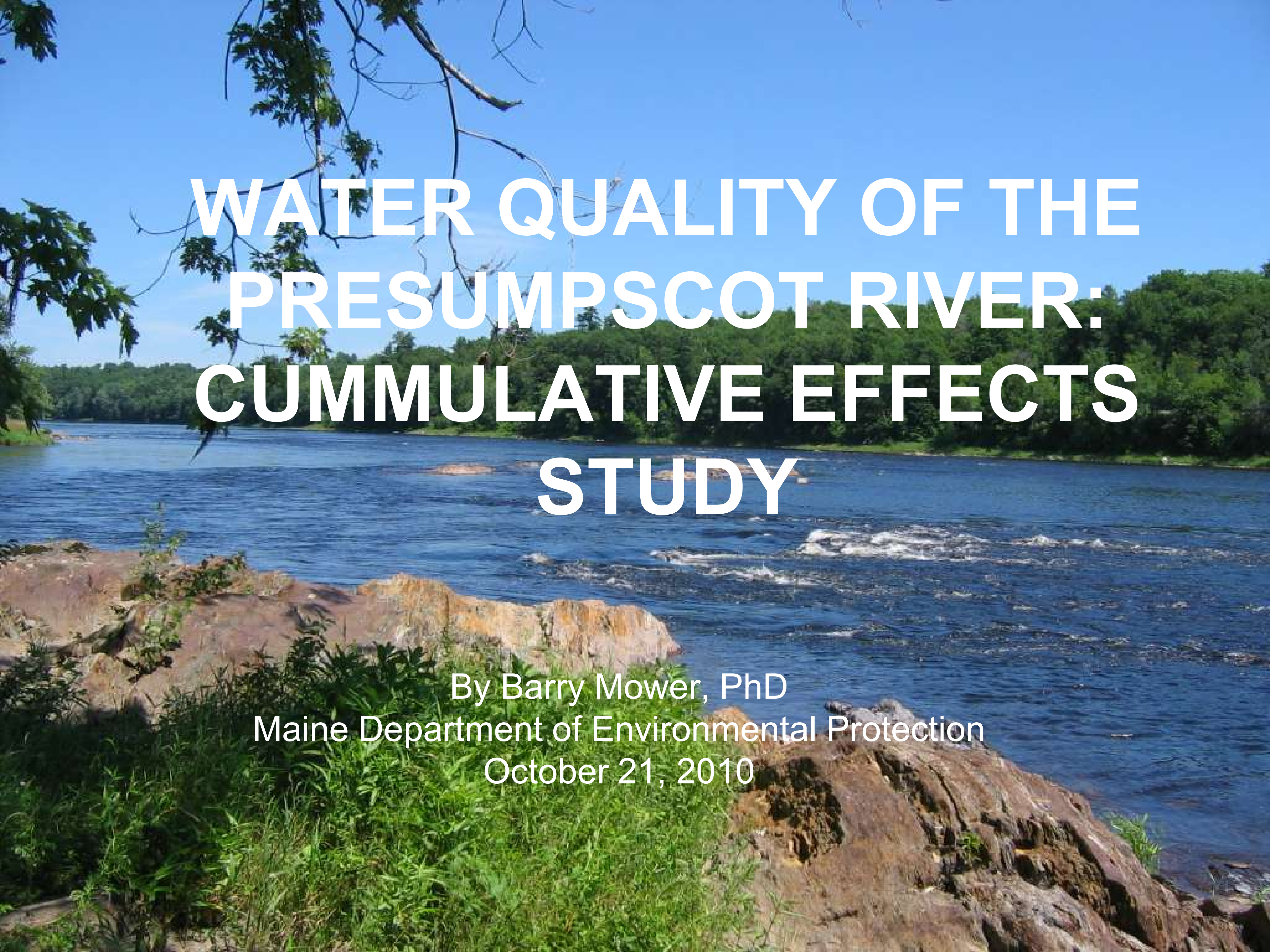
2010

# Water Quality of the Presumpscot River: Cumulative Effects Study (2010 State of the Bay Presentation)

Barry Mower
*Maine Department of Environmental Protection*



# WATER QUALITY OF THE PRESUMPSCOT RIVER: CUMMULATIVE EFFECTS STUDY

By Barry Mower, PhD
Maine Department of Environmental Protection
October 21, 2010

# HISTORICAL USE OF MAINE RIVERS

NATIVE AMERICANS- FOOD & WATER, TRAVEL, TRADE, CULTURAL CEREMONIES

1500-1600s- EXPLORATION, TRAVEL, TRADE, SETTLEMENT

1700-1800s- MUNICIPAL DRINKING WATER, LOCAL COMMERCE, SHIPPING, WATER POWER, ICE CUTTING

1900s- HYDROELECTRIC POWER, INDUSTRIAL/MUNICIPAL WATER SUPPLY & WASTE DISPOSAL, LOG DRIVES

2000- HYDROPOWER, IRRIGATION, ECONOMIC DEVELOPMENT, RECREATION & AESTHETIC/SPIRITUAL, WATER SUPPLY?

# US CLEAN WATER ACT

SENATOR EDMUND S MUSKIE
FATHER OF THE CWA

GOAL: RESTORE & MAINTAIN PHYSICAL, CHEMICAL, BIOLOGICAL INTEGRITY

OBJECTIVES:

- TREATMENT OF ALL DISCHARGES
- FISHABLE/SWIMMABLE
- ZERO DISCHARGE

# MAINE WATER CLASSIFICATION PROGRAM

**GENERAL PROVISIONS –**

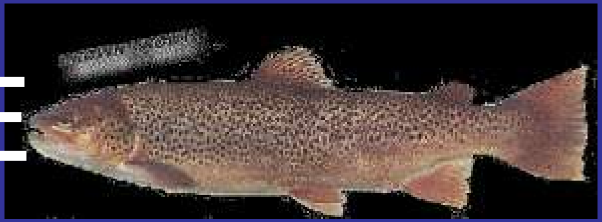
NO DISCHARGE OF COLOR, TASTE, TURBIDITY, TOXICITY, RADIOACTIVITY, PH, UNTREATED WASTE, DA<10 MI2

**CLASSIFICATIONS –** RIVERS AA, A, B, C
- LAKES GPA

**CLASSIFICATION STANDARDS-**

DESIGNATED USES
CRITERIA,
ANTIDEGRADATION

# FISHABLE



- DESIGNATED USES: CLASS C RIVERS
  - HABITAT FOR FISH & OTHER AQUATIC LIFE
  - SUPPORT INDIGENOUS SPECIES OF FISH
  - MAINTAIN THE STRUCTURE & FUNCTION OF THE RESIDENT BIOLOGICAL COMMUNITY

# SUPPORT INDIGENOUS SPECIES OF FISH

- SURVIVAL
- GROWTH
- REPRODUCTION
- FISH HEALTH

# DEP PROGRAMS

- GOAL: FISHABLE/SWIMMABLE
- CURRENT: AWQC, WET, BIOMONITORING, SWAT
- LIMITATION: DETECT ONLY GROSS DISTURBANCES
- NEW: EFFECTS DRIVEN CUMMULATIVE EFFECTS ASSESSMENT OF FISH POPULATIONS- CEA

# Endocrine-Disrupting Chemicals

## An Endocrine Society Scientific Statement

Evanthia Diamanti-Kandarakis, Jean-Pierre Bourguignon, Linda C. Giudice, Russ Hauser, Gail S. Prins, Ana M. Soto, R. Thomas Zoeller, and Andrea C. Gore

The Endocrine Society®

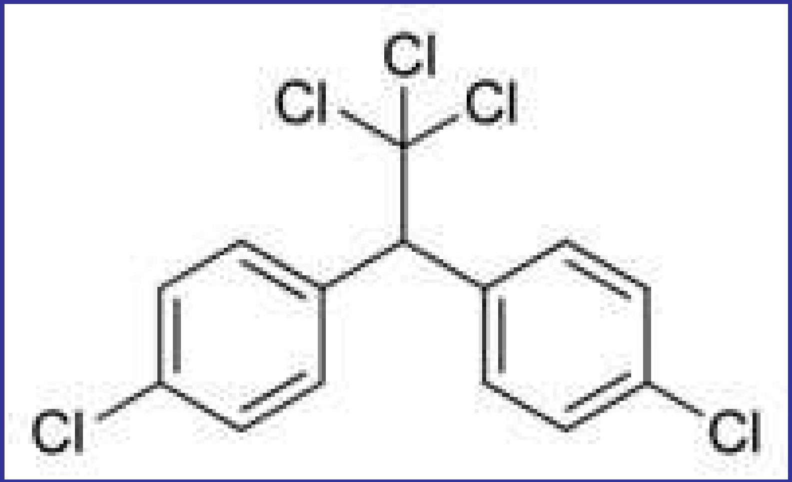
# ACRONYMS

| | |
|---|---|
| EDs | Endocrine Disruptors |
| EDCs | Endocrine Disrupting Chemicals |
| ECs | Emerging Contaminants |
| CECs | Contaminant of Emerging Concern |
| PBTs | Persistent, Bioaccumulative, & Toxic |
| POPs | Persistent Organic Pollutants |
| PPCPs | Pharmaceuticals & Personal Care Products |

# ENDOCRINE DISRUPTION

- NEW NAME FOR SOME WELL KNOWN CHEMICAL EFFECTS

- DichloroDiphenylTrichloroethane



# NEWLY DISCOVERED EDCs

- EE2 ethinylestradiol
- APE’s - alkyl phenyl ethoxylates, NPE
- BFRs - PBDEs
- BPA bisphenol A
- PESTICIDES
- PHTHALATEs

# ENDOCRINE DISRUPTORS

- HPG -AXIS
  - ESTROGENS AND ANTI-ESTROGENS
  - ANDROGENS AND ANTI-ANDROGENS
- HPT AXIS
  - THYROID MODULATORS
- OTHERS
  - STRESS REACTION, OSMOTIC HOMEOSTASIS

# SOURCES

- There are about 90 prescription pills, creams and injections that contain estrogen and its sister compounds according to the University of Maryland School of Medicine.

# EPA's 9 POTW STUDY

EPA
United States
Environmental Protection
Agency

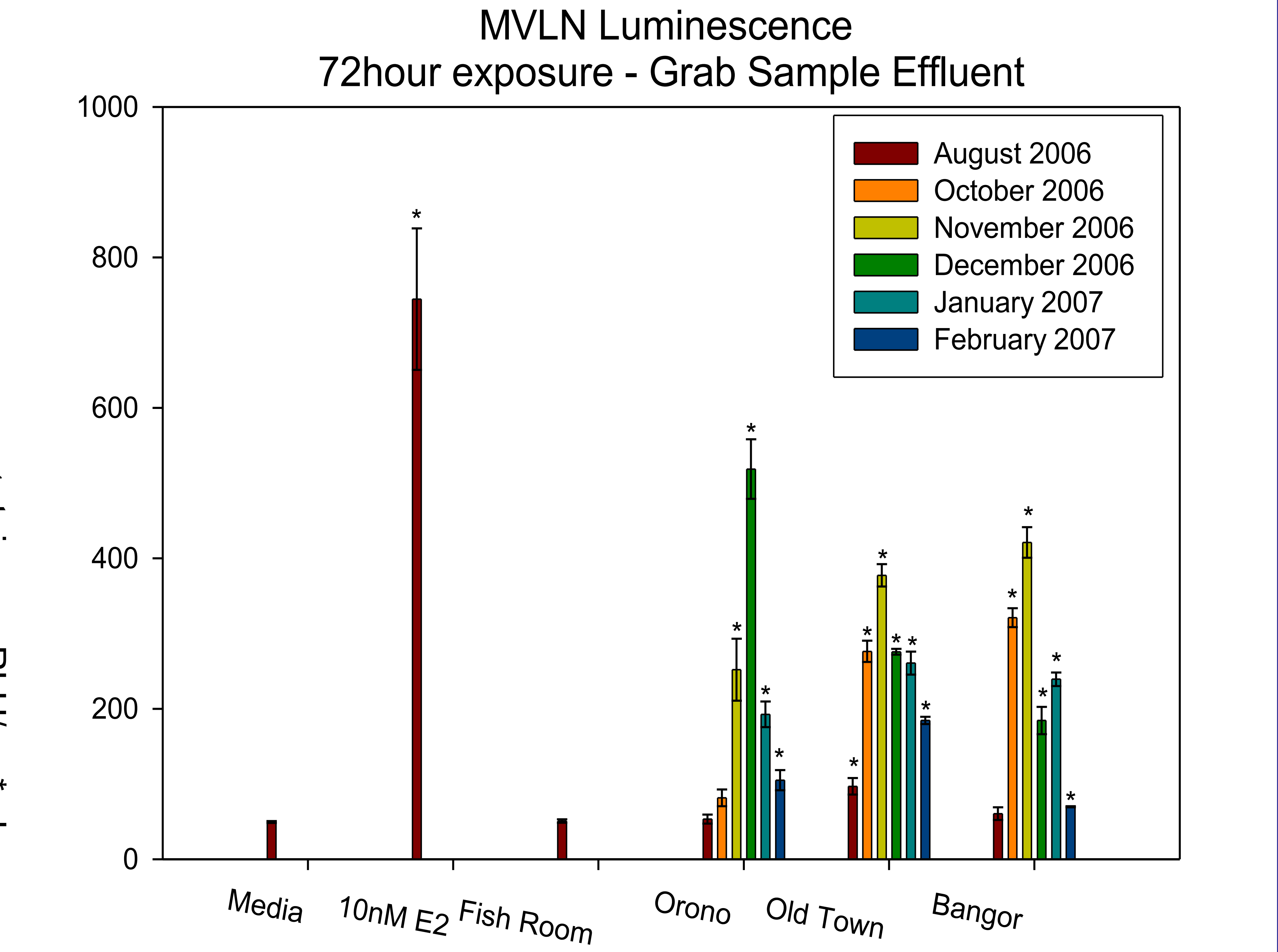
**Occurrence of Contaminants of Emerging Concern in Wastewater From Nine Publicly Owned Treatment Works**

August 2009

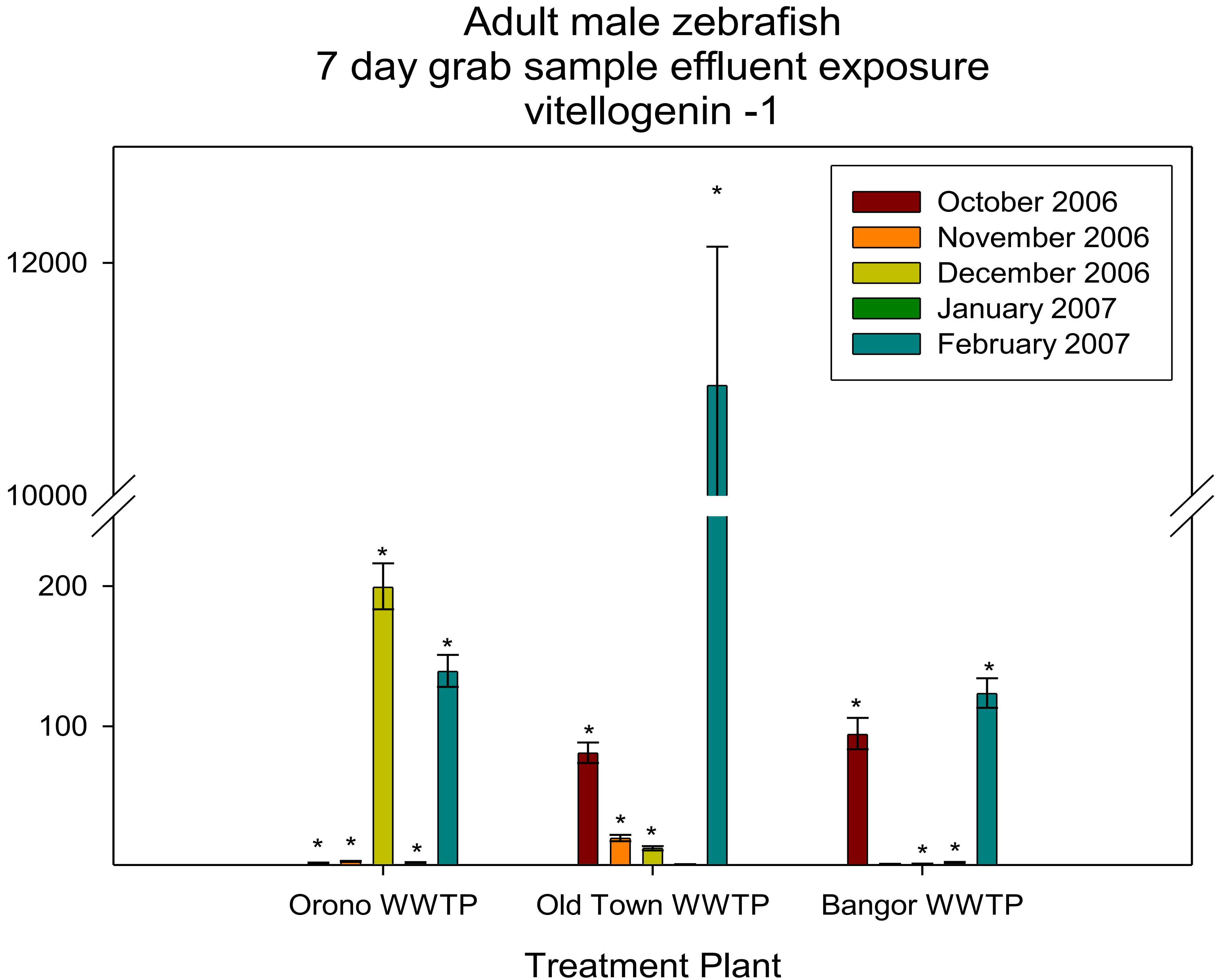
http://www.epa.gov/waterscience/ppcp/studies/9potwstudy.pdf

# UMO EFFLUENT STUDIES

- Dr. Greg Mayer, UMO
- Studies of 3 effluents
- *In vitro study of MVLN Cell Exposure and Luminescence Assay measuring vitellogenin expression*
- *In vivo study of transcription of hepatic vitellogenin mRNA* in zebrafish



MVLN Luminescence
72hour exposure - Grab Sample Effluent
1000
800
600
400
200
0
August 2006
October 2006
November 2006
December 2006
January 2007
February 2007
Media
10nM E2
Fish Room
Orono
Old Town
Bangor



Adult male zebrafish
7 day grab sample effluent exposure
vitellogenin -1
October 2006
November 2006
December 2006
January 2007
February 2007
12000
10000
200
100
Orono WWTP
Old Town WWTP
Bangor WWTP
Treatment Plant

# CEA EFFECTS-DRIVEN

# CUMMULATIVE EFFECTS ASSESSMENT

- FIELD STUDIES IN SCANDANAVIA, CANADA, UK, US, NEW ZEALAND, INDIA, S AMERICA
- BIOMARKERS AND POPULATION INDICES
- DISCHARGES FROM STPs AND PULP AND PAPER MILLS DISRUPTED REPRODUCTION IN FISH
- LAB STUDIES HAVE SHOWN SIMILAR EFFECTS

# METABOLIC DISRUPTION PATTERN
## (CHANGE IN CHEMICAL OR ENERGY RESOURCES)

- BIOMARKERS: MFO (P450, CYP1A)
  VTG (VITELLOGENIN)
- POPULATION INDICES
  (ALTERED ENERGY STORAGE & UTILIZATION)
  - DECREASED REPRODUCTION
    - GSI (GONAD SIZE) & CSS (SEX STEROIDS)
    - DELAYED MATURATION & INCREASED AGE
    - INTERSEX
  - CHANGES IN GROWTH
  - INCREASED LSI (LIVER SIZE) & K (CONDITION)

**Figure 3.3.1a. Mean MFO levels in white sucker from the Presumpscot River above (PWD) and below (PWB) Westbrook, 2007. (letters = significant difference from upstream station, p<0.05)**

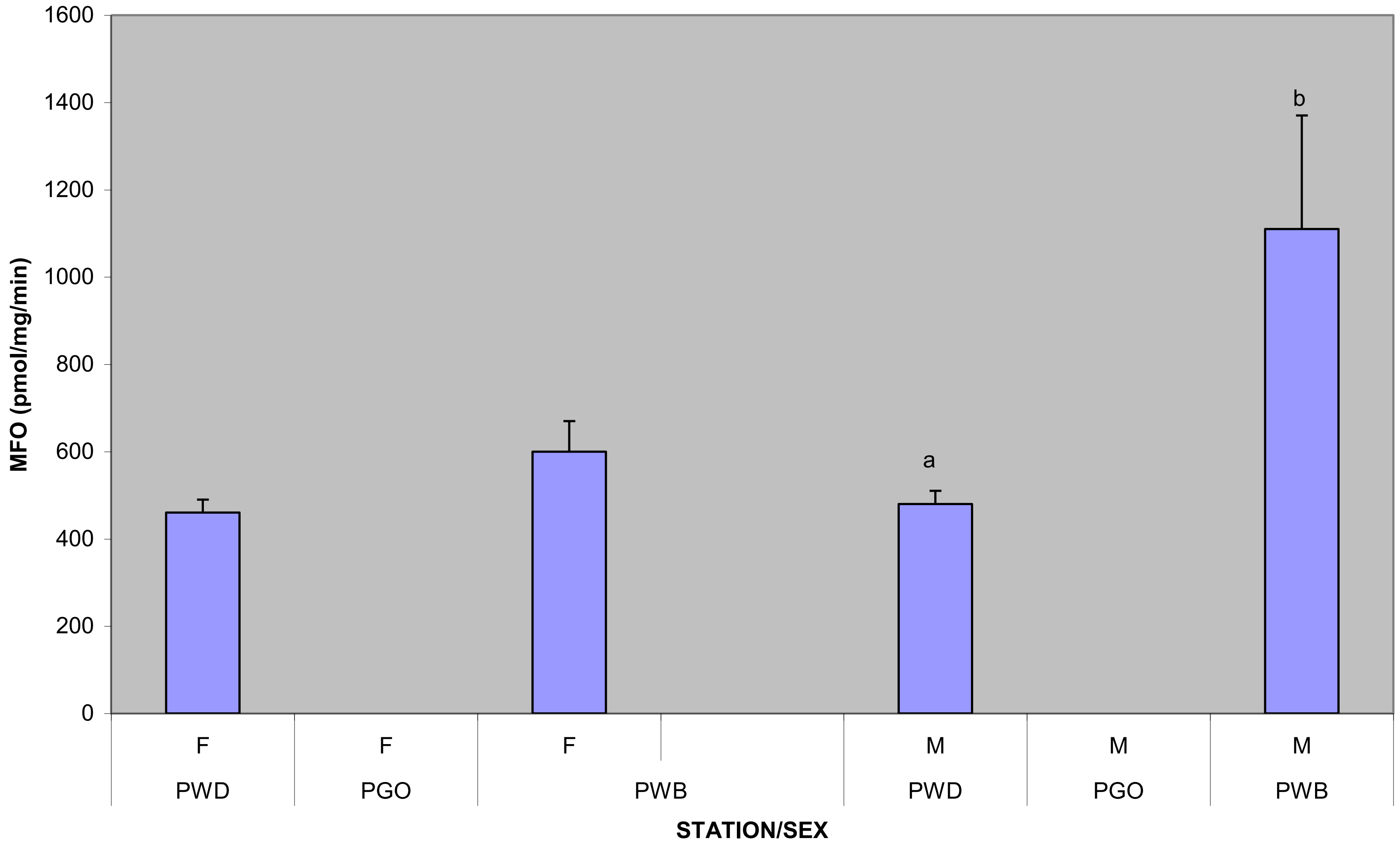


**Figure 3.3.1b. Mean levels of MFO in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2008. (letters = siginificant differences from upstream station, p<0.05)**

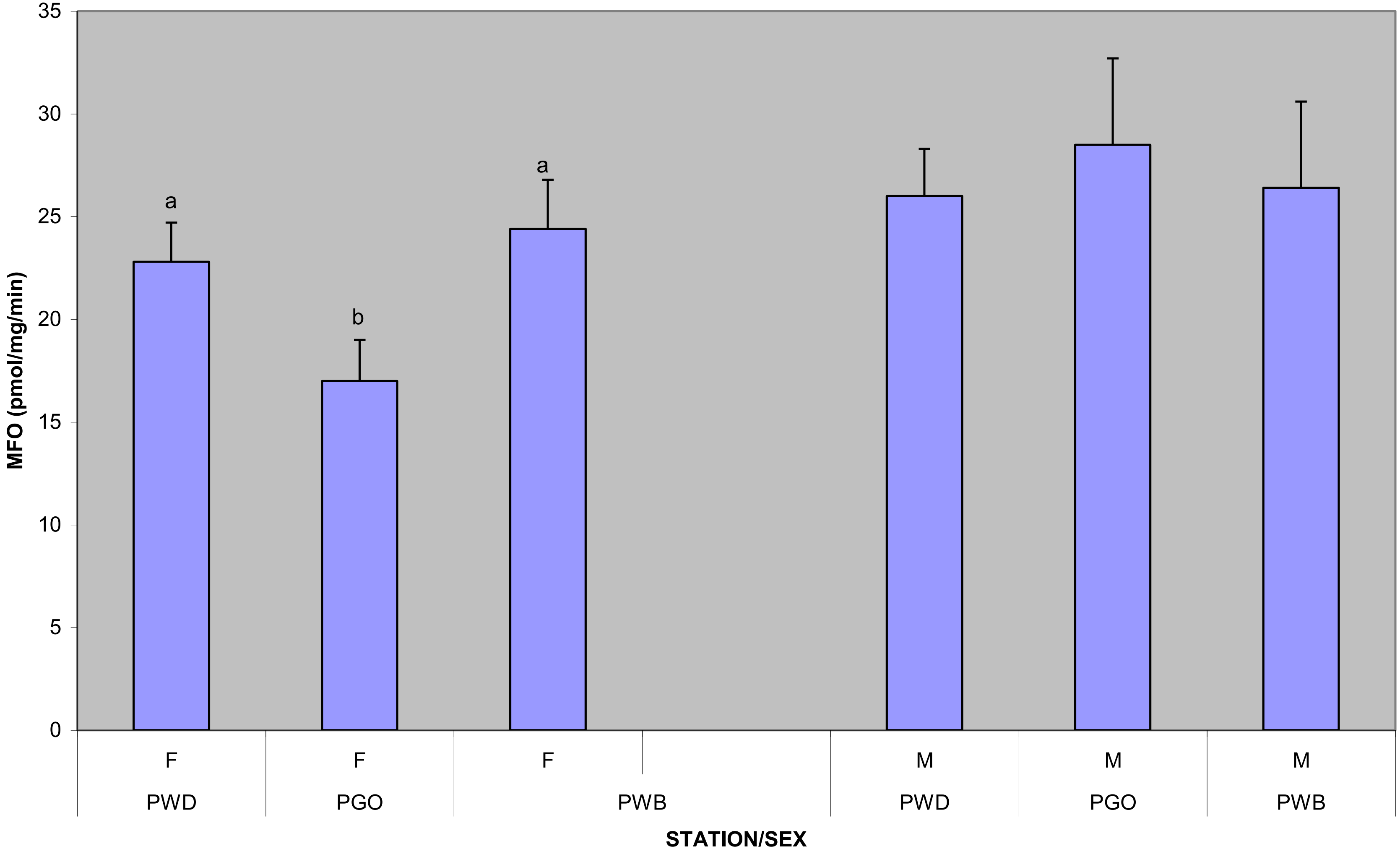


**Figure 3.3.2. Mean levels of circulating sex steroids (testosterone-T and estradiol-E2) in female white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007 & 2008). (different letters = significant differences at p<0.05)**

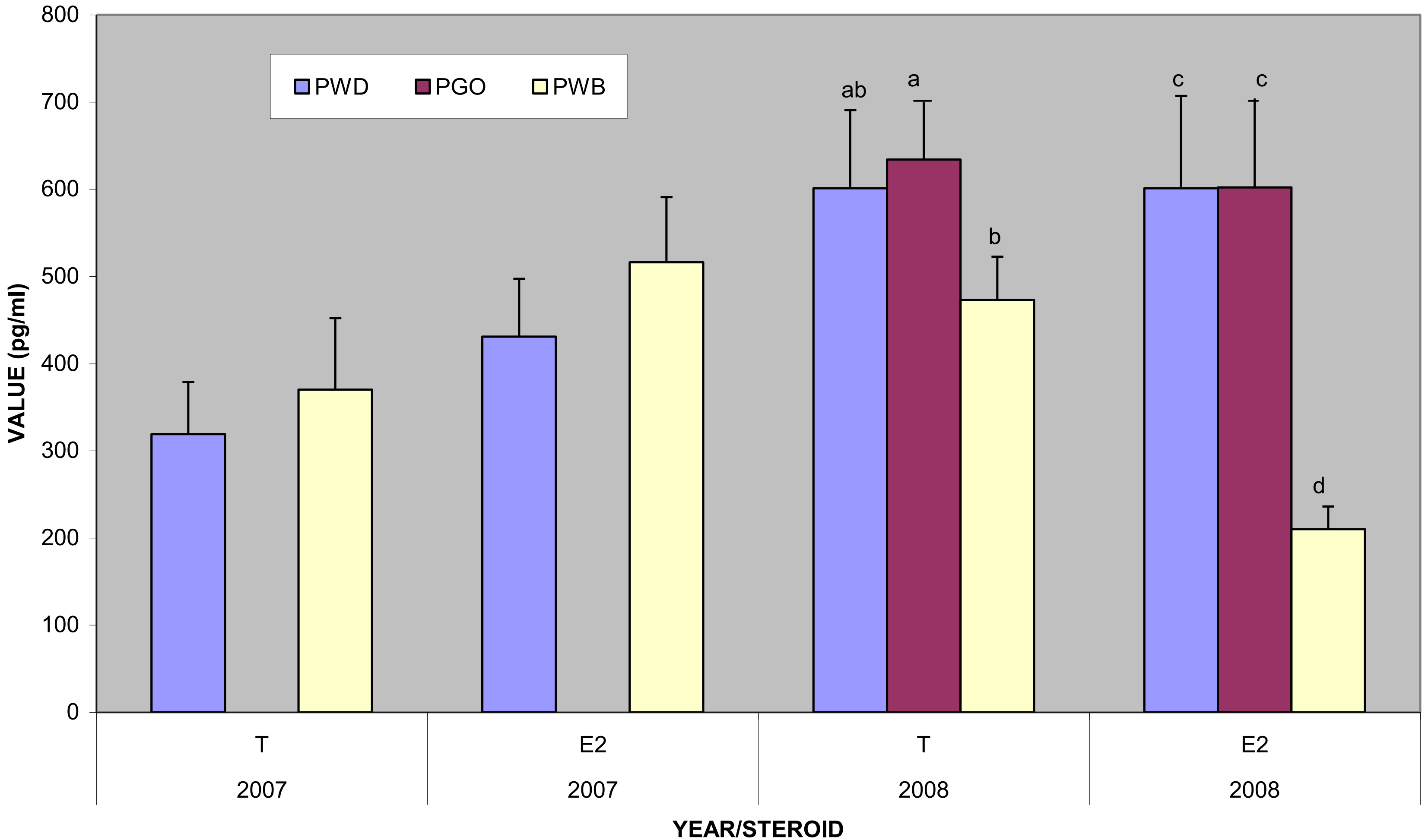


**Figure 3.3.3. Mean levels of circulating sex steroids (testosterone-T and 11-ketotestosterone-KT) in male white sucker from the Presumpscot River above (PWD, PGO) and below (PWD) Westbrook, 2007 & 2008 (letters = significant differences by steroid p<0.05)**

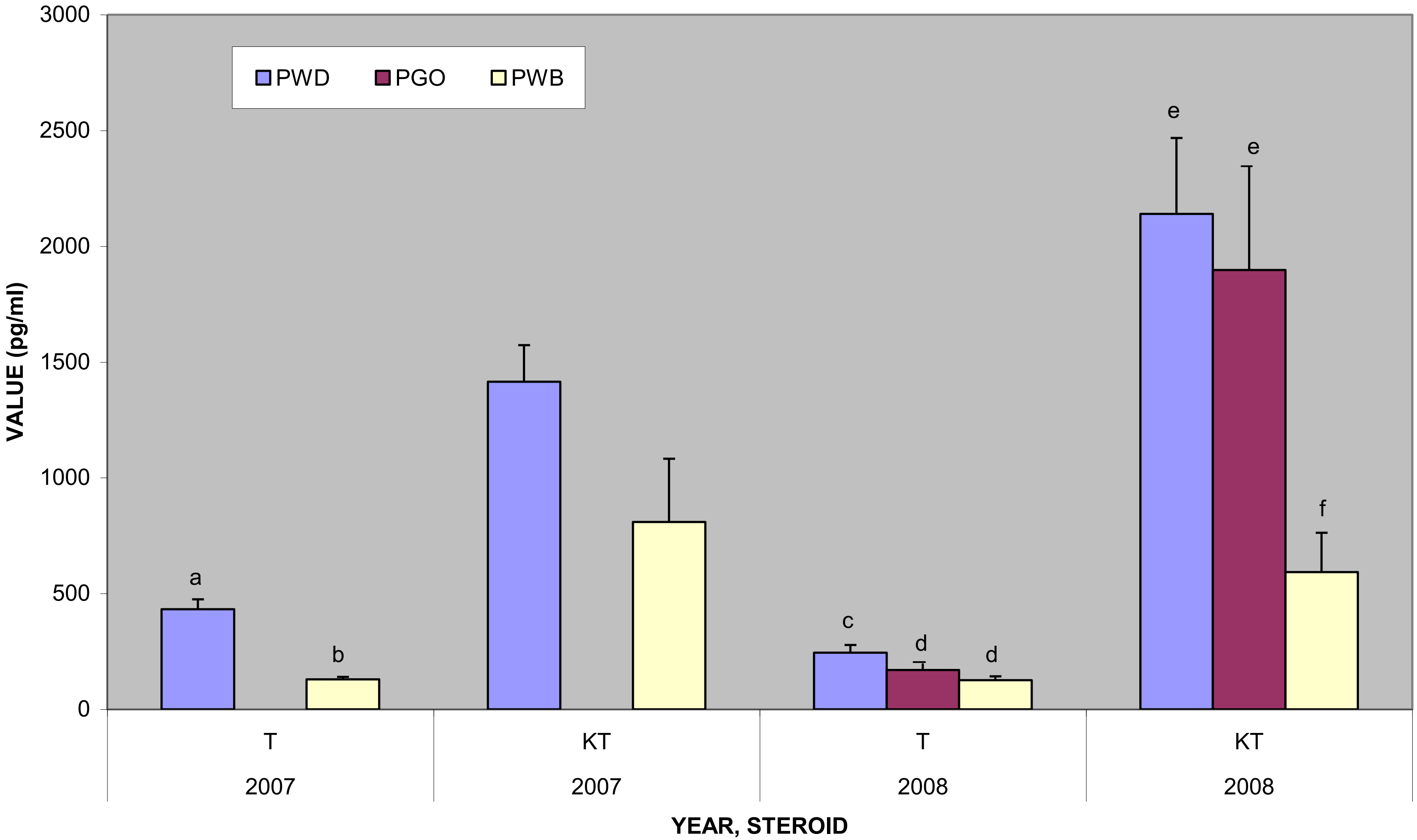


**Figure 3.3.4. Mean age of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009 (letters show significant differences within sex & year, $p<0.05$)**

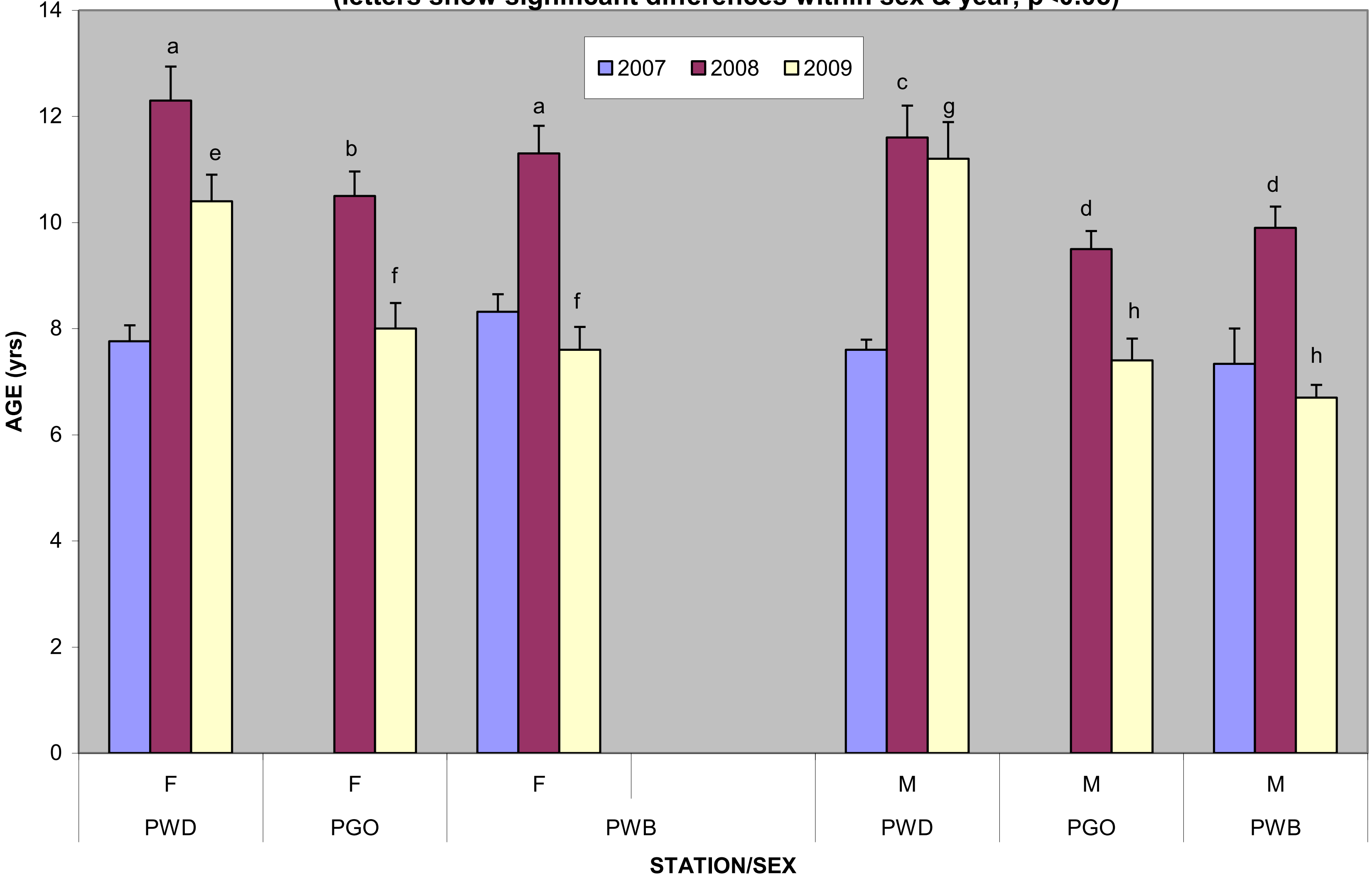


**Figure 3.3.5. Mean length of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009 (letters show significant differences within sex & year, p<0.05)**

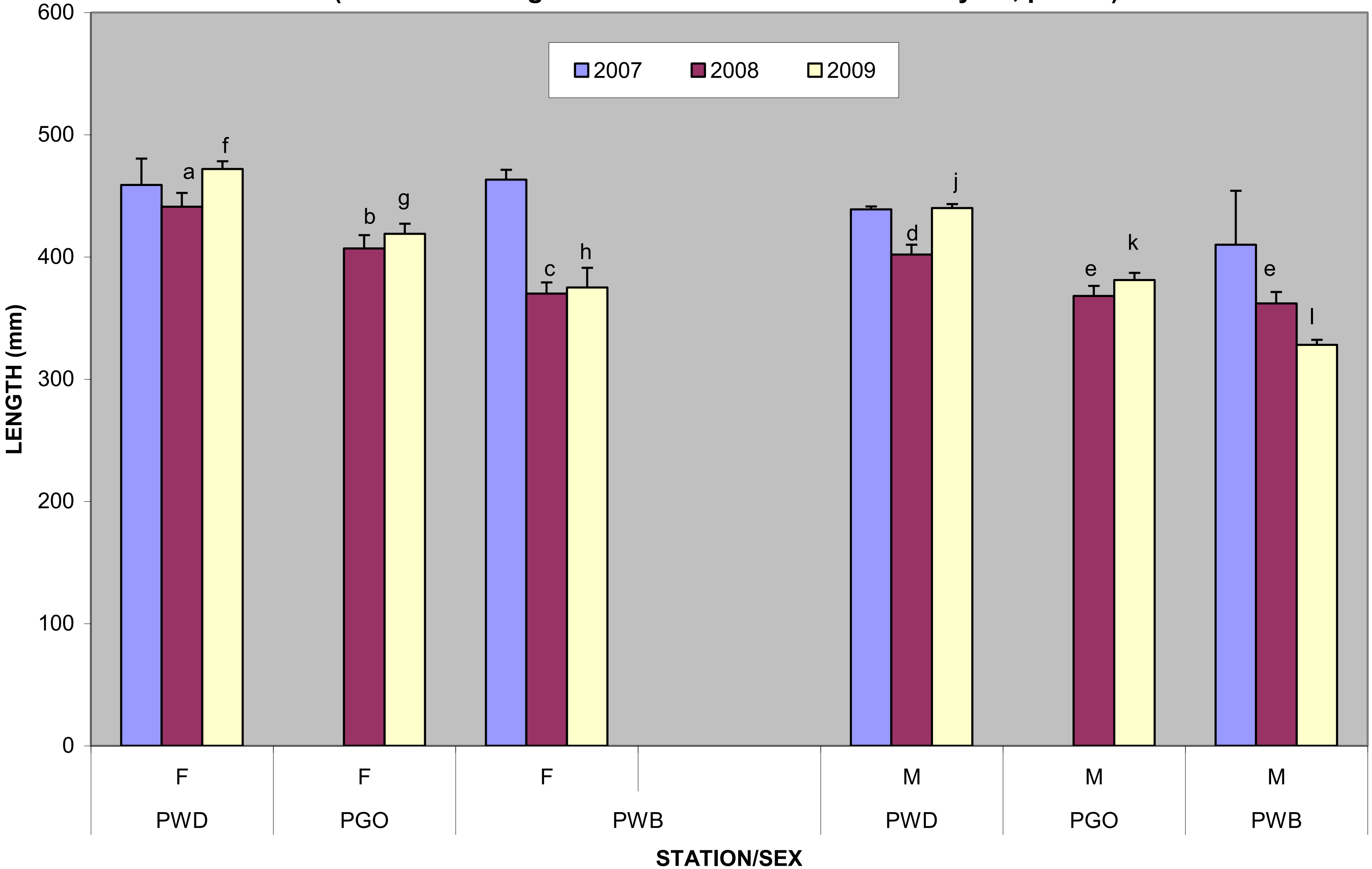


**Figure 3.3.6. Mean condition factor (K) of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009 (letters show significant differences within sex & year, p<0.05)**

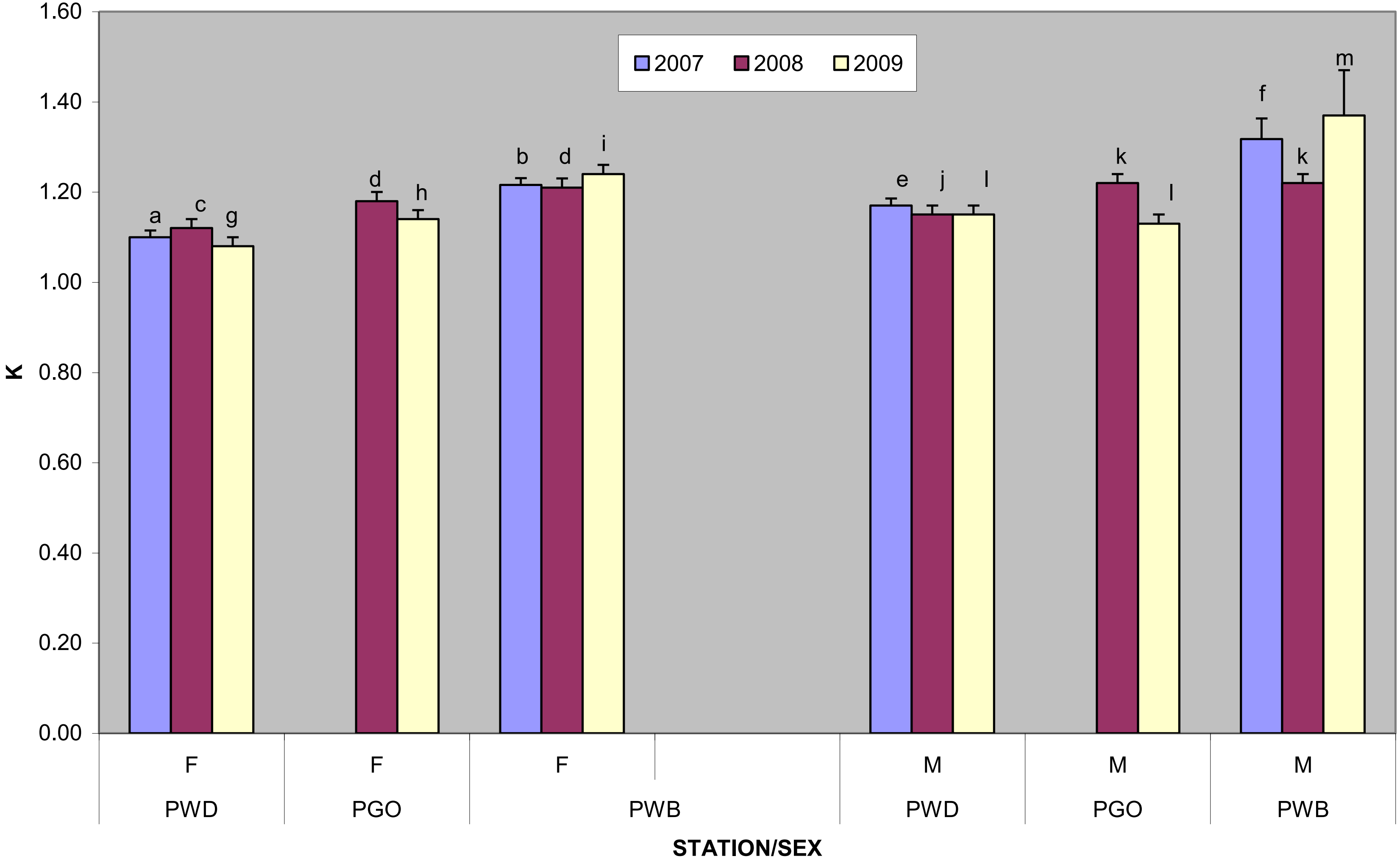


**Figure 3.3.7. Mean GSI in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009 (letters show significant differences within sex & year, p<0.05)**

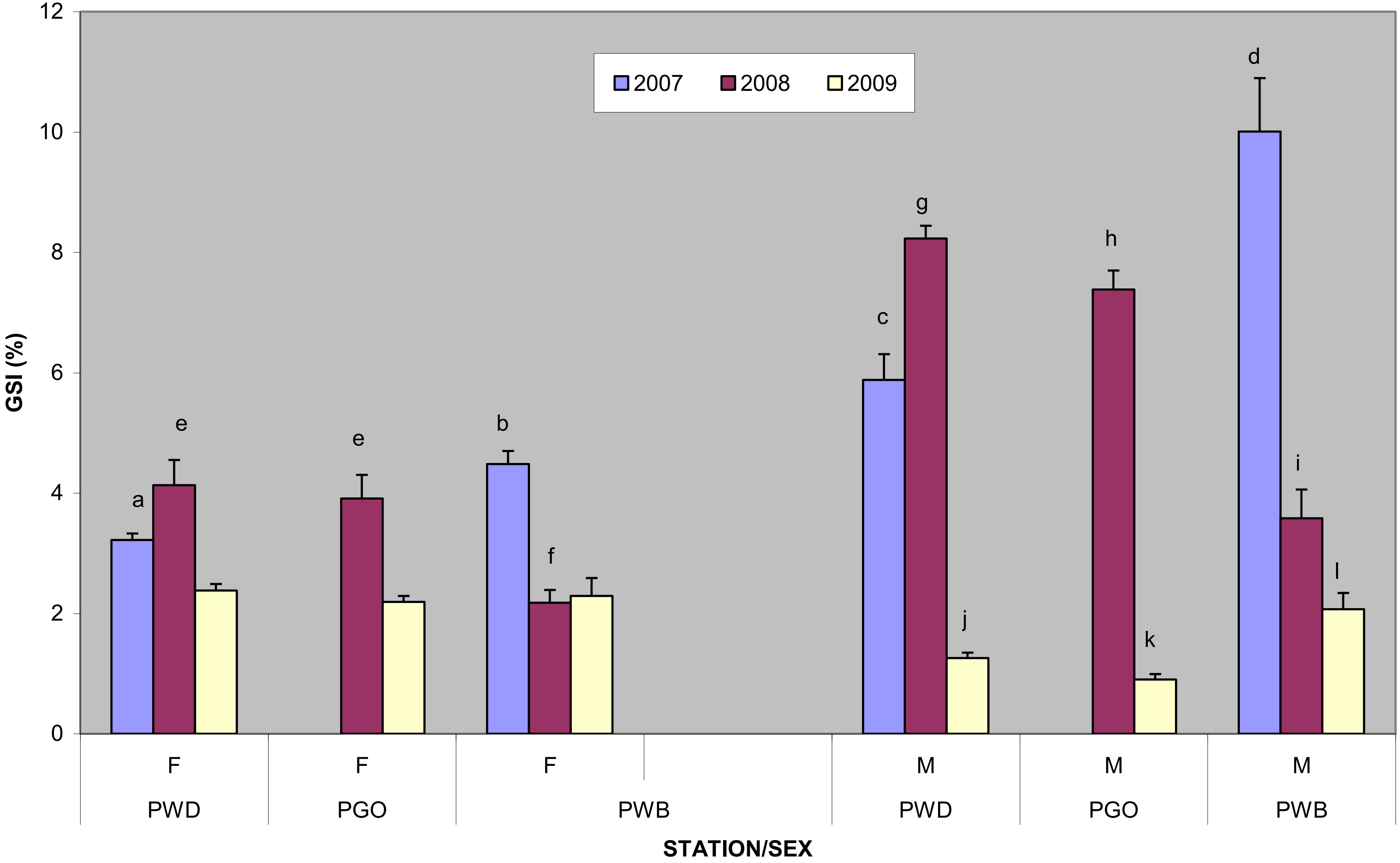


**Figure 3.3.8. Mean LSI in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009. (letters show significant differences within sex and year, p<0.05)**

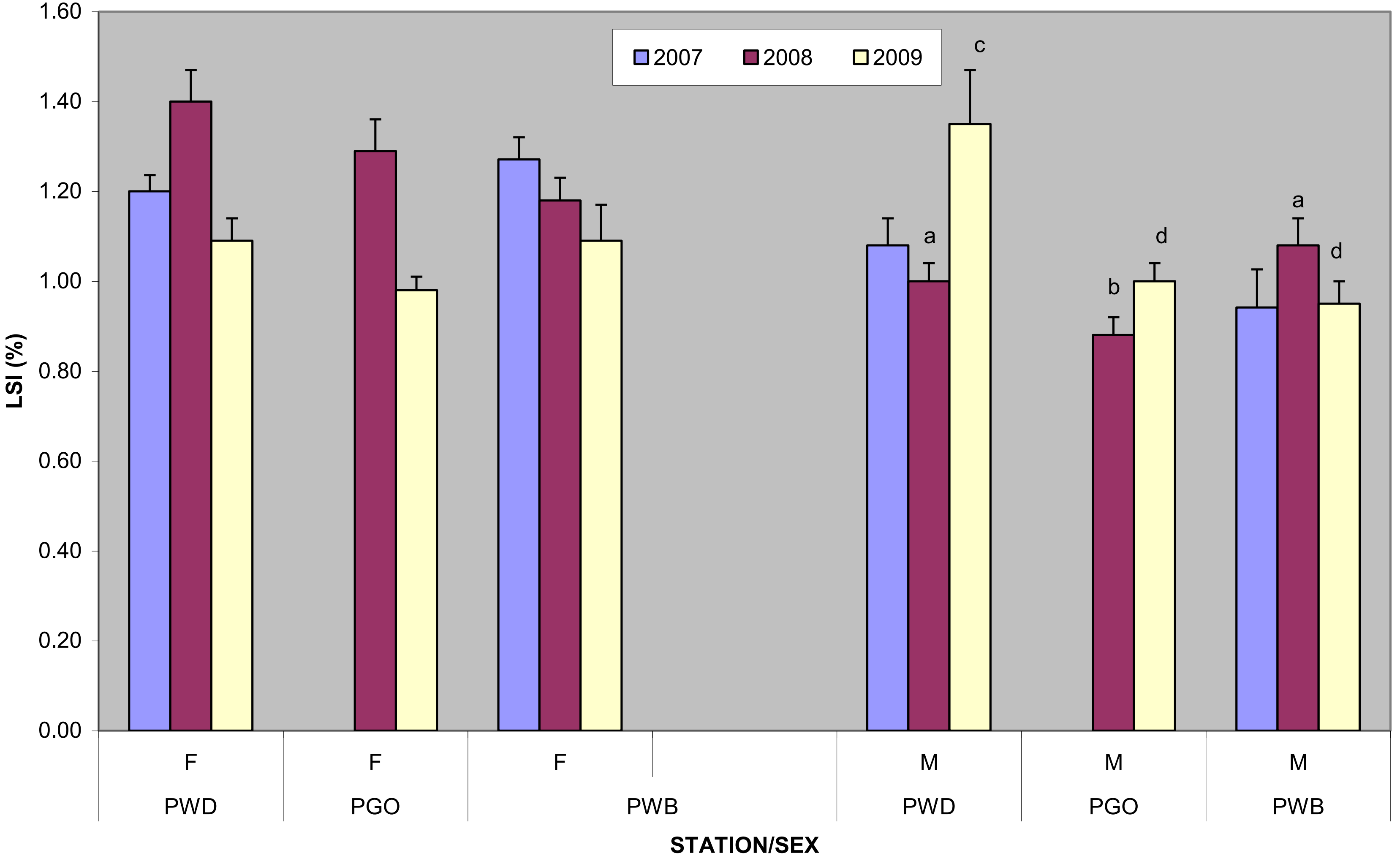


**Figure 3.3.9. Mean percentage of previtellogenic (P), endovitellogenic (E), & vitellogenic (V) oocytes from female white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007 & 2008**

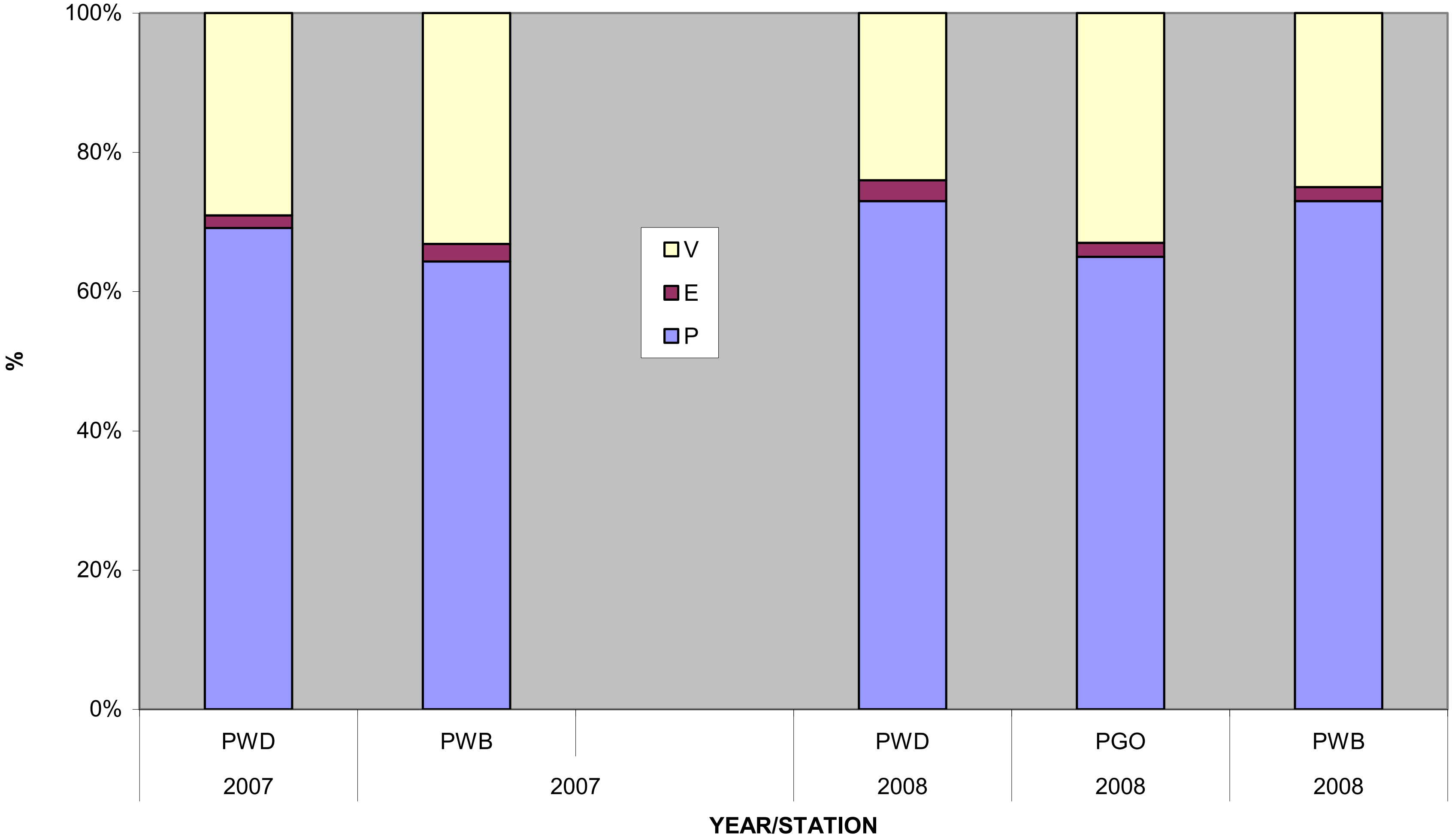


**Figure 3.3.10. Mean size (µm2) of vitellogenic oocytes in female white sucker from the Presumpscot River above (PWD, PGO) & below (PWB) Westbrook, 2007 & 2008 (different letters show significant differences within years)**

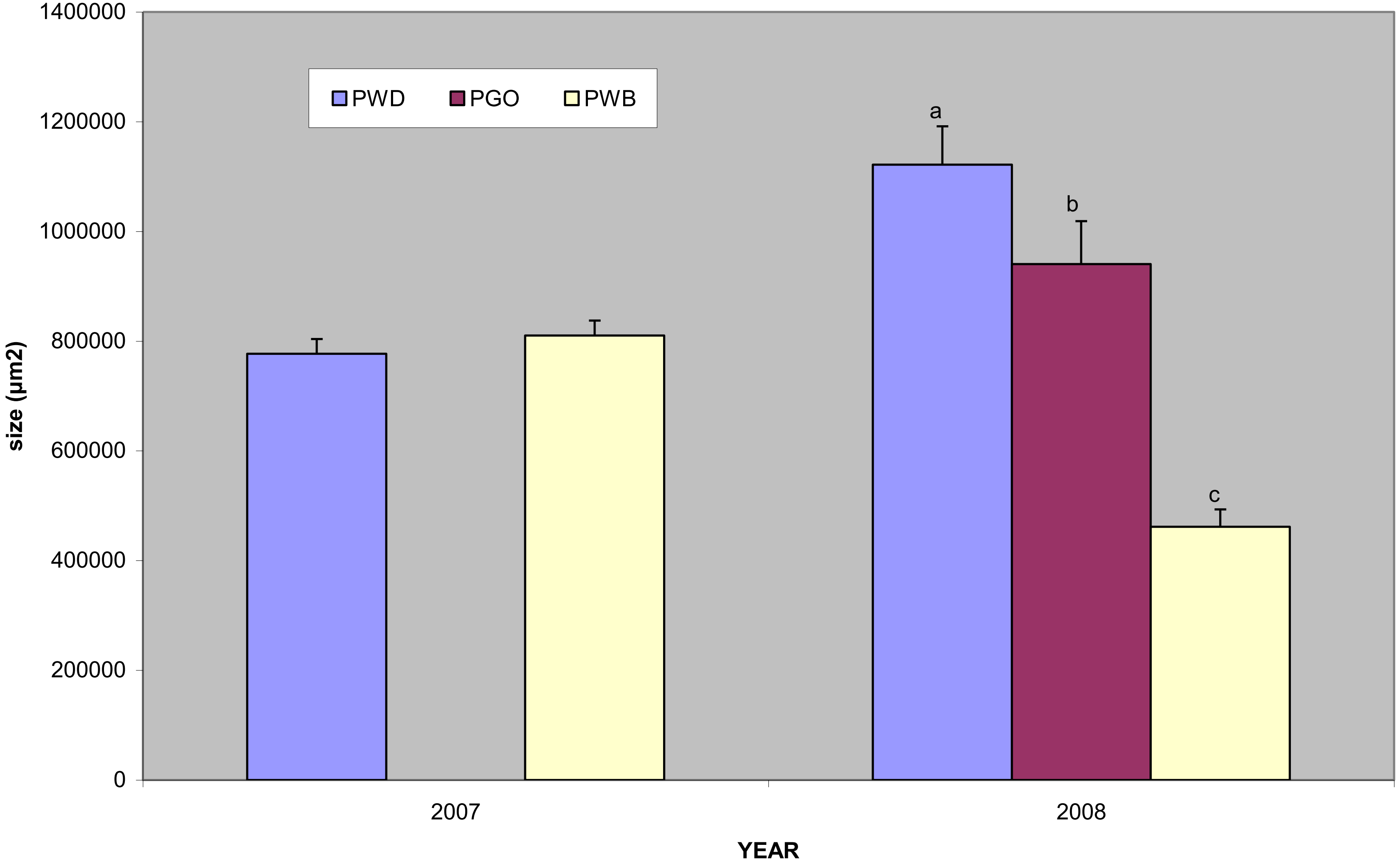
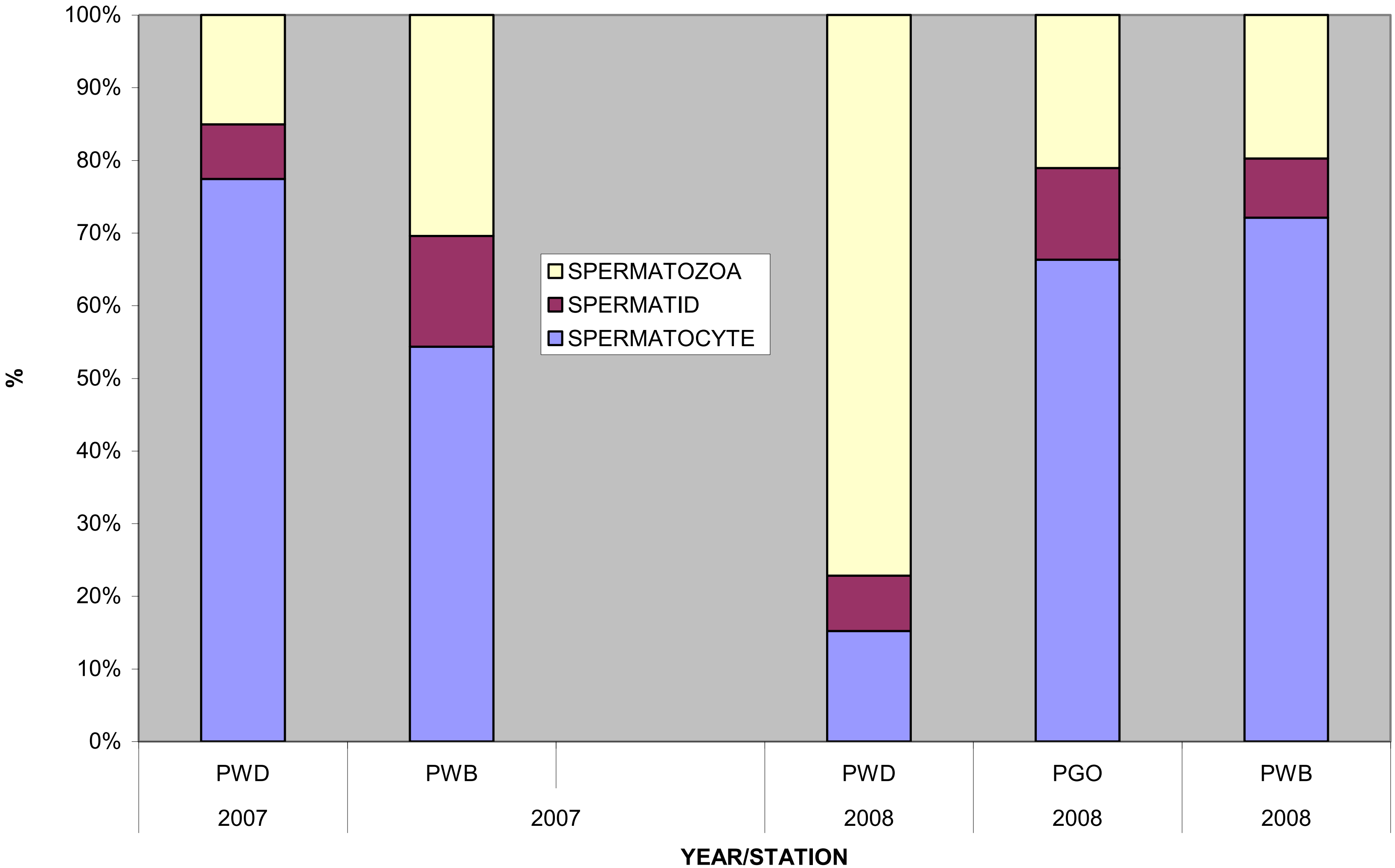


**Figure 3.3.11. Mean percentage of spermatocytes, spermatids, spermatozoa in male white sucker testes from the Presumpscot River above (PWD, PGO) & below (PWB) Westbrook, 2007 & 2008**



## Vitellogenin (VTG) in female white sucker plasma from the Presumpscot River, 2007-2008

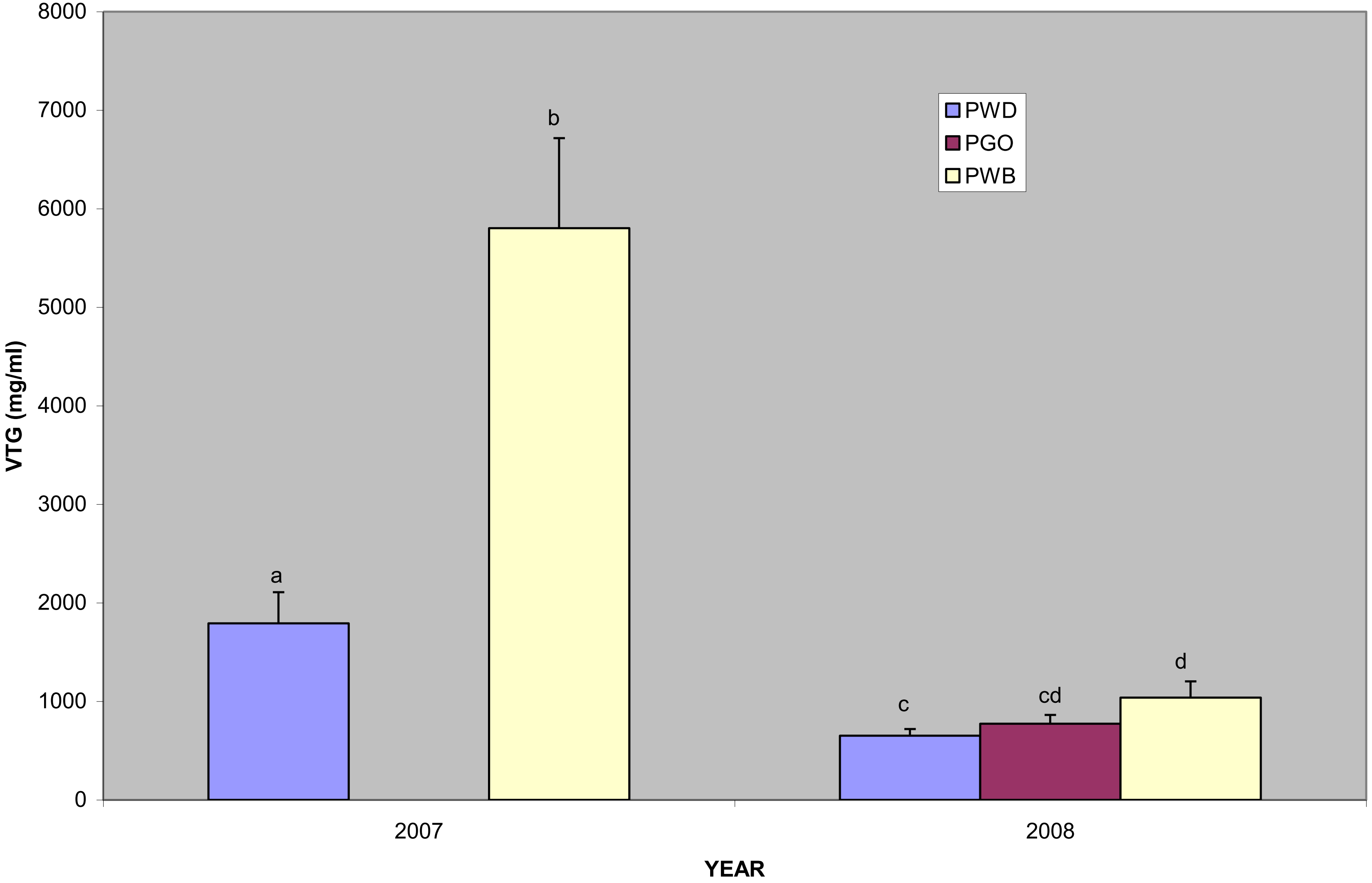


**Figure 3.3.13. Mean vitellogenin (VTG) concentrations in male white sucker from the Presumpscot River above (PWD, PGO) and below (PWD) Westbrook, 2007 & 2008 (different letters show significant differences within years)**

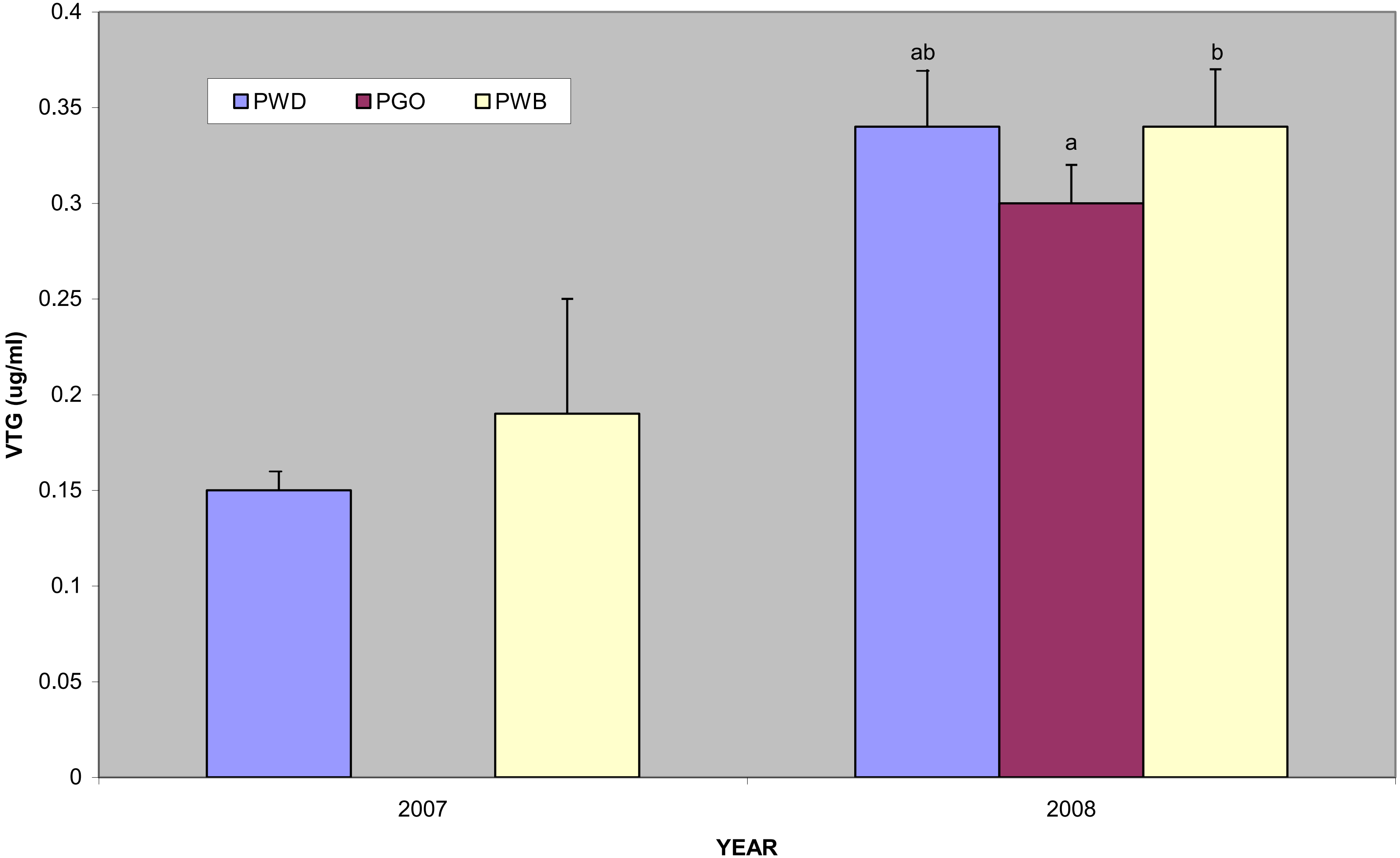


Table 3.3.2. Catch rates (CPUE) of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009

| STATION | SEX | 2007 CPUE #/d/1000ft | 2008 CPUE #/d/1000ft | 2009 CPUE #/d/1000ft |
|---|---|---|---|---|
| PWD | F | 28 | 15 | 9 |
| PGO | F | | 28 | 14 |
| PWB | F | 6 | 17 | 3 |
| | | | | |
| PWD | M | 19 | 16 | 6 |
| PGO | M | | 14 | 10 |
| PWB | M | 1 | 14 | 1 |


sappi usutu

Table 3.3.3. Responses of white sucker in the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009.

| STATION | SPECIES | sex | AGE | LENGTH | GSI | K | LSI | KSI | SSI |
|---|---|---|---|---|---|---|---|---|---|
| Ha: | | | + | + | - | + | + | + | + |
| 2007 | | | | | | | | | |
| PWD | WHS | F | | | | | | | |
| PWB | WHS | F | 0 | 0 | + | + | 0 | 0 | 0 |
| | | | | | | | | | |
| PWD | WHS | M | | | | | | | |
| PWB | WHS | M | 0 | 0 | + | 0 | 0 | 0 | 0 |
| | | | | | | | | | |
| 2008 | | | | | | | | | |
| PWD | WHS | F | | | | | | | |
| PGO | WHS | F | - | - | 0 | + | 0 | + | 0 |
| PWB | WHS | F | 0 | - | - | 0 | 0 | 0 | - |
| PWD/PWB | WHS | F | 0 | - | - | + | 0 | 0 | 0 |
| | | | | | | | | | |
| PWD | WHS | M | | | | | | | |
| PGO | WHS | M | - | - | - | + | - | 0 | 0 |
| PWB | WHS | M | 0 | 0 | - | 0 | + | 0 | 0 |
| PWD/PWB | WHS | M | - | - | - | + | 0 | 0 | 0 |
| | | | | | | | | | |
| 2009 | | | | | | | | | |
| PWD | WHS | F | | | | | | | |
| PGO | WHS | F | - | - | 0 | + | 0 | 0 | - |
| PWB | WHS | F | 0 | - | 0 | - | 0 | + | 0 |
| PWD/PWB | WHS | F | - | - | 0 | + | 0 | + | - |
| | | | | | | | | | |
| PWD | WHS | M | | | | | | | |
| PGO | WHS | M | - | - | - | 0 | - | 0 | - |
| PWB | WHS | M | 0 | - | + | + | 0 | 0 | - |
| PWD/PWB | WHS | M | - | - | + | + | - | 0 | - |

+ - 0 = significantly greater, lesser or no different from station above

Table 3.3.1. WATER QUALITY OF THE PENOBSCOT RIVER 2008

| STATION | FLOW[1] | BOD[1] | NITROGEN[2] | NITROGEN[3] | PHOSPHORUS[2] | PHOSPHORUS[3] | BOD |
|---|---|---|---|---|---|---|---|
| | 1000 m3/d | kg/d | ug/l | kg/d | ug/l | kg/d | mg/l |
| PWD | | | 230 | | 5 | | |
| PGO | | | | | | | |
| PR1 | | | 250 | | 9 | | |
| WESTBROOK STP | 13.0 | 117 | 16967 | 220 | 3700 | 48 | |
| PR2 | | | 355 | | 39 | | |
| SAPPI | 19.2 | 124 | 2503 | 48 | 437 | 8.4 | |
| PWB PR3 | | | 447 | | 53 | | |
| PWB PR4 | | | 350 | | 43 | | |
| Mill Stream | 17.1 | | 650 | | 82 | 1.2 | |
| PWB PR5 | | | 350 | | 48 | | |
| PWB PR6 | | | 390 | | 53 | | |
| Piscataqua R | 66 | | 940 | | 26 | 1.5 | |
| PR8 | | | 437 | | 61 | | |

discharges or tributaries to the river

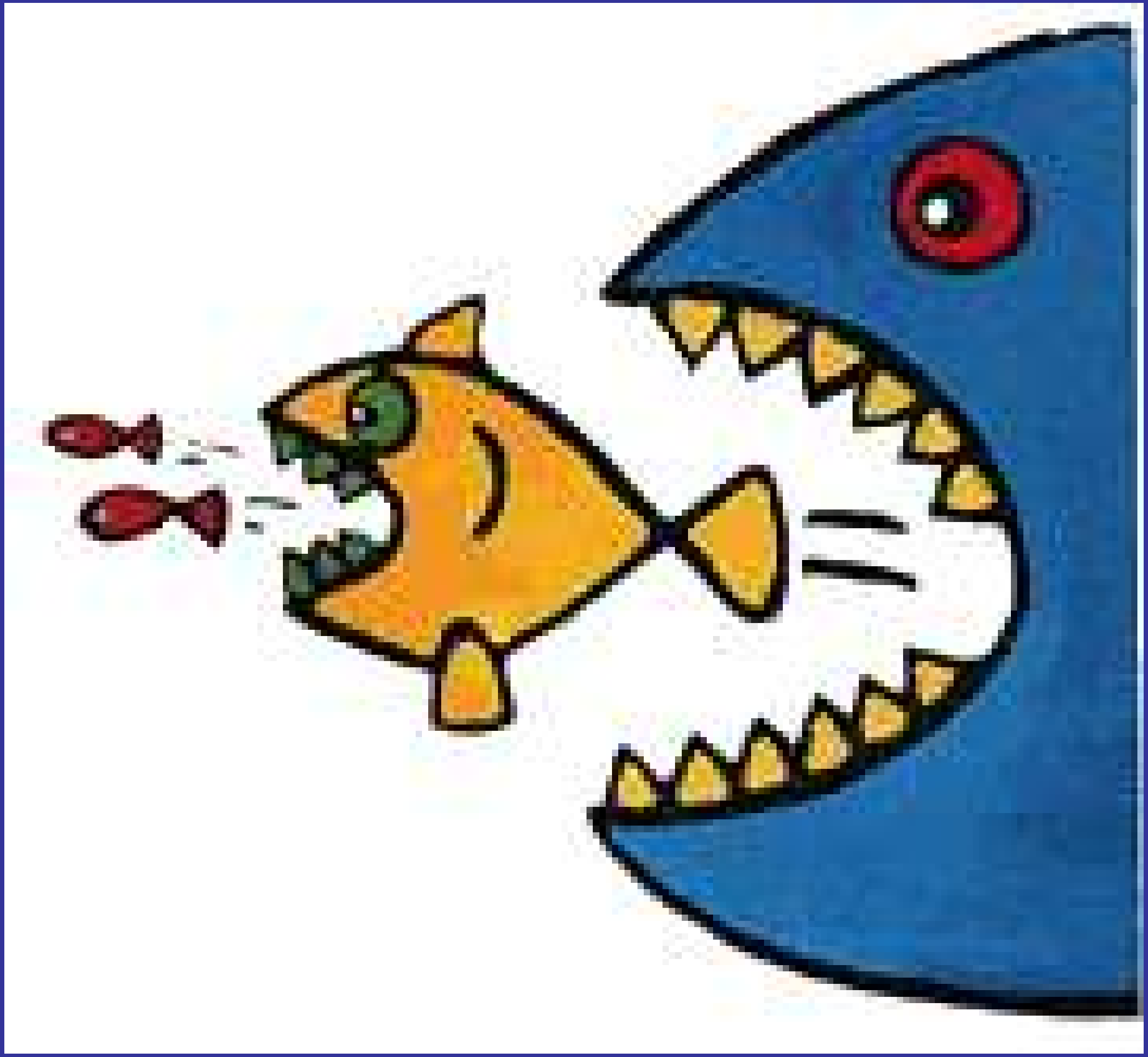
[1] mean monthly for 2007-2008

[2] mean August 2,4,5, 2008

[3] mean monthly flow 2007-2008 X August 2008 nitrogen/phosphorus concentrations X conversion factor.

# CONCLUSIONS

- SOME INDIVIDUAL RESPONSES OF ED
- NO ED RESPONSES FOR ALL YEARS
- NO OVERALL PATTERN OF ED
- GROWTH (LENGTH) LOWER BELOW
- CATCH RATES LOWER BELOW
- WQ DATA SHOW EUTROPHICATION
- REDUCED FISH SPECIES RICHNESS, ABUNDANCE, BIOMASS BELOW
- IBI SHOWS REDUCED FITNESS FISH POPULATION
- POSSIBLY DUE TO DISCHARGES, URBAN RUNOFF, HYDROLOGIC CHANNALIZATION



Jim Lavrakas / Anchorage Daily News

AS RIVERS FLOW FROM SOURCE TO SEA

THEY CHRONICLE THEIR HISTORY

GIVEN THEIR PAST USE & ABUSE

PERHAPS IT IS TIME FOR A CHANGE

# Questions?


HEY VINNIE! I HEARD THEY'RE GONNA CLEAN UP THE ELIZABETH RIVER! VINNIE? VIN? PAL?