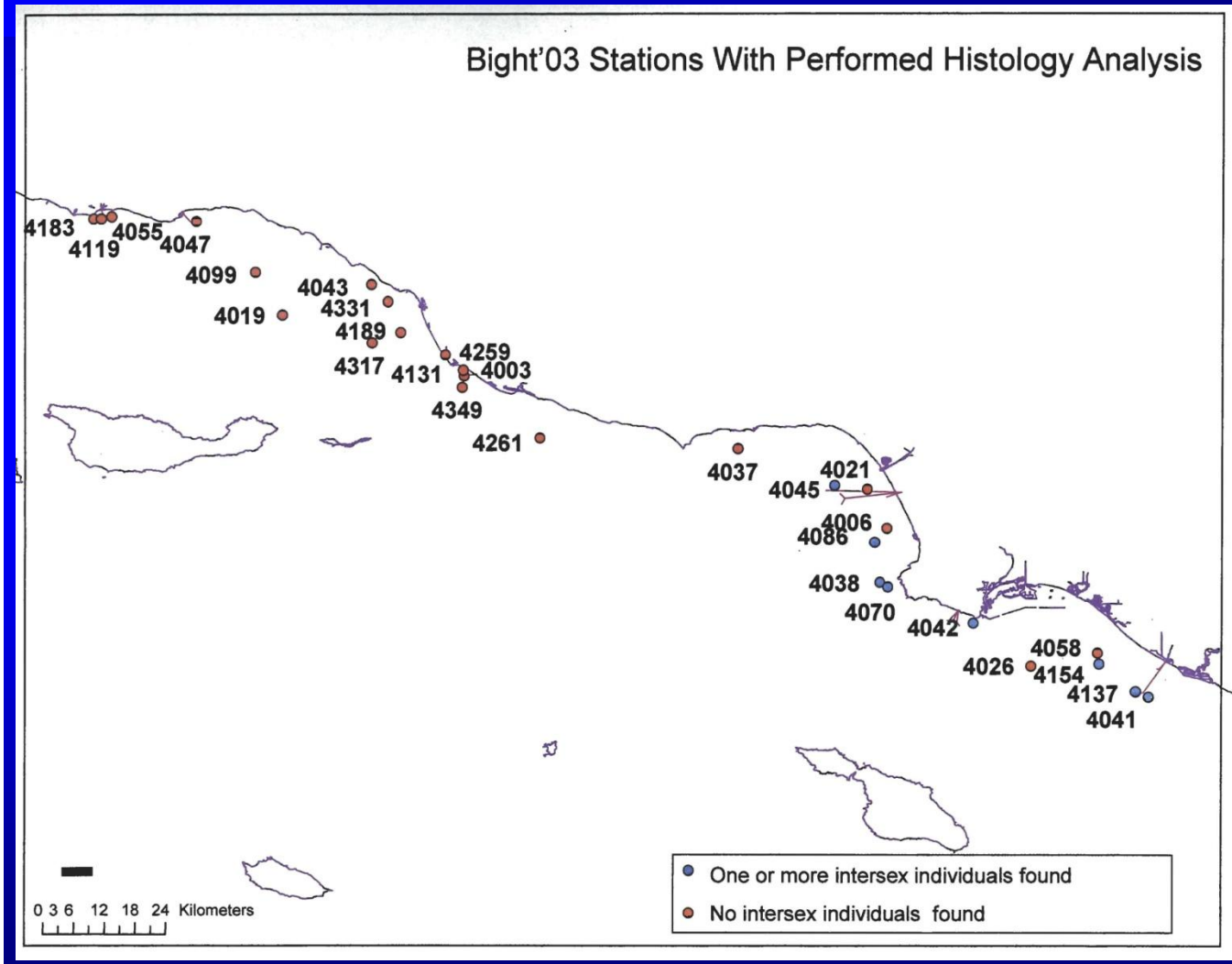
- Increased Vtg near LA region



Bight'03 Pilot Study Findings

Testis-ova in Male Flatfish Near LA

Station, Species, Total Fish, # Abnormal Fish	*Significance (p value)*
4041, HT, 3, 2	NS (0.20)
4042, HT, 4, 1	NS (0.50)
4045, HT, 4, 1	NS (0.50)
4070, HT, 5, 1	NS (0.50)
4038, ES, 7, 2	NS (0.23)
4154, ES, 5, 2	NS (0.22)
4086, ES, 8, 1	NS (0.50)
4137, ES, 1, 1	NS (0.50)



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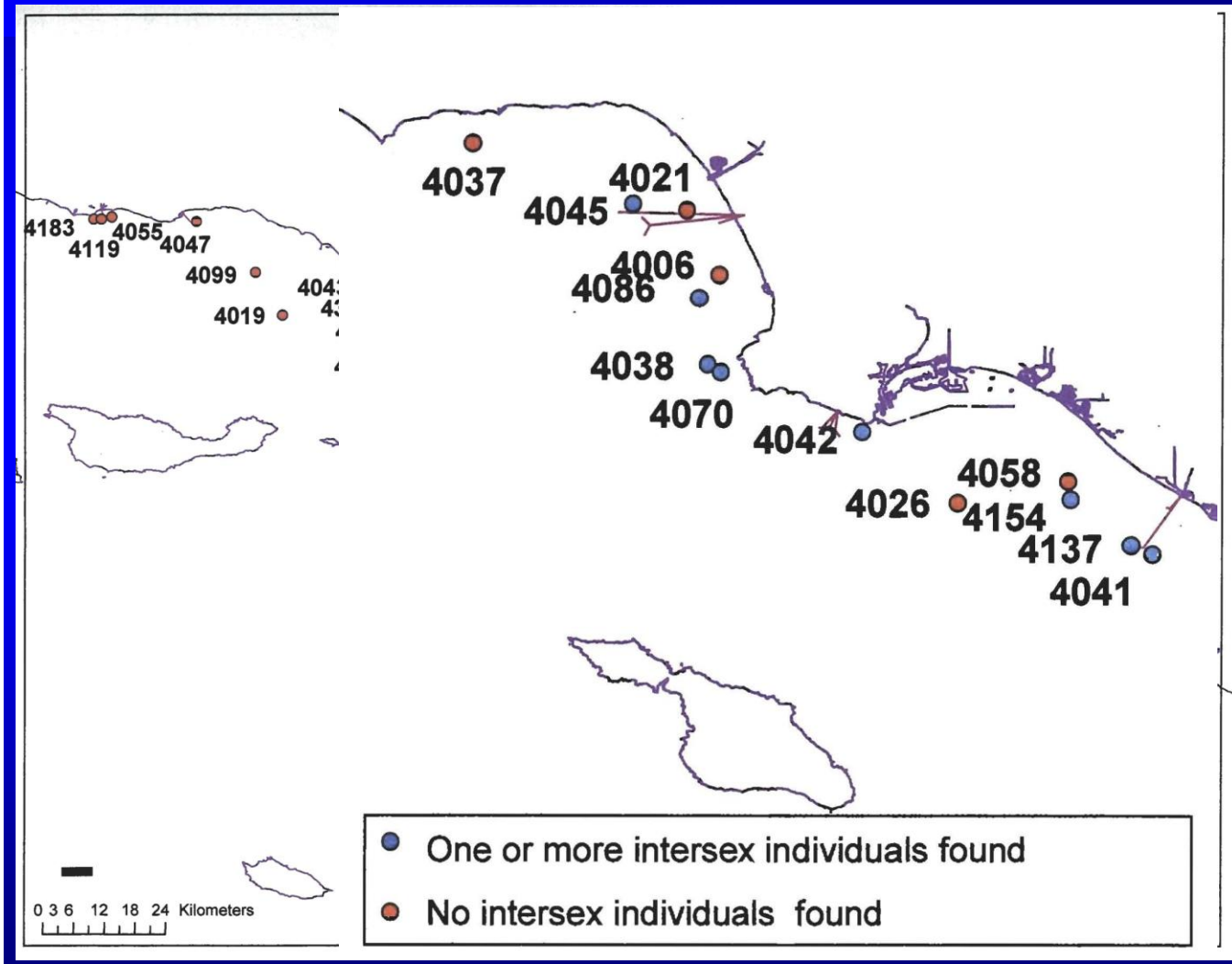


Unanswered Questions

- Are these responses significant and repeatable?
- Are these responses due to wastewater discharges?
- What chemical(s) are causing these effects?
- Which exposure pathways are involved?
- Are there any reproductive or population level impacts?

Sampling of Headlines

Sewage Altering Fish, Study Reports: Male bottom-dwellers with female sex characteristics are found near outfall pipes in waters off Los Angeles and Orange counties.

By Marla Cone, Times Staff Writer
11/14/05

Sampling of Headlines

Sewage pollutants cause southern California male fishes to bear eggs

2005-11-15 00:32:11 XinhuaEnglish

Sampling of Headlines

Sunscreen Sexually Alters Fish
United Press International
11/15/05

Sampling of Headlines

Male fish with eggs in sewage off California coast - Reuters

11/15/05

Sampling of Headlines

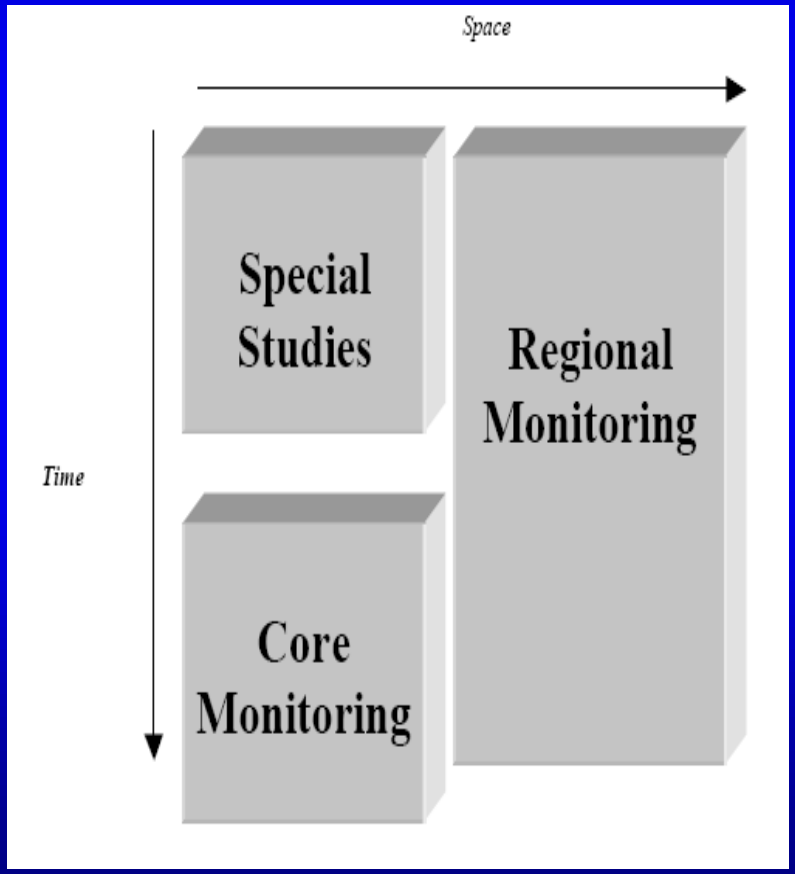
Feminized fish fuel further study: Early results suggest pollution might cause subtle alterations in two fish species.

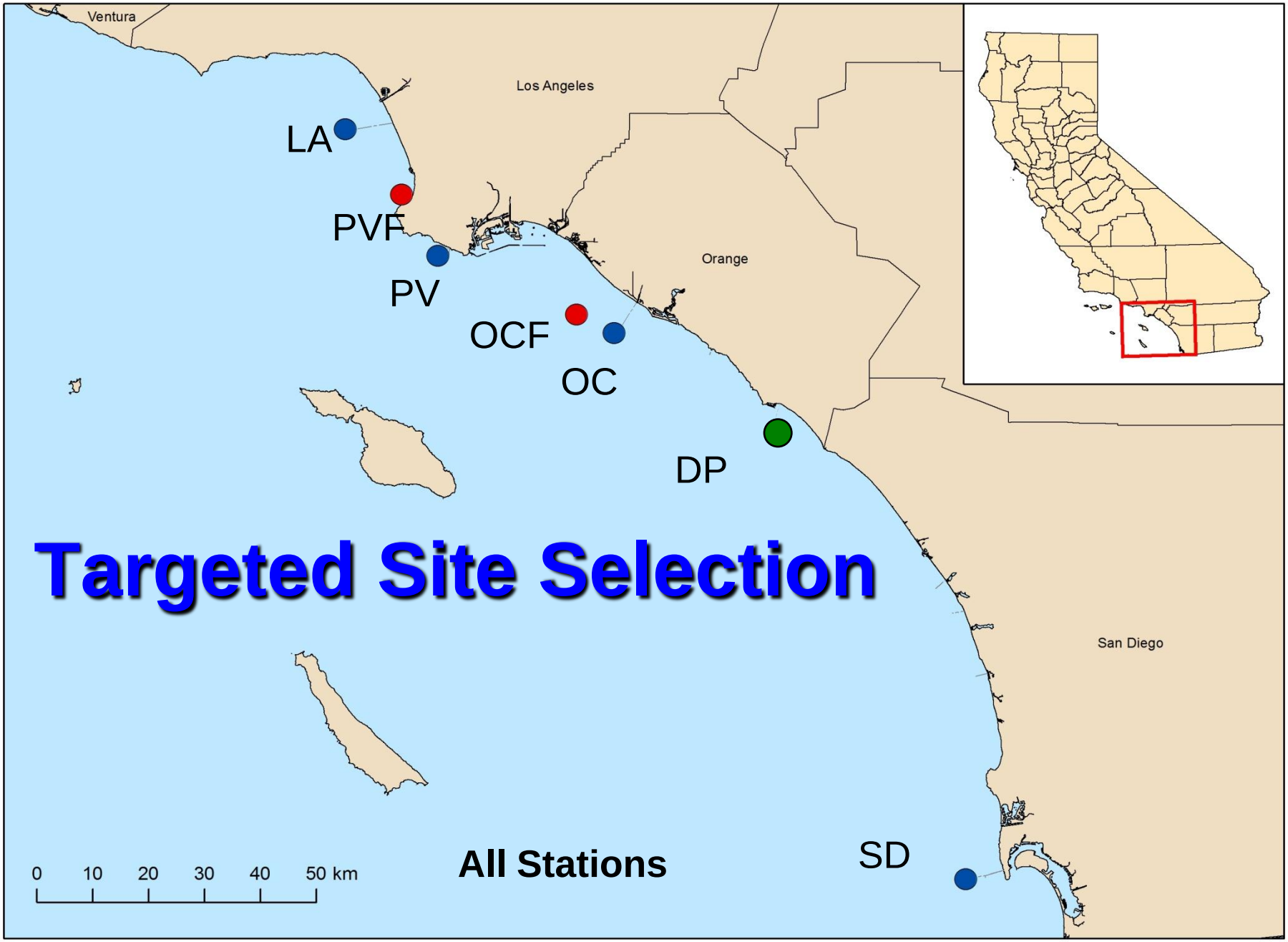
By PAT BRENNAN
The Orange County Register
11/16/05

Development of 2006 Study

- Multi-agency funded collaborative study
  - 5 POTWs, 3 Universities, several contract labs
  - Coordinated by SCCWRP
  - Streamlined by Bight history and **MMP** special studies provision

Model **M**onitoring **P**rogram




Ventura
Los Angeles
Orange
San Diego
LA
PVF
PV
OCF
OC
DP
SD
Targeted Site Selection
All Stations
0 10 20 30 40 50 km

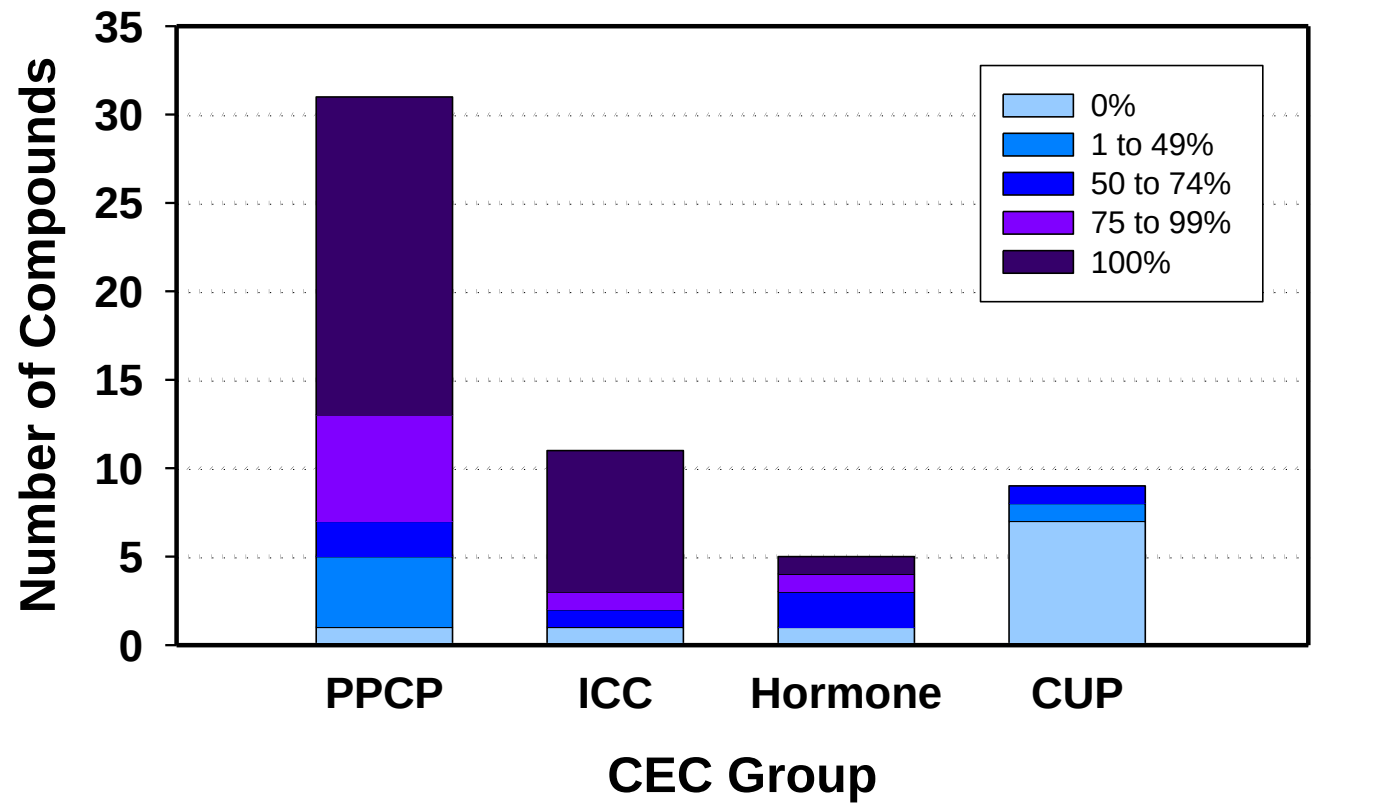
Study Design:
Evaluation of Exposure and Effects

- **What chemicals are discharged?**
  - **Municipal wastewater discharges (Final effluent)**
- **Are fish exposed?**
  - **Site water and sediment**
  - **Flatfish Liver**
- **Are there biological effects near outfalls?**
  - **Hornyhead turbot**

Model Organism Selection
Hornyhead Turbot

- Common local species
- Contact with sediment
- Benthic feeder
- Site fidelity
- Previous impacts
- HT specific microarray (MA)

CEC Occurrence in Effluent



- Treatment is only partially effective
- Treatment method makes a difference
- CECs are entering SCB via POTW discharges

Effluent/Site Water Contaminants

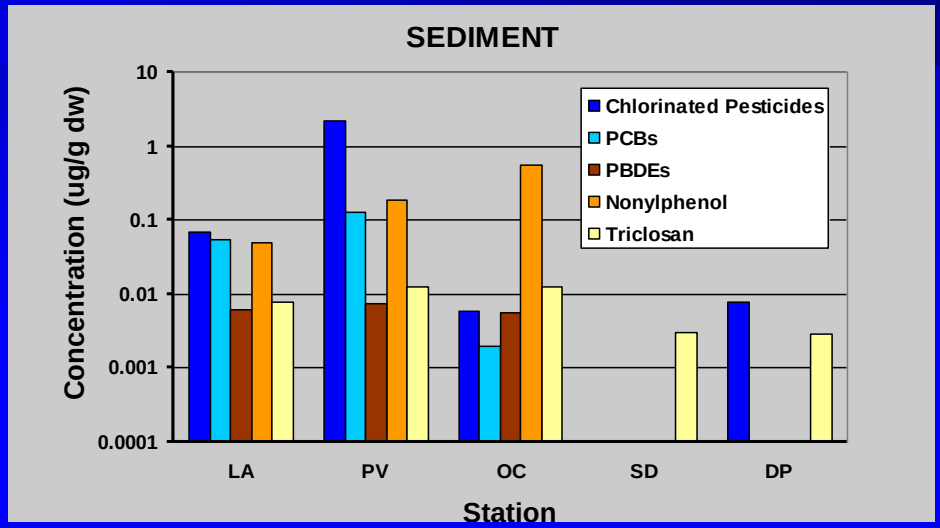
Frequency of Detection

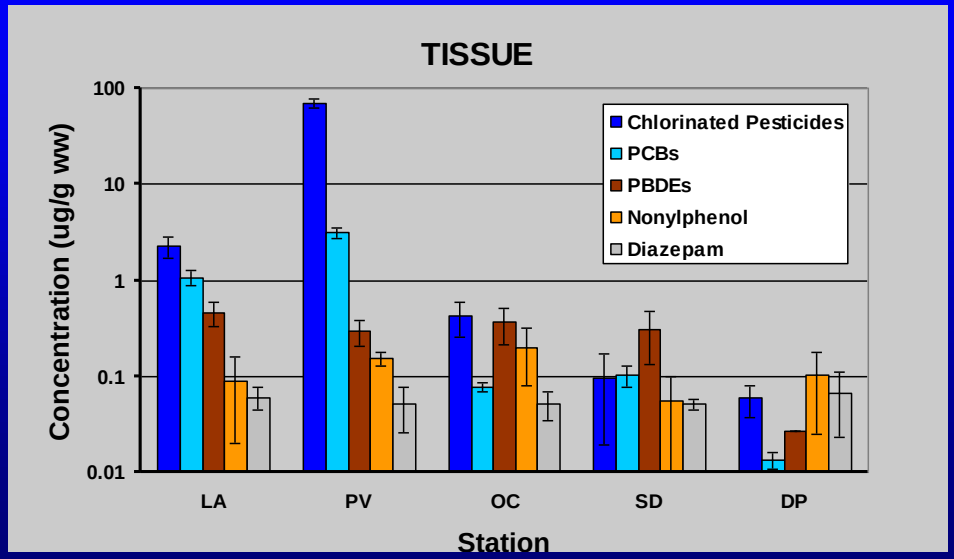
Use	Chemical Name	Seawater		Effluent		Dilution Factor
		Mean (µg/L)	Occurrence %	Mean (µg/L)	Occurrence %	
Pain reliver	Naproxen	0.0035	75	4.2580	100	1200
Antibiotic	Trimethoprim	0.0005	60	0.6222	100	1164
Antibiotic	Sulfamethoxazole	0.0008	70	0.9172	100	1112
Cholesterol regulator	Gemfibrozil	0.0030	90	3.1531	100	1048
Tranquilizer	Meprobamate	0.0004	50	0.3816	100	990
Beta-blocker	Atenolol	0.0023	90	2.1319	100	909

- Direct exposure from highly diluted effluent for some CECs (hydrophilic PPCPs) likely
- Fate of hydrophobic CECs likely to be sediments

Sediment and Fish Tissues

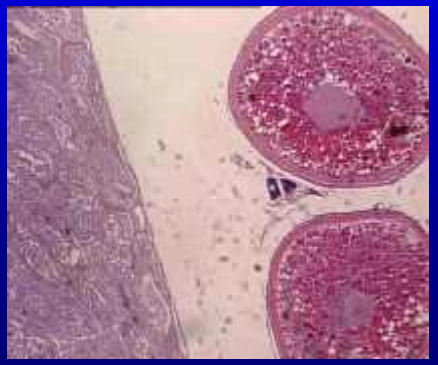
- Exposure observed throughout SCB
  - CECs entering the southern California coastal food web
  - Evidence of bioaccumulation
- Impacts of legacy contamination cannot be ignored
  - Similar modes of action
  - Similar distributions
- Is the exposure biologically significant?





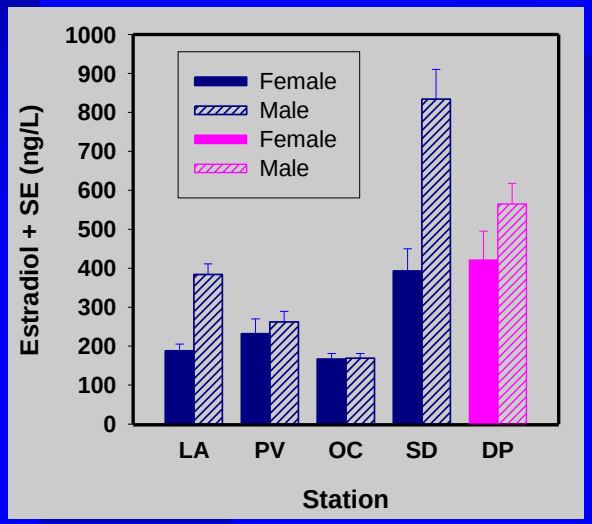
Measures of Biological Exposure & Effect

- Blood plasma
  - Hormones
  - Vitellogenin
- Tissue
  - Feminization
  - Egg degeneration
- Reproduction
  - Maturity
  - Gender ratio
- Population size
  - Long-term trends

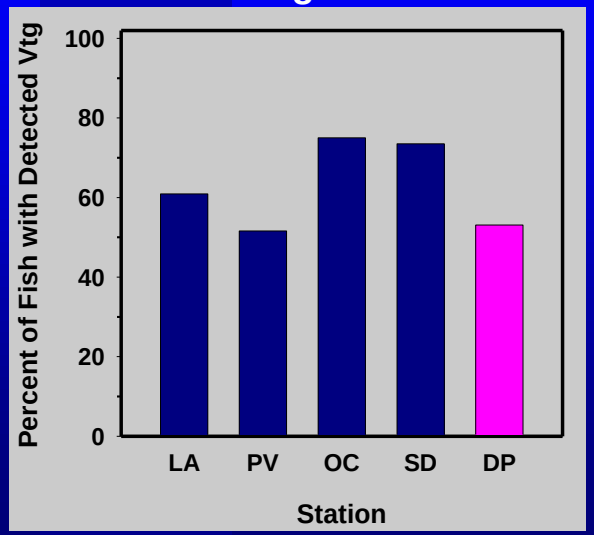


Molecular Responses

Plasma Estradiol

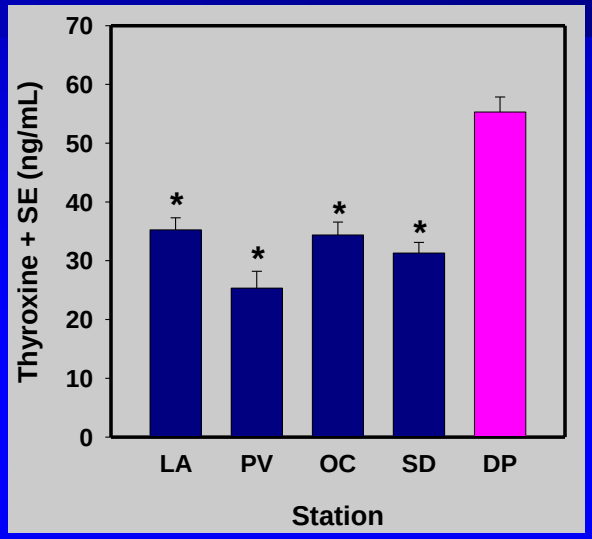


Plasma Vitellogenin: Males

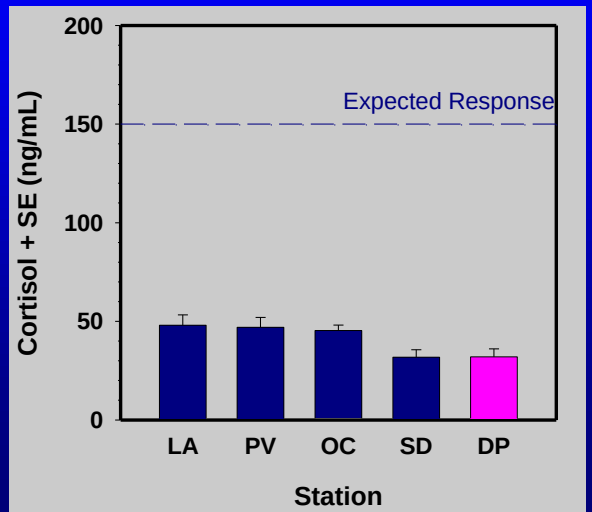


- Alterations in multiple hormone systems observed
- Little relation to POTW discharges (thyroxine?)
- Baseline conditions uncertain

Thyroxine

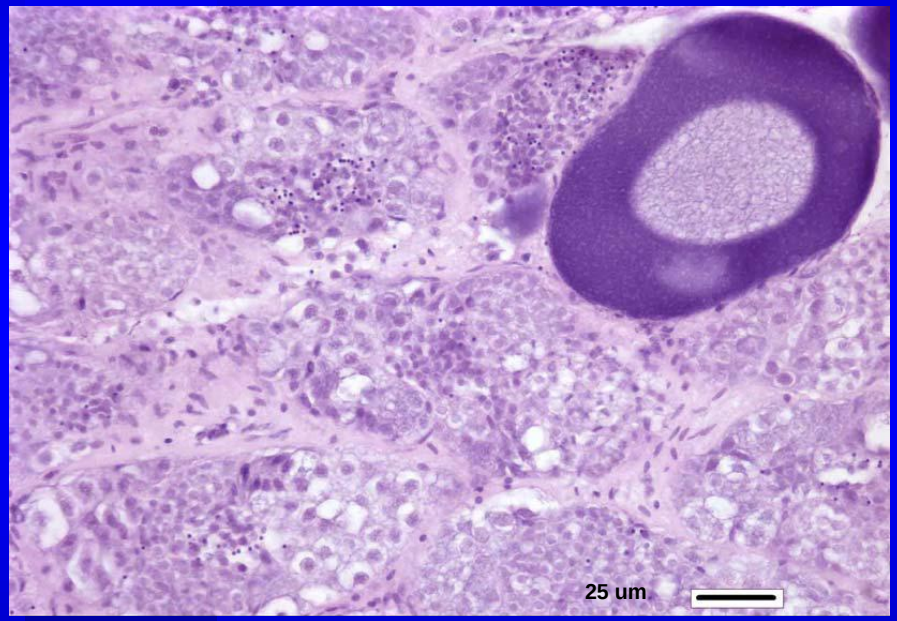


Cortisol

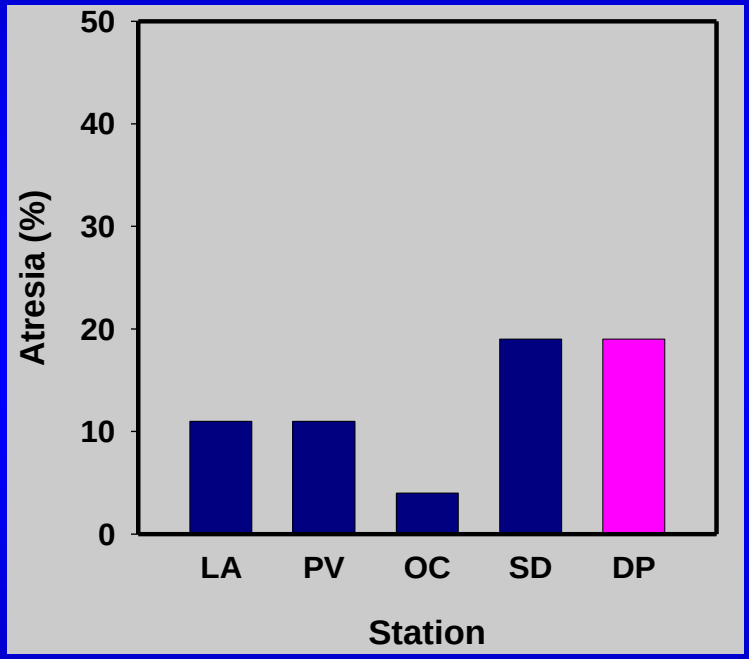


Effects on Reproductive Organs

Testis-ova



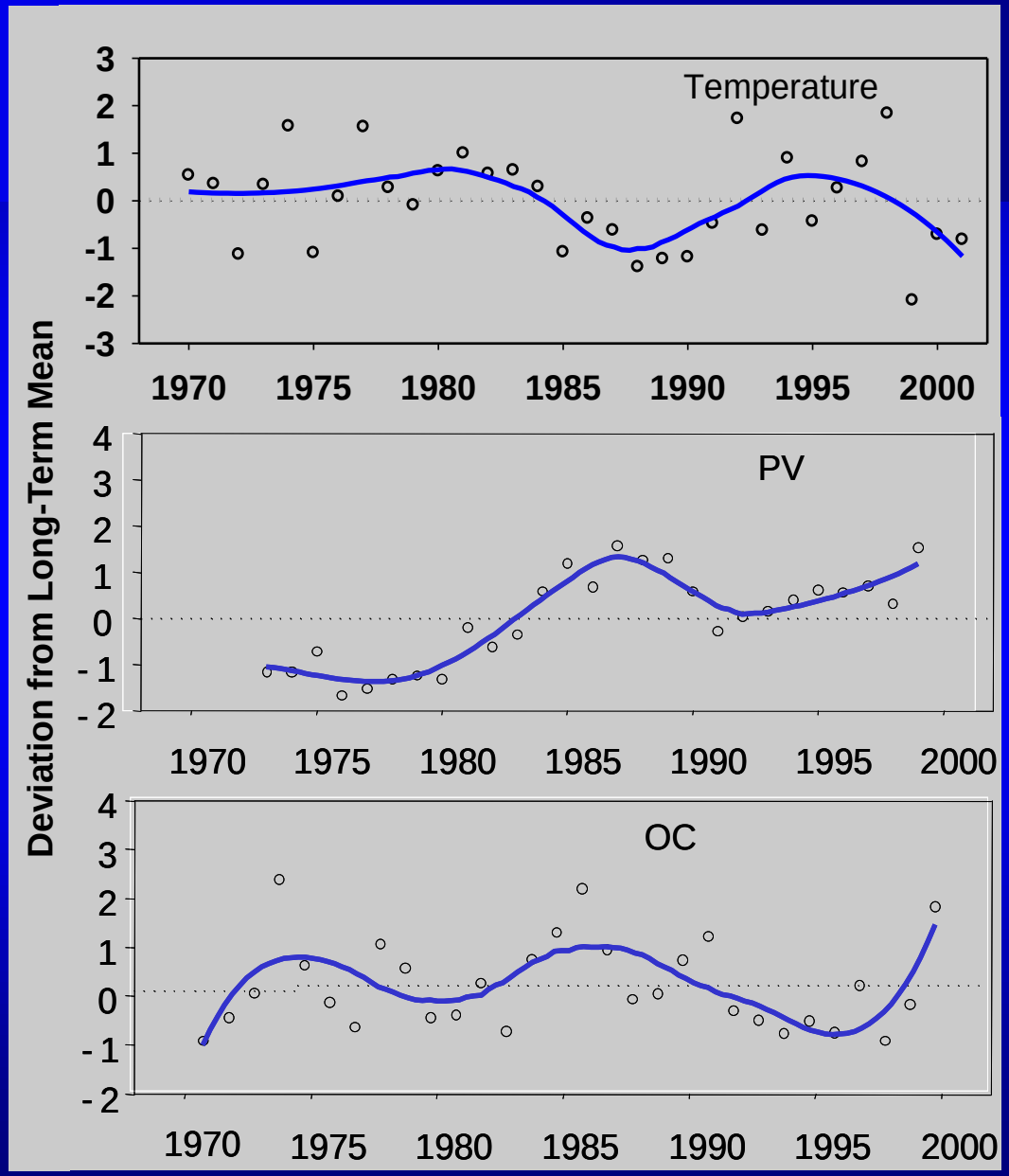
Ovary Degeneration (Atresia)



- No evidence of histological abnormalities
  - 1 occurrence of testis-ova in 373 males examined (OCF)
  - Contradicts results from Bight'03 study
  - Atresia in females seems normal and related to reproductive stage

Population Trends

- No evidence of recent declines
- Recent population changes correlated with oceanographic shifts



M.J. Allen, Pers. Comm.

General Conclusions

- Sources and fates of CECs in SCB
  - POTW discharge of CECs confirmed
  - CECs detected in receiving water, sediments, and fish
  - CEC exposure confirmed for some CECs, likely for others
  - Evidence of bioaccumulation of some CECs
    - Concern for apex predators?

- Biological effects in SCB flatfish
  - Molecular responses observed but cause and biological/ecological significance is uncertain
  - Tissue, organism, and population level impacts not evident
  - More information needed to determine appropriate monitoring or management actions

Next Steps

- What is normal for HT?
  - Define baseline conditions
  - Additional reference sites
  - Determine Spatial/temporal variability
- Evaluate/improve indicators used to assess impact
  - Can molecular assays be reliable predictors of impacts of concern?
- Which chemicals are of greatest concern?
  - Additional blood/tissue analyses
  - Other habitats
  - Dose Response Studies
    - Sediment extracts
    - Effluents
    - Reference CECs
    - Molecular tools

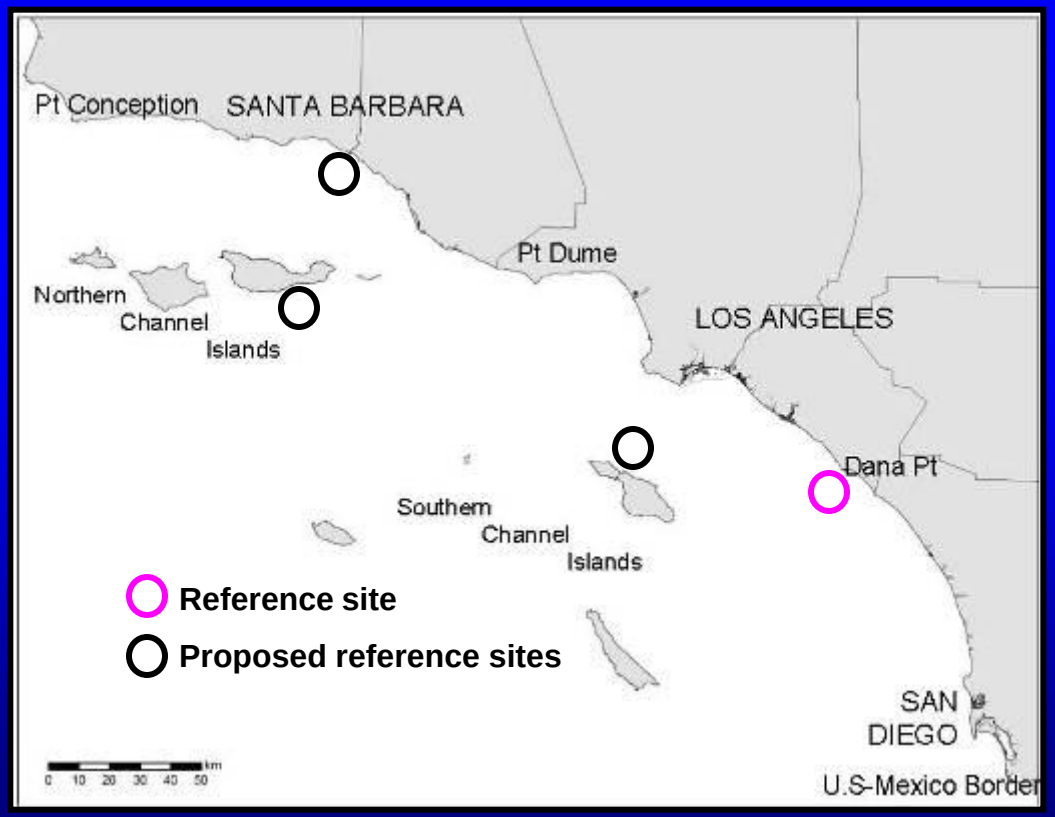
Questions?

Next Steps

Continue collaborative studies

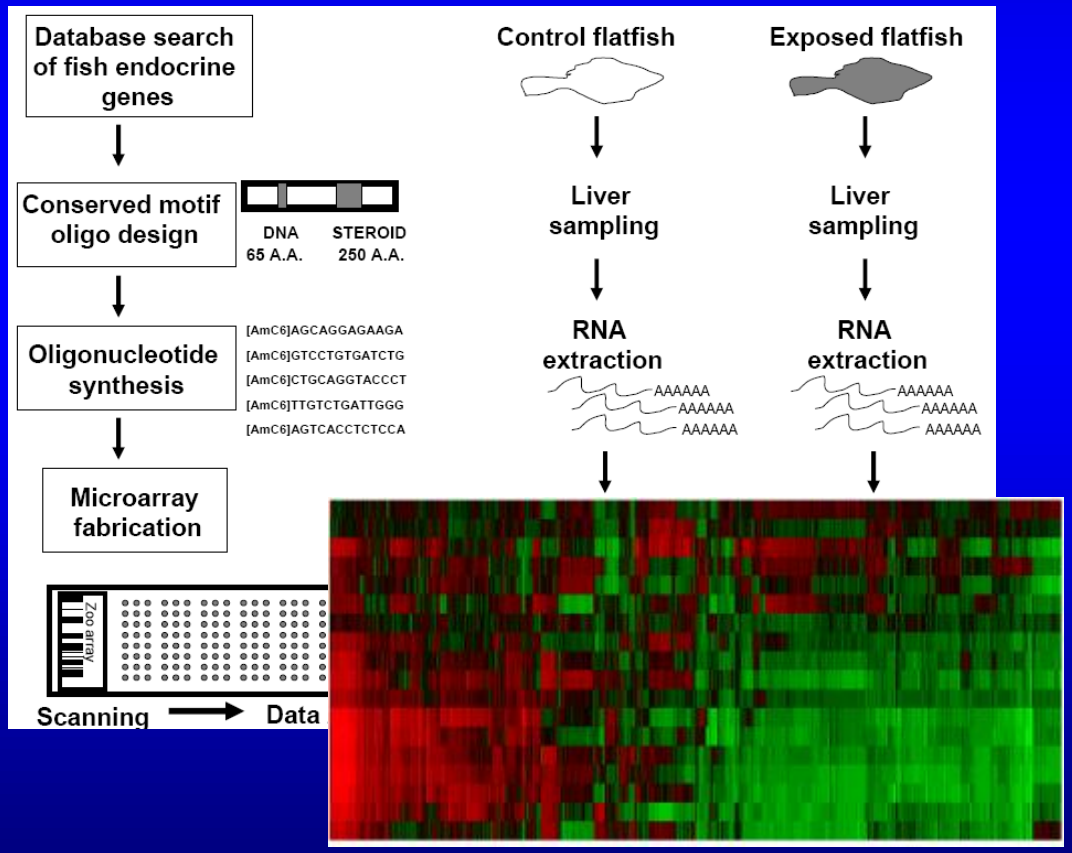
Address data gaps to provide greater certainty in interpretation

- **What is normal?**
  - **Define baseline conditions**
  - **Additional reference sites**
  - **Determine Spatial/temporal variability**



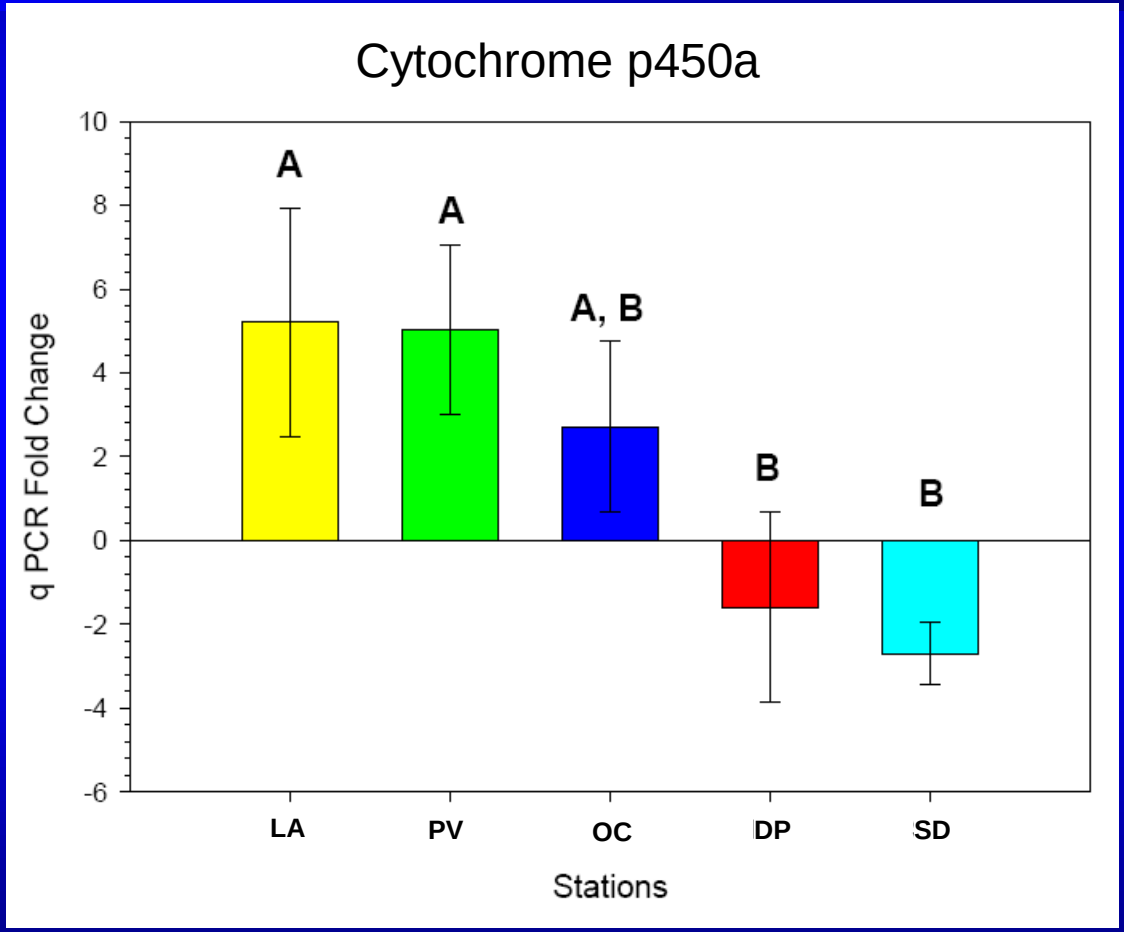
Next Steps

- What is normal?
- What are the best indicators?
  - Additional molecular tools
  - Gene microarray
    - Multiple species
  - PCR
  - Lab exposures
  - New collaborations needed



Preliminary qPCR Results

- **Encouraging preliminary results**
- **Apparent differences among sites for some genes**
- **Variability, sensitivity, and relevance issues complicate interpretation**



POTW Effluent Exposures

- Identify hormone and molecular responses to wastewater effluent
- Assist in method development and calibration
- Experiments in progress
- 14-day exposures of hornyhead turbot
- 5% and 0.5% wastewater

Next Steps

- What is normal?
- What are the best indicators?
- Which chemicals are of greatest concern?
  - Additional tissue analyses
  - Other habitats

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