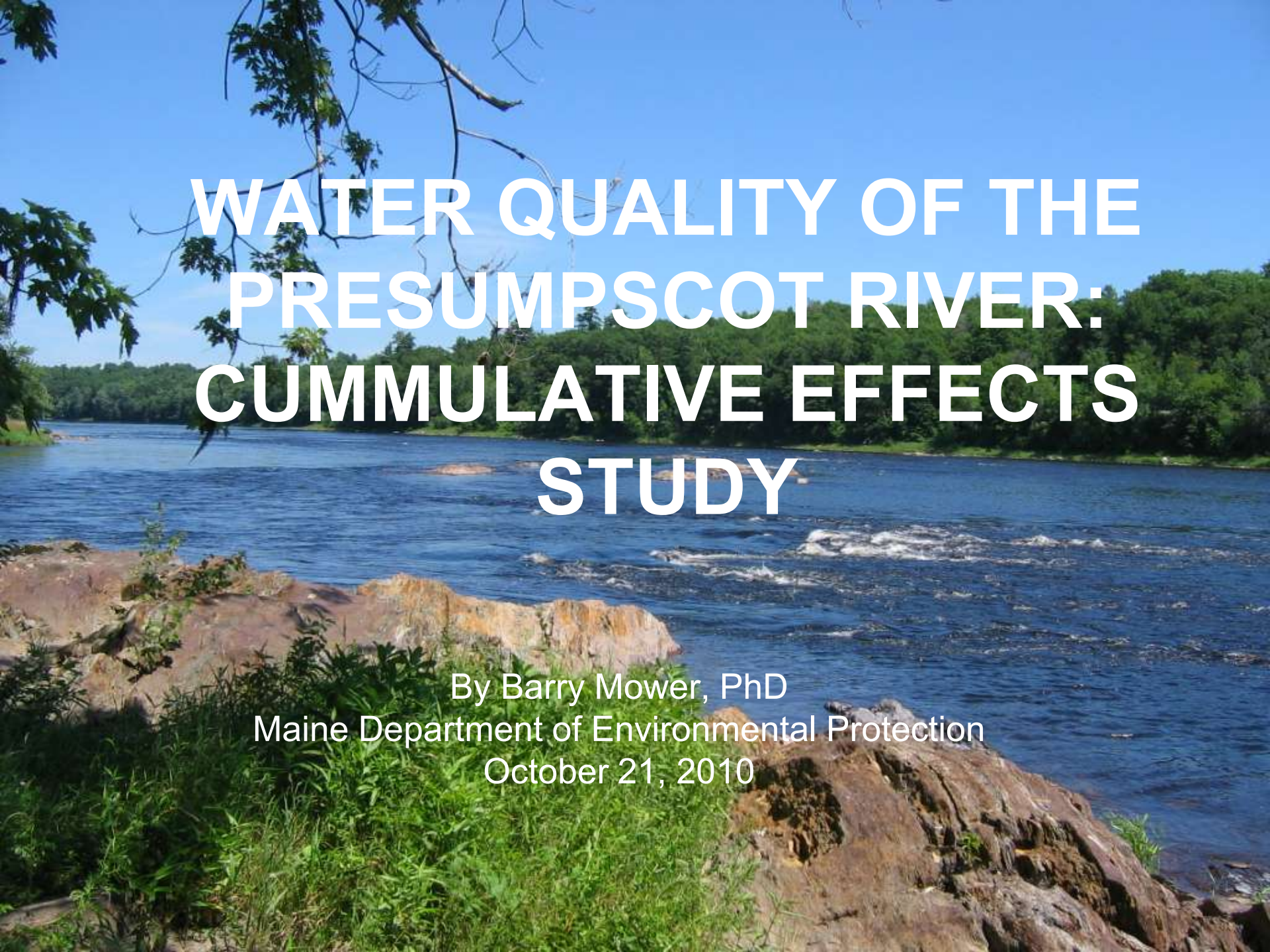


WATER QUALITY OF THE PRESUMPSCOT RIVER: CUMMULATIVE EFFECTS STUDY

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®

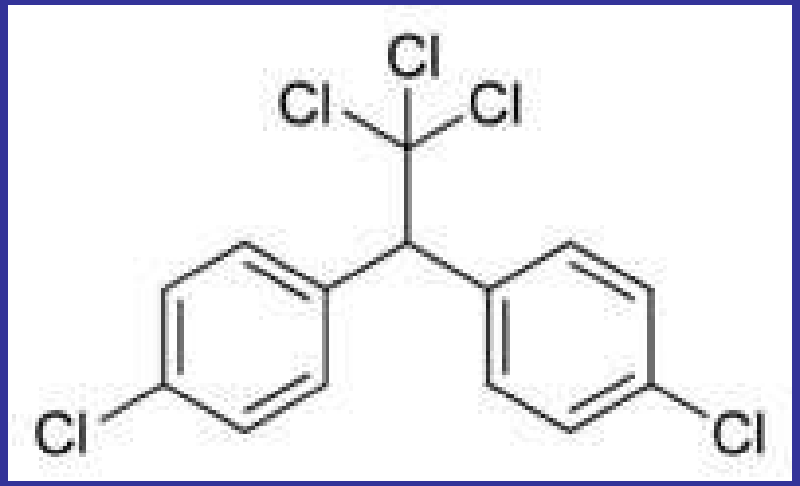
ACRONYMS

- 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

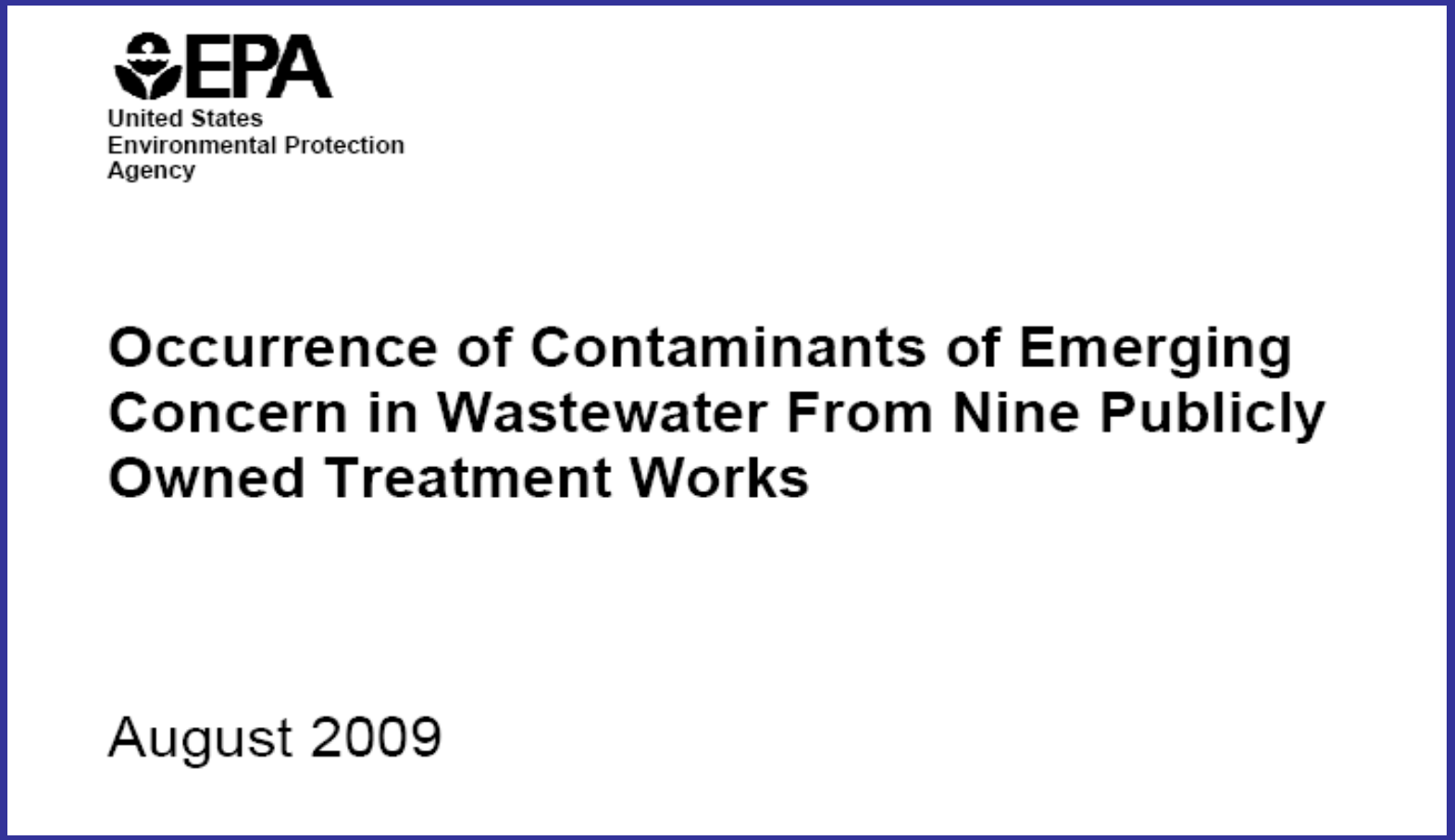
ENDOCRINE DISRUPTORS

- 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.

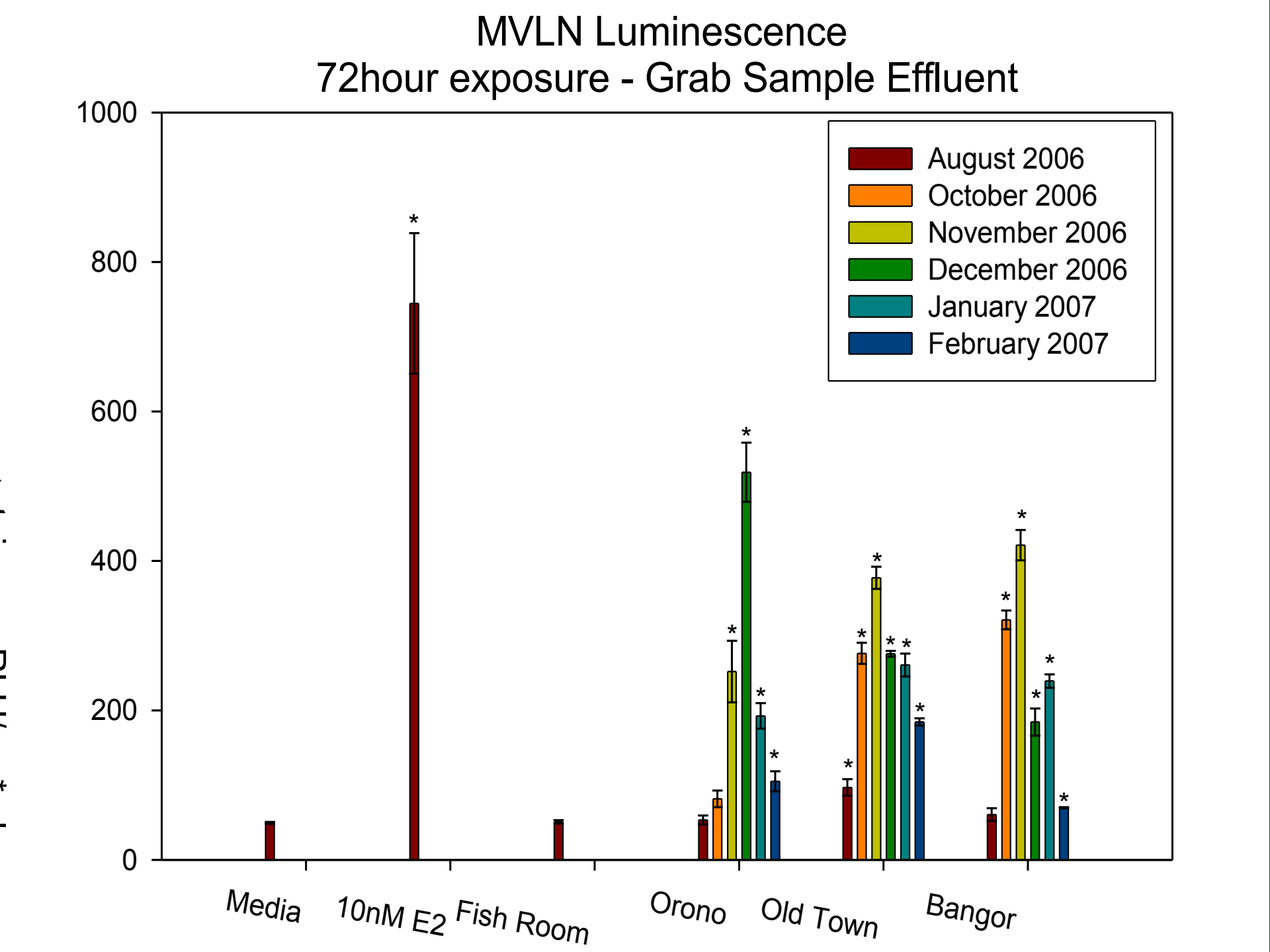
EPA's 9 POTW STUDY

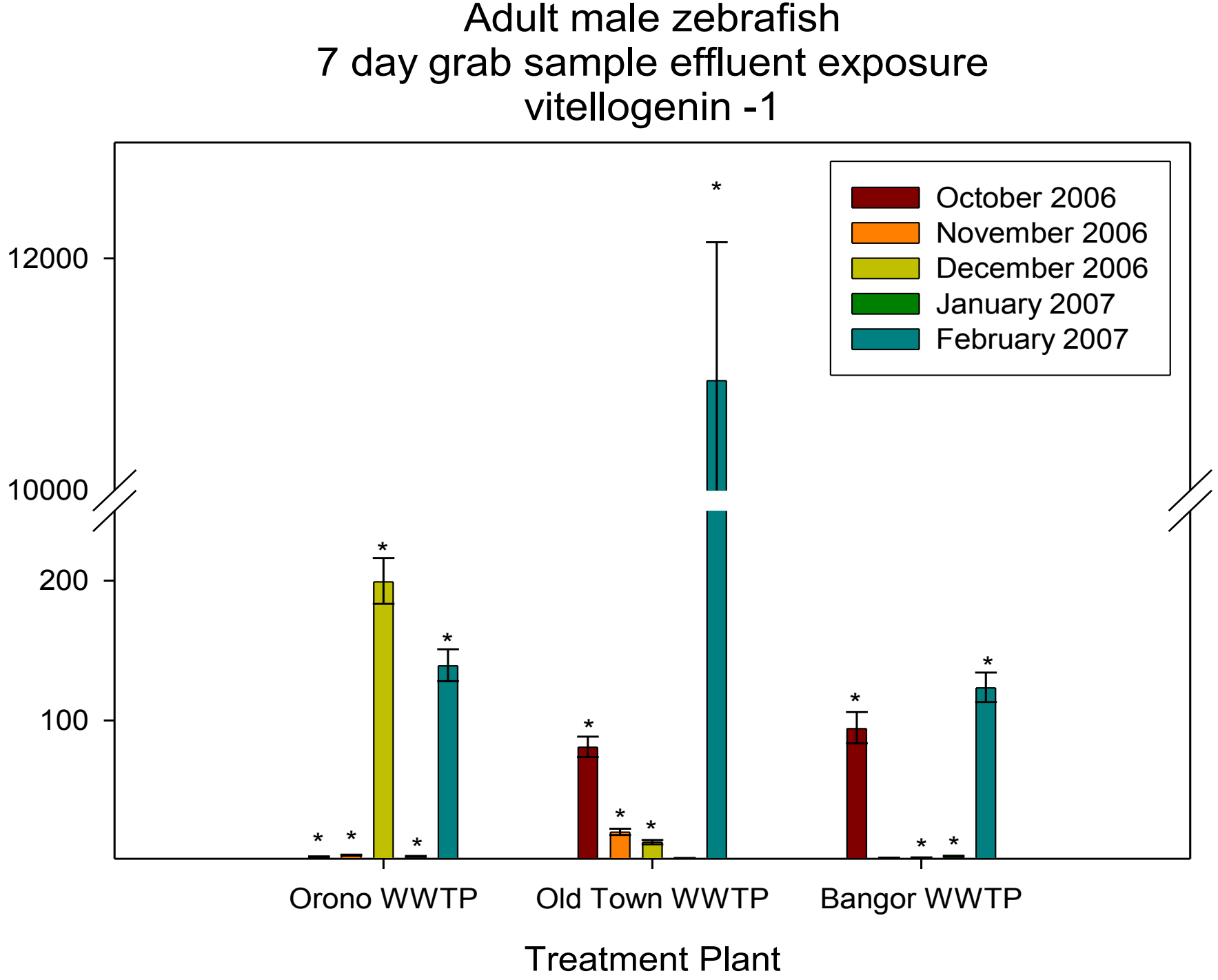


http://www.epa.gov/waterscience/ppcp/studies/9potwstudy.pdf

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)

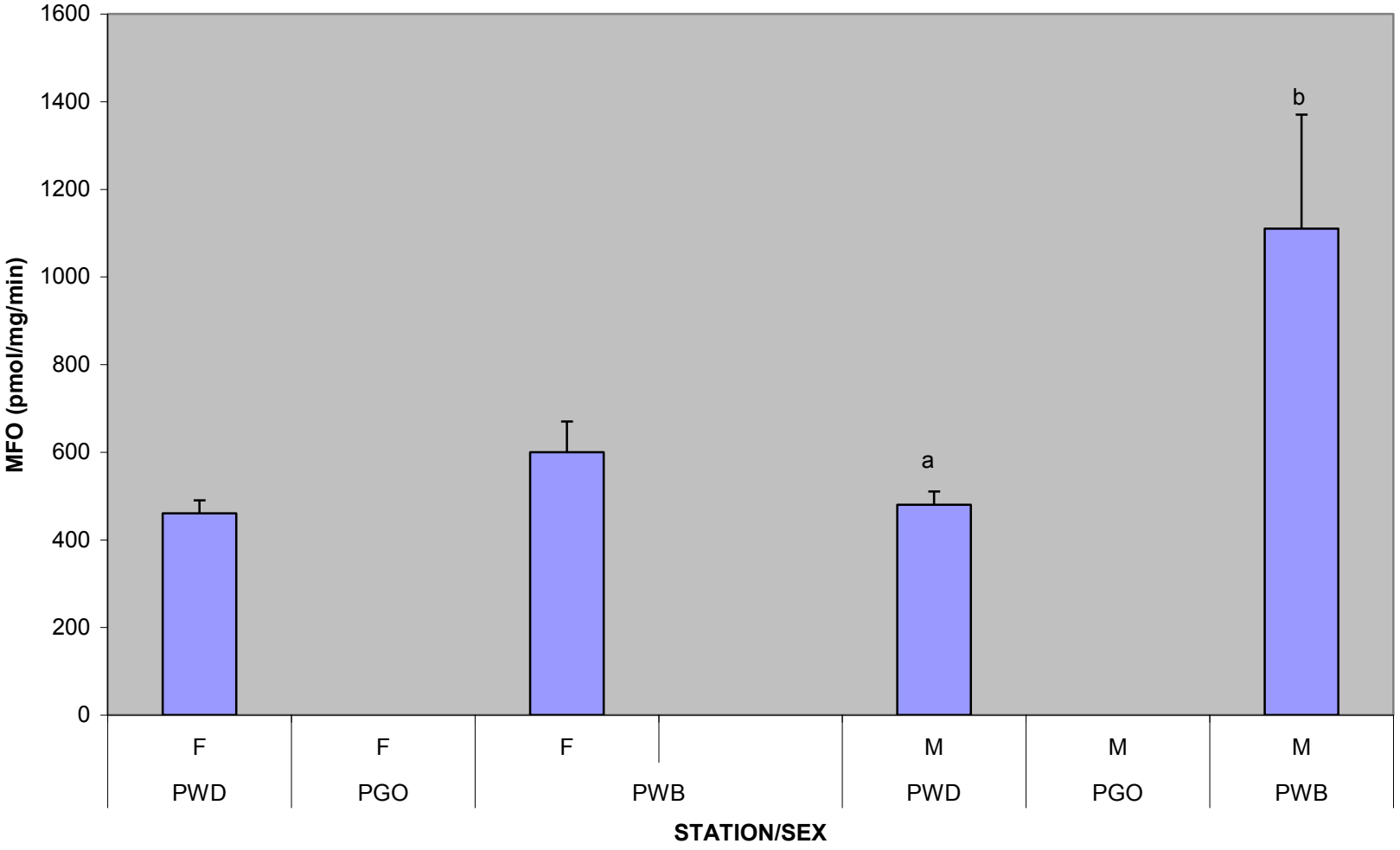


Figure 3.3.1b. Mean levels of MFO in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2008.
(letters = siginificant differences from upstream station, p<0.05)

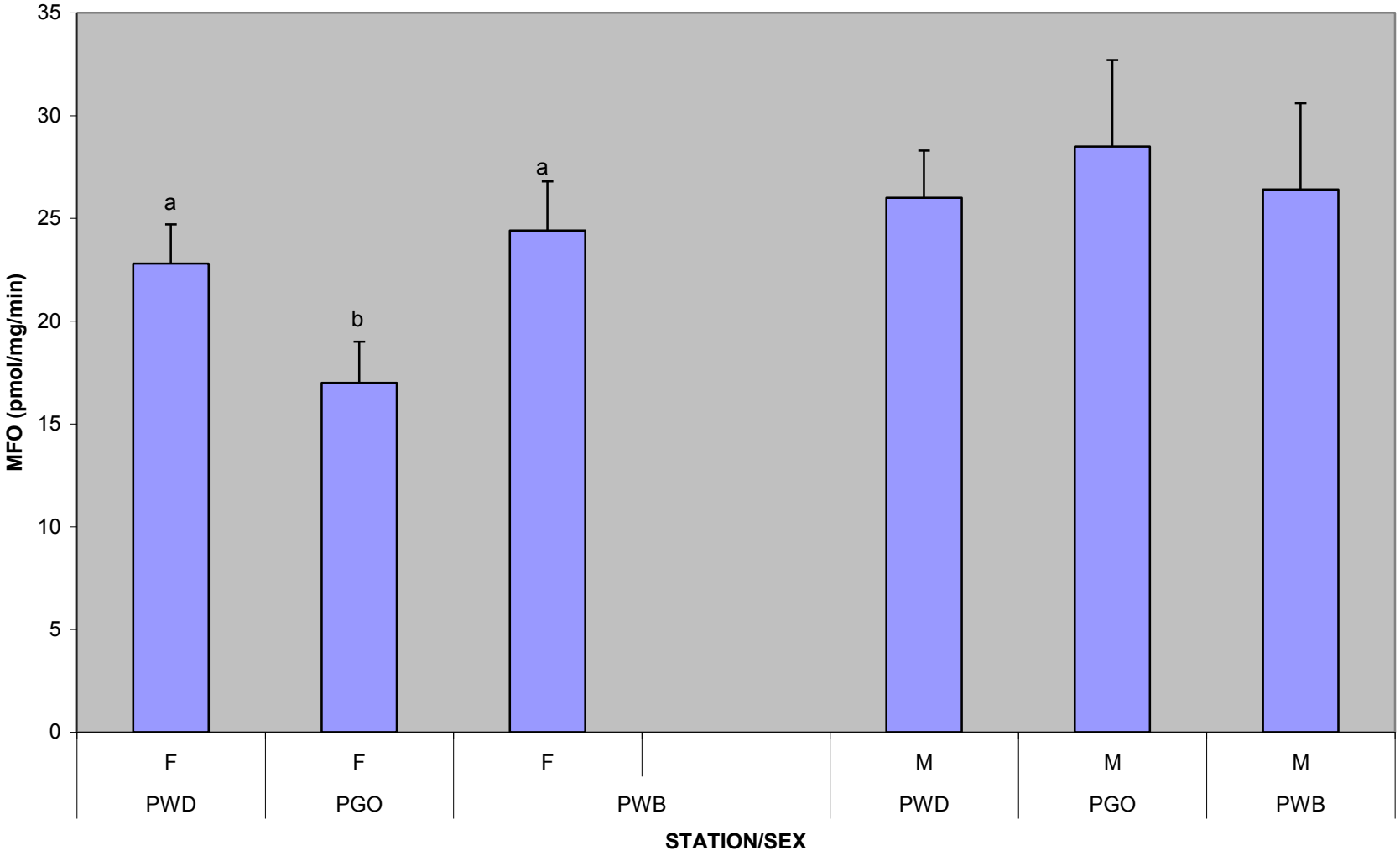


Figure 3.3.2. Mean levels of circulating sex steroids (testosterone-T and estradiol-E2) in female white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007 & 2008). (different letters = significant differences at p<0.05)

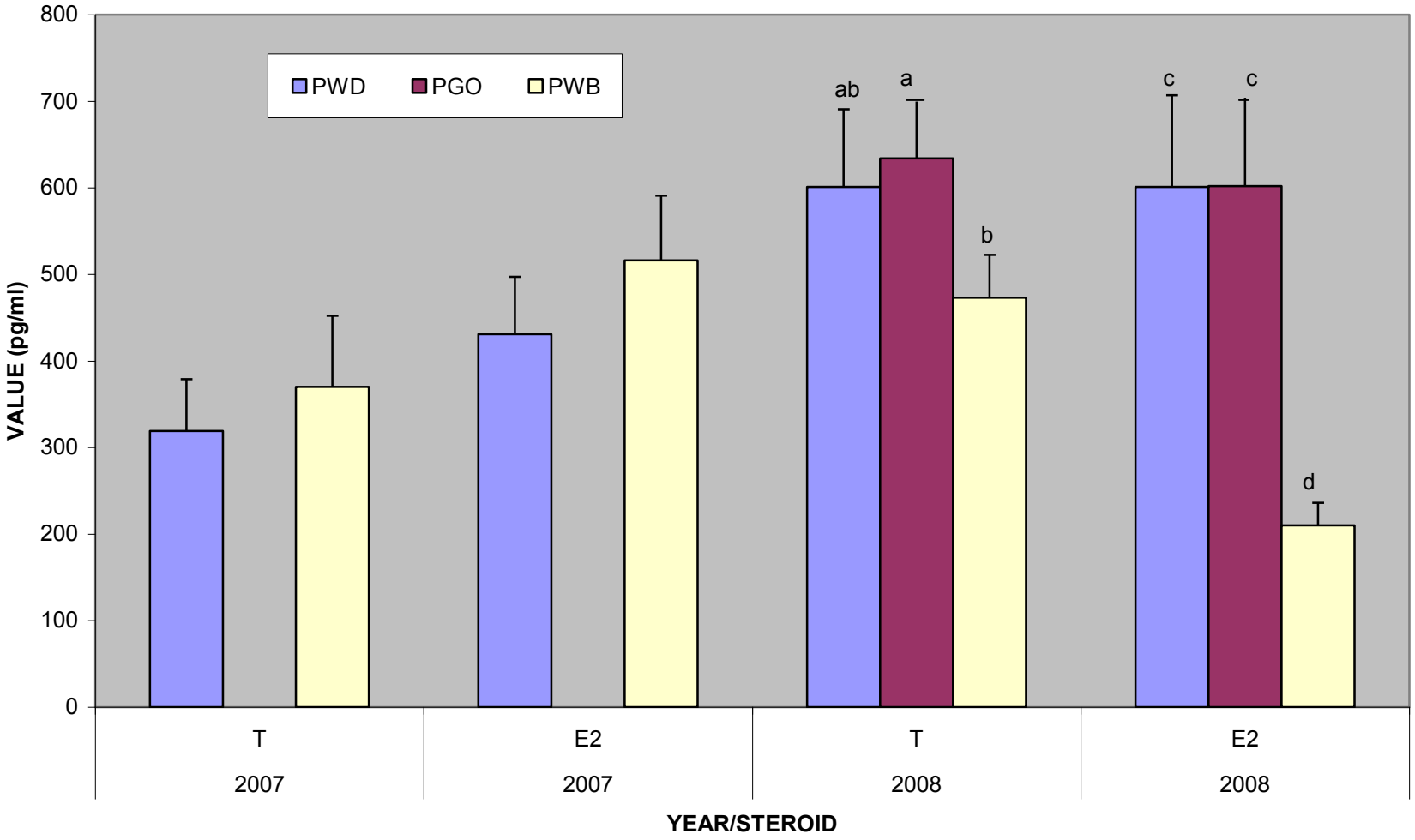


Figure 3.3.3. Mean levels of circulating sex steroids (testosterone-T and 11-ketotestosterone-KT) in male white sucker from the Presumpscot River above (PWD, PGO) and below (PWD) Westbrook, 2007 & 2008 (letters = significant differences by steroid p<0.05)

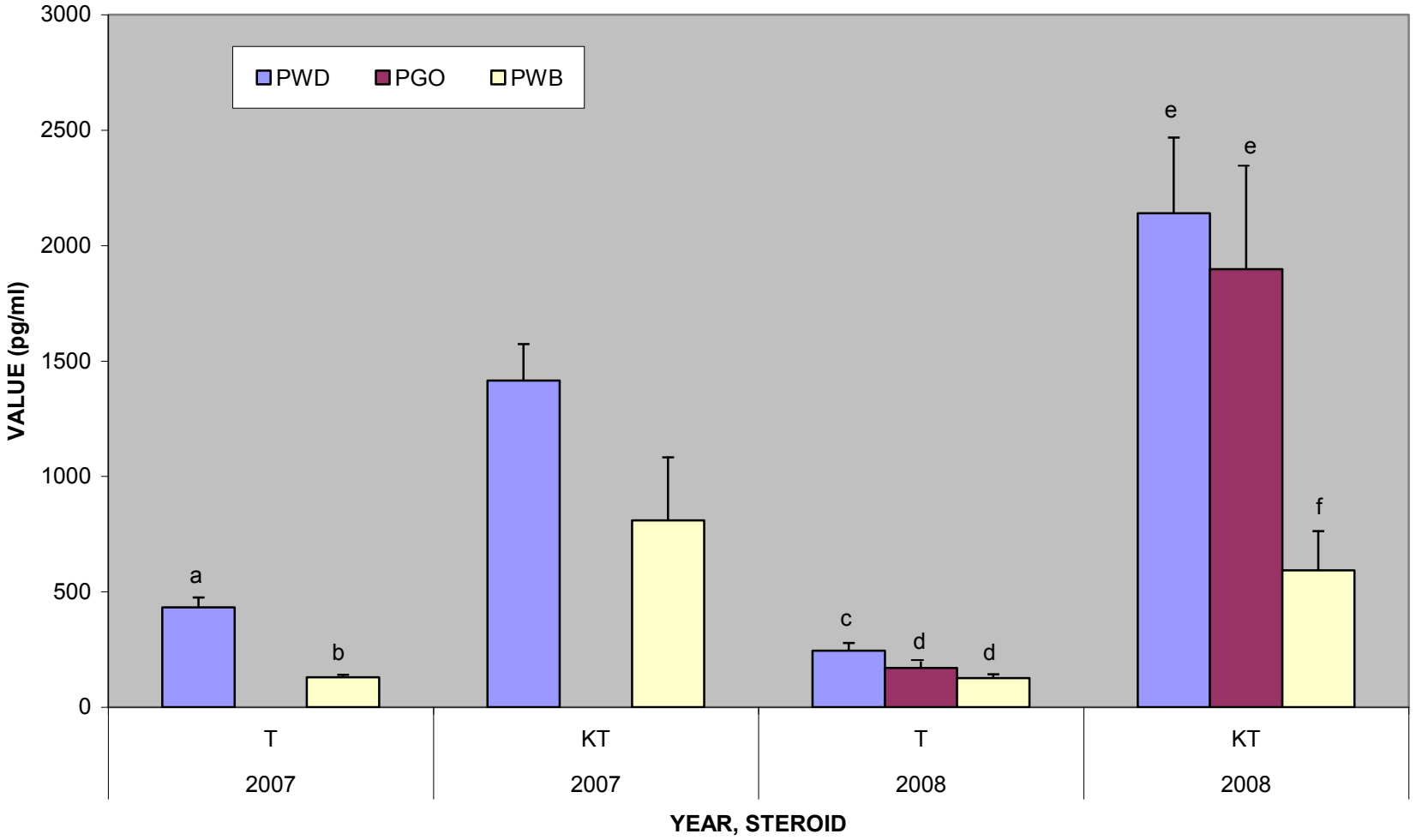


Figure 3.3.4. Mean age of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009
(letters show significant differences within sex & year, p<0.05)

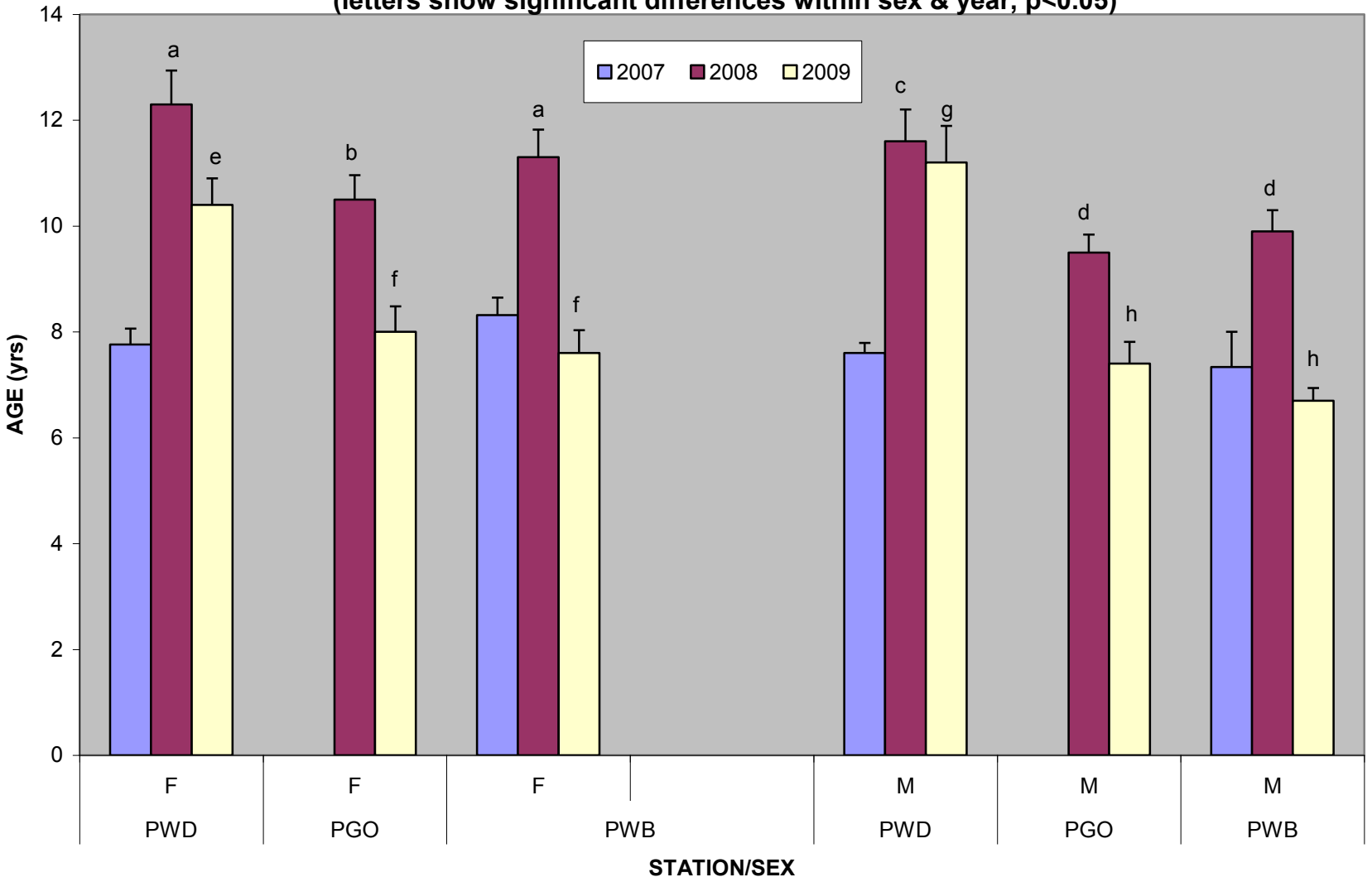


Figure 3.3.5. Mean length of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009
(letters show significant differences within sex & year, p<0.05)

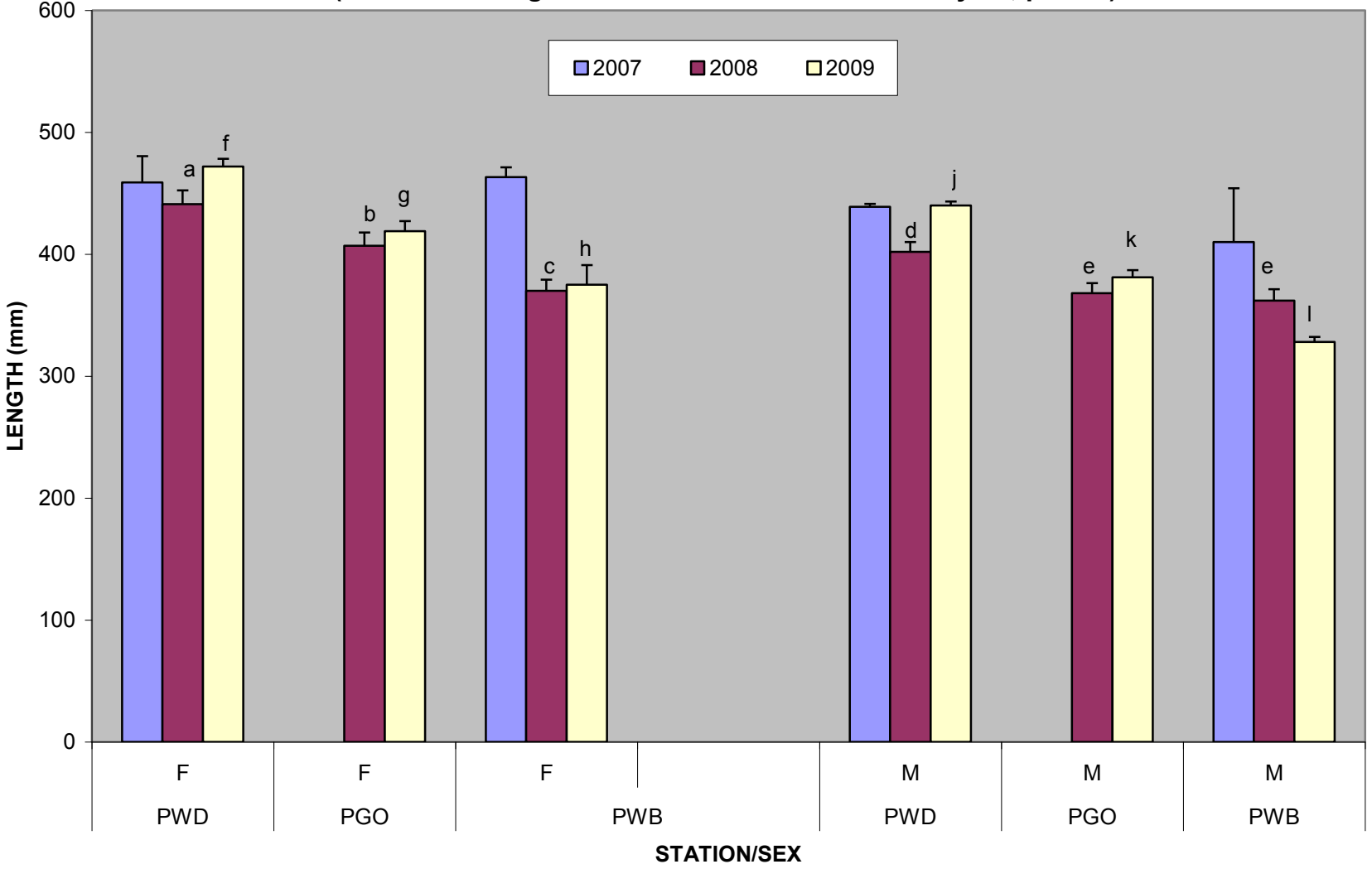


Figure 3.3.6. Mean condition factor (K) of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009 (letters show significant differences within sex & year, p<0.05)

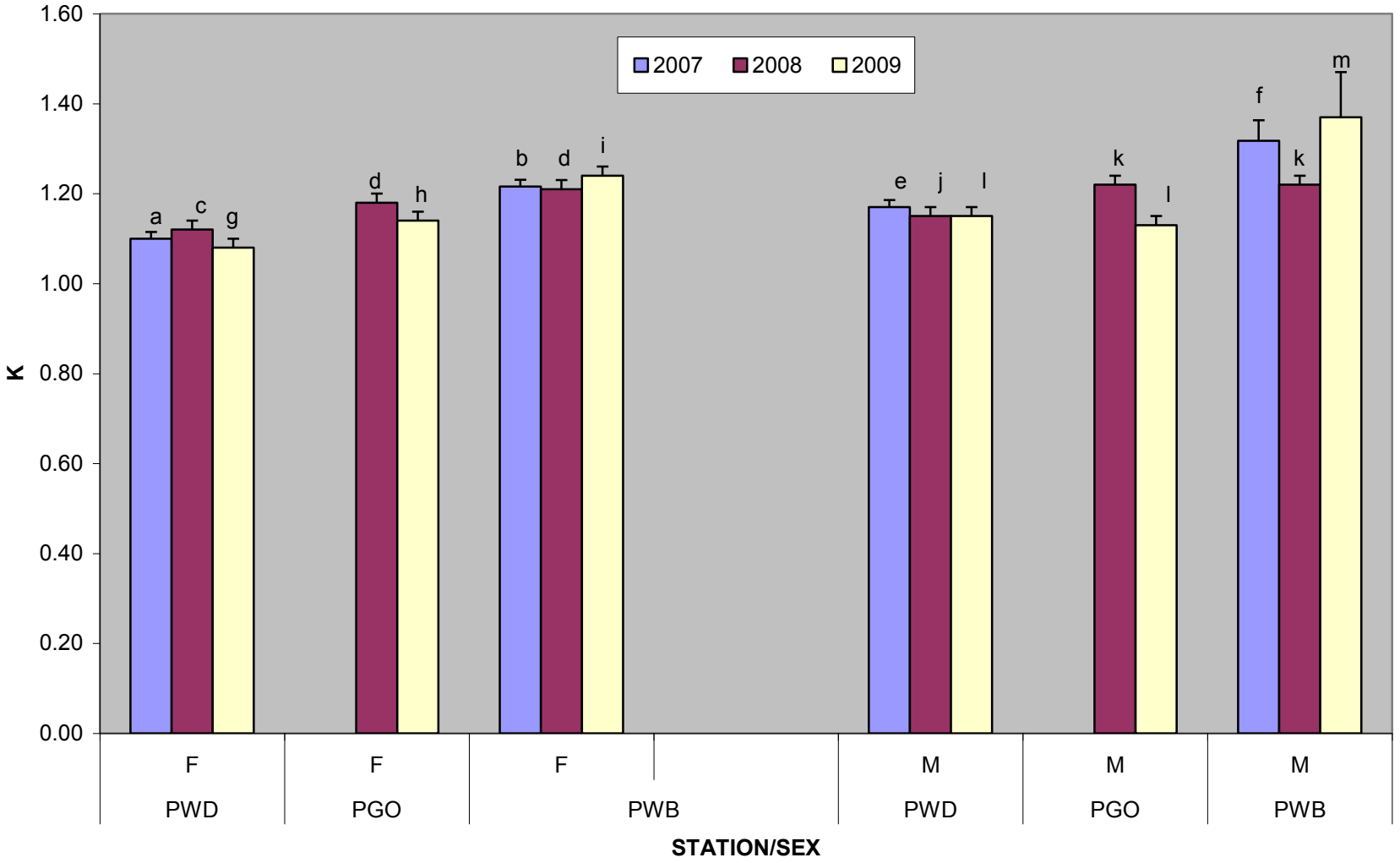


Figure 3.3.7. Mean GSI in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009
(letters show significant differences within sex & year, p<0.05)

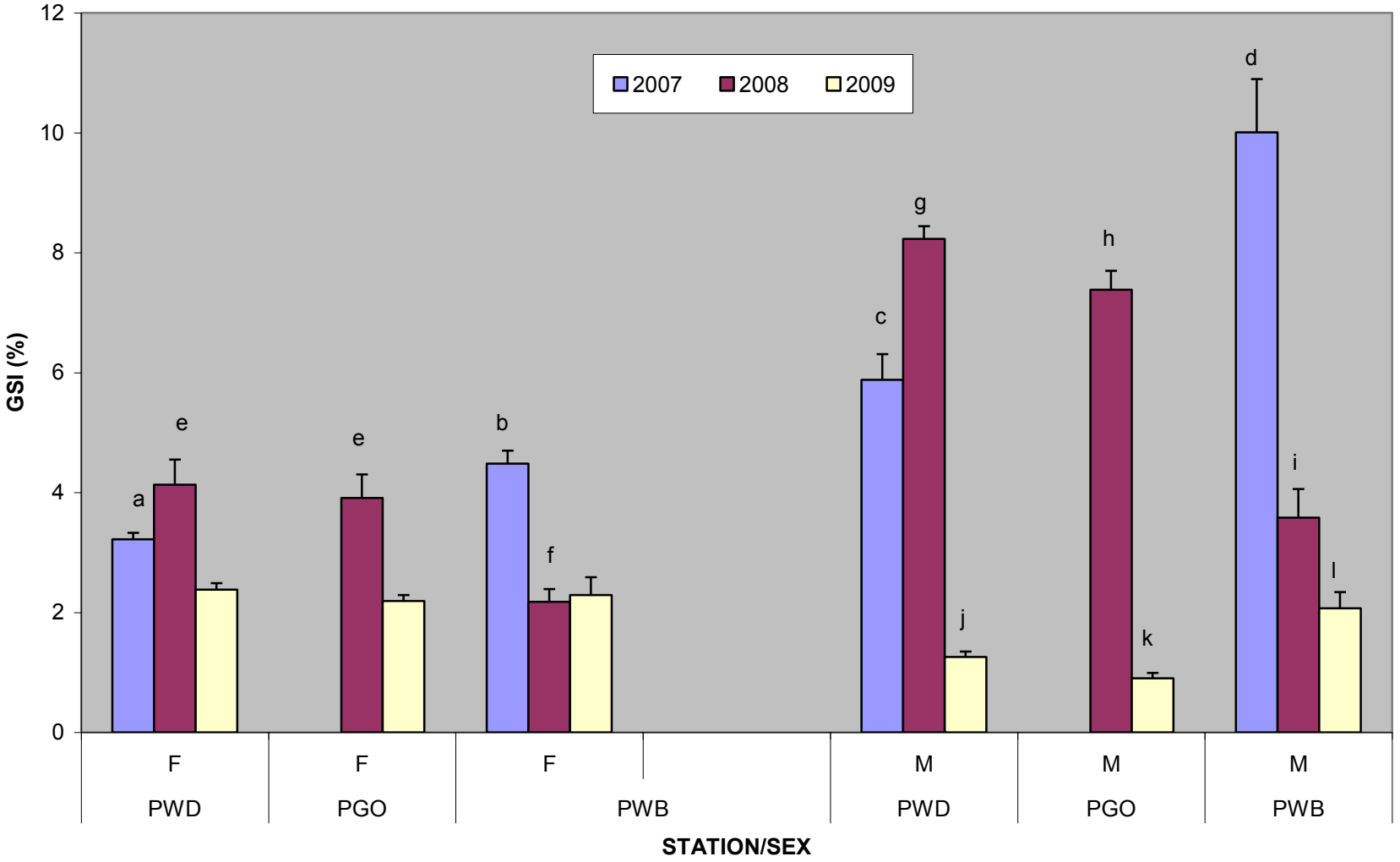


Figure 3.3.8. Mean LSI in white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009.
(letters show significant differences within sex and year, p<0.05)

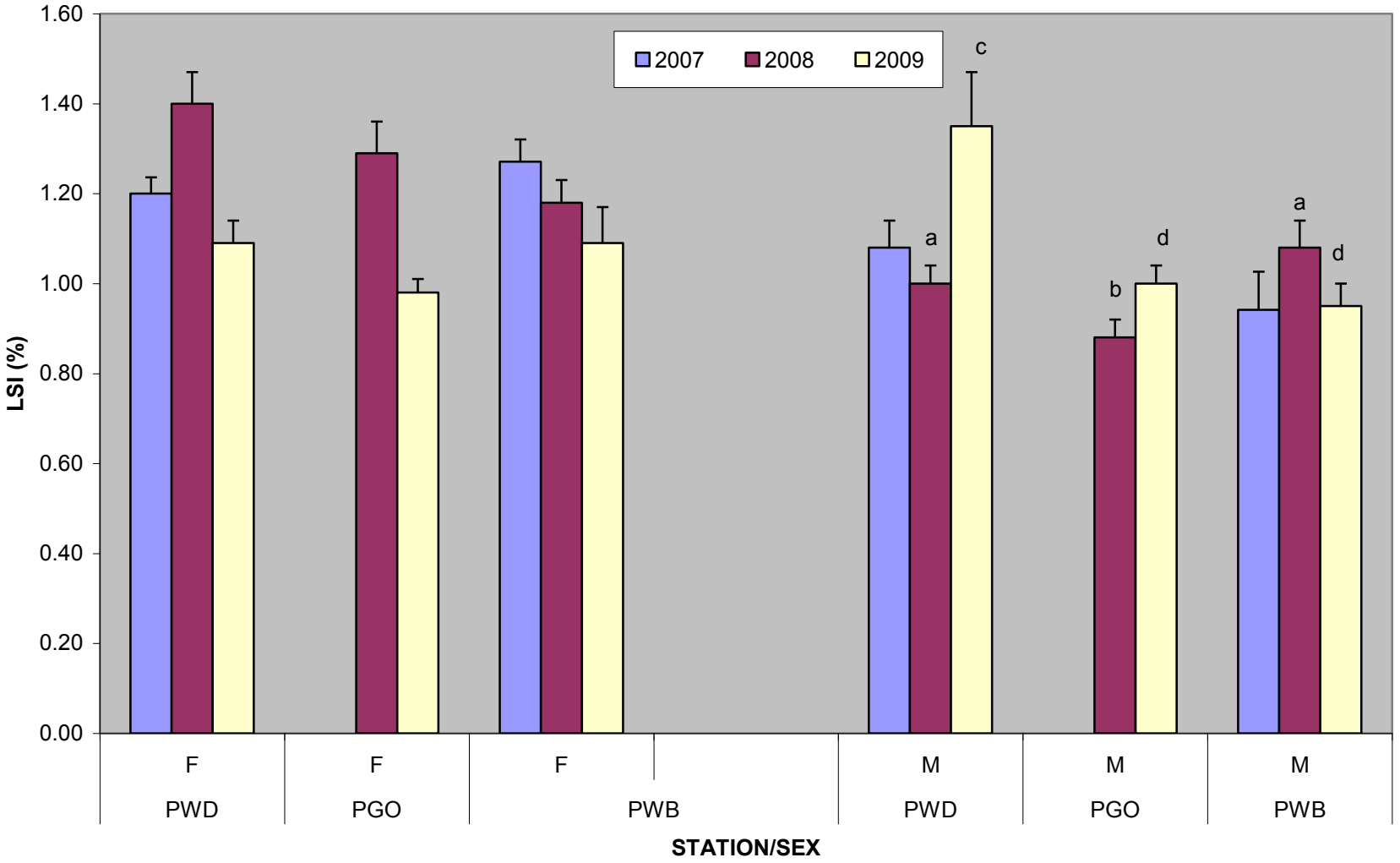


Figure 3.3.9. Mean percentage of previtellogenic (P), endovitellogenic (E), & vitellogenic (V) oocytes from female white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007 & 2008

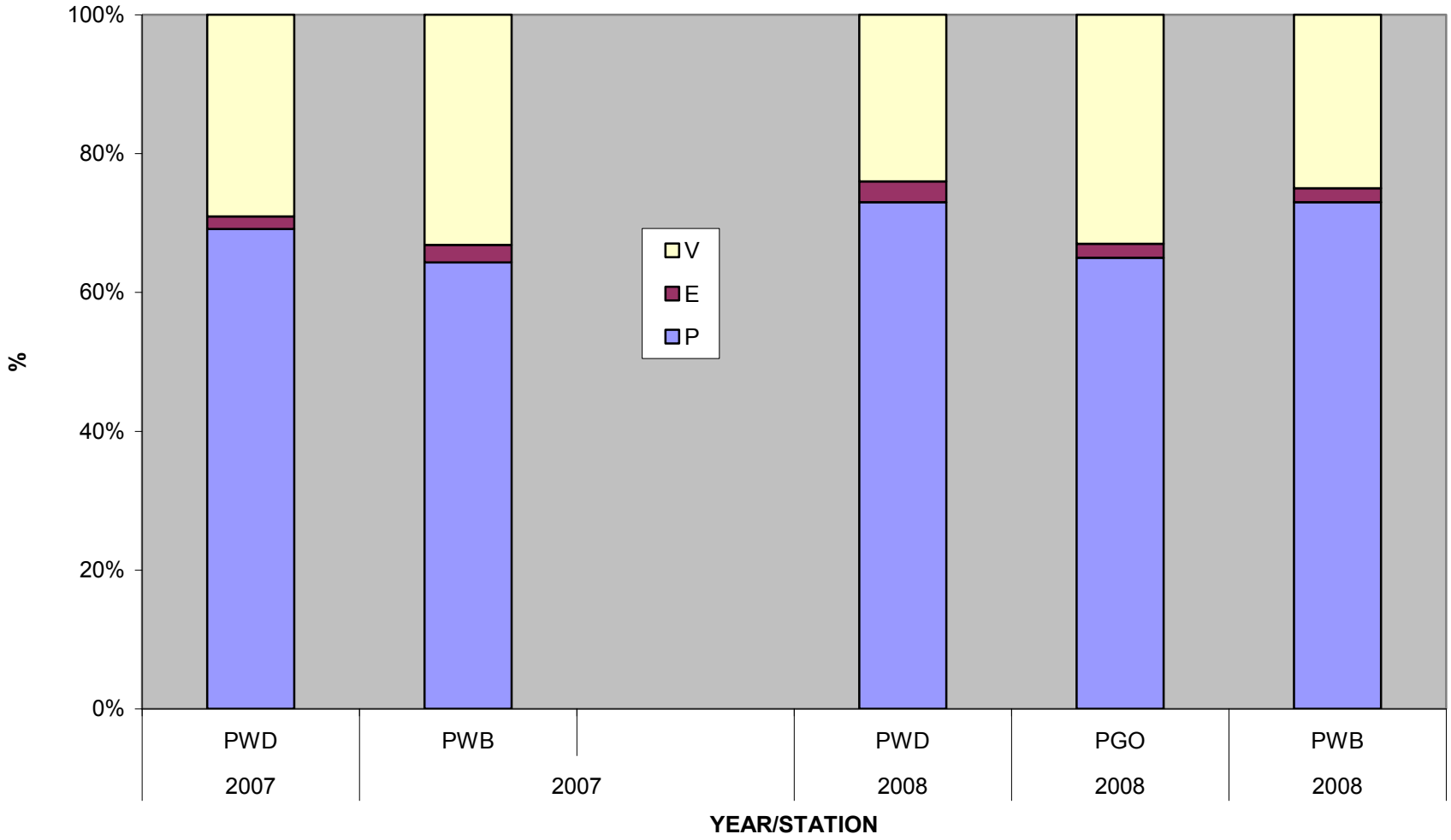


Figure 3.3.10. Mean size (µm2) of vitellogenic oocytes in female white sucker from the Presumpscot River above (PWD, PGO) & below (PWB) Westbrook, 2007 & 2008 (different letters show significant differences within years)

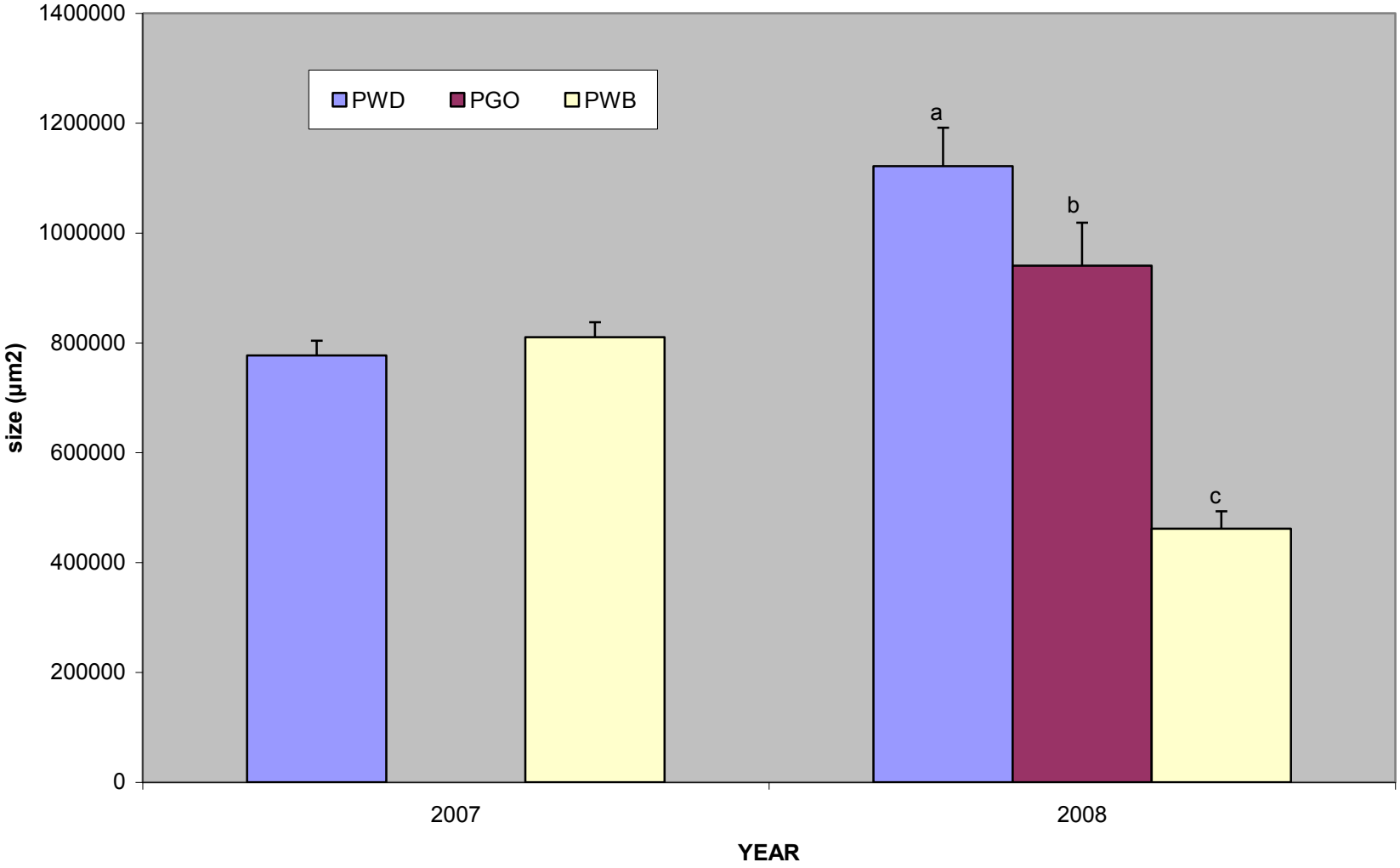
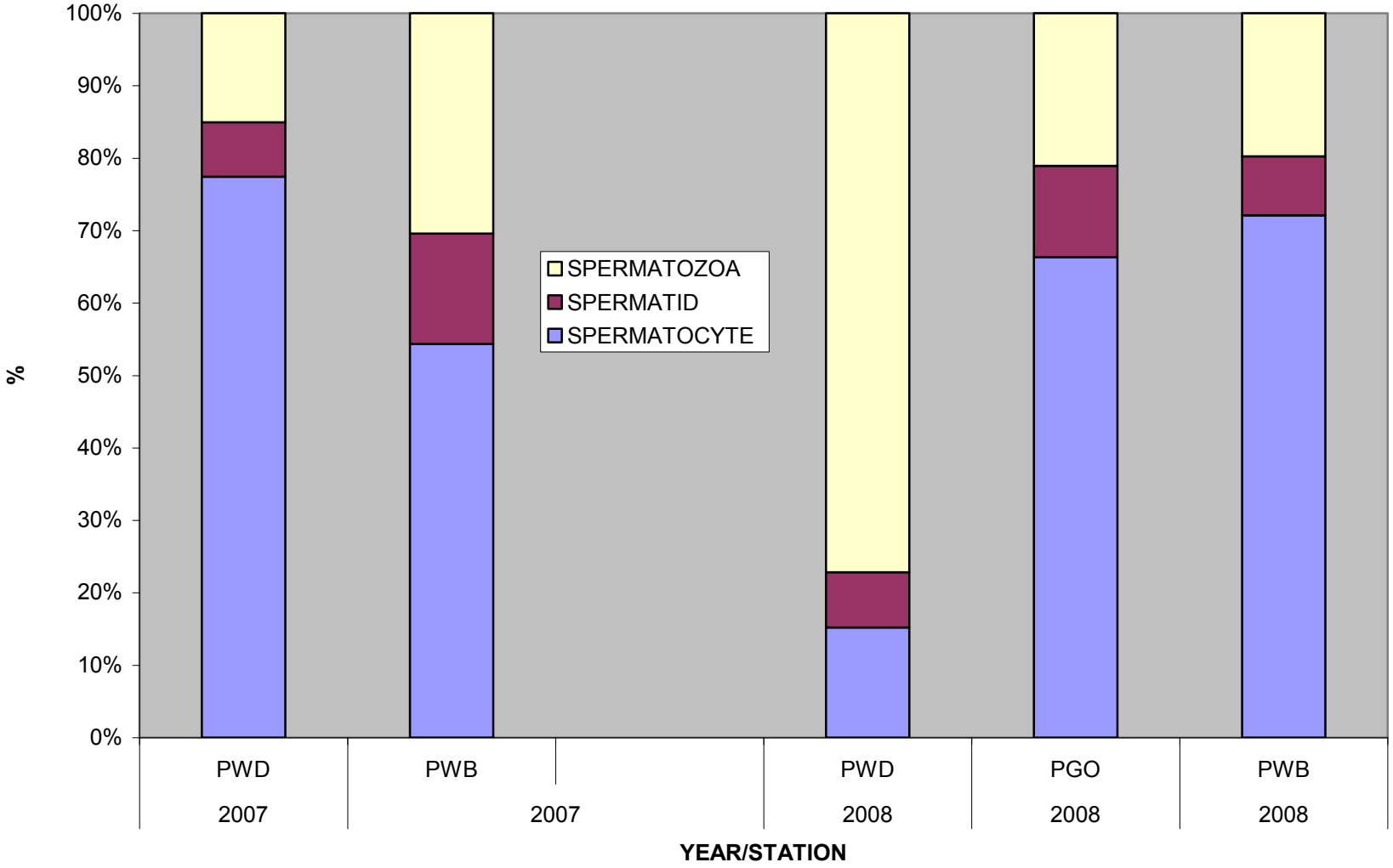


Figure 3.3.11. Mean percentage of spermatocytes, spermatids, spermatozoa in male white sucker testes from the Presumpscot River above (PWD, PGO) & below (PWB) Westbrook, 2007 & 2008



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

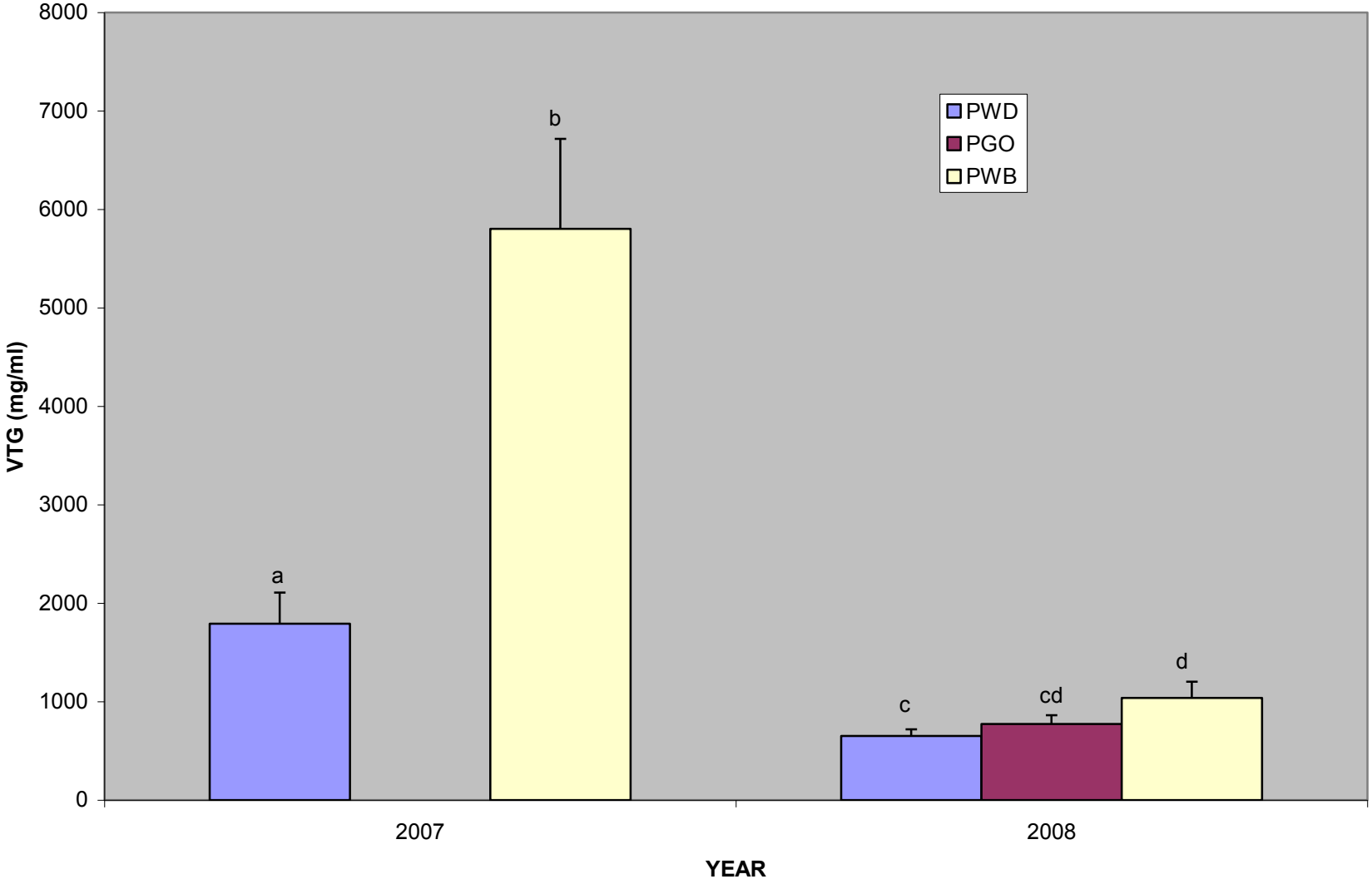


Figure 3.3.13. Mean vitellogenin (VTG) concentrations in male white sucker from the Presumpscot River above (PWD, PGO) and below (PWD) Westbrook, 2007 & 2008 (different letters show significant differences within years)

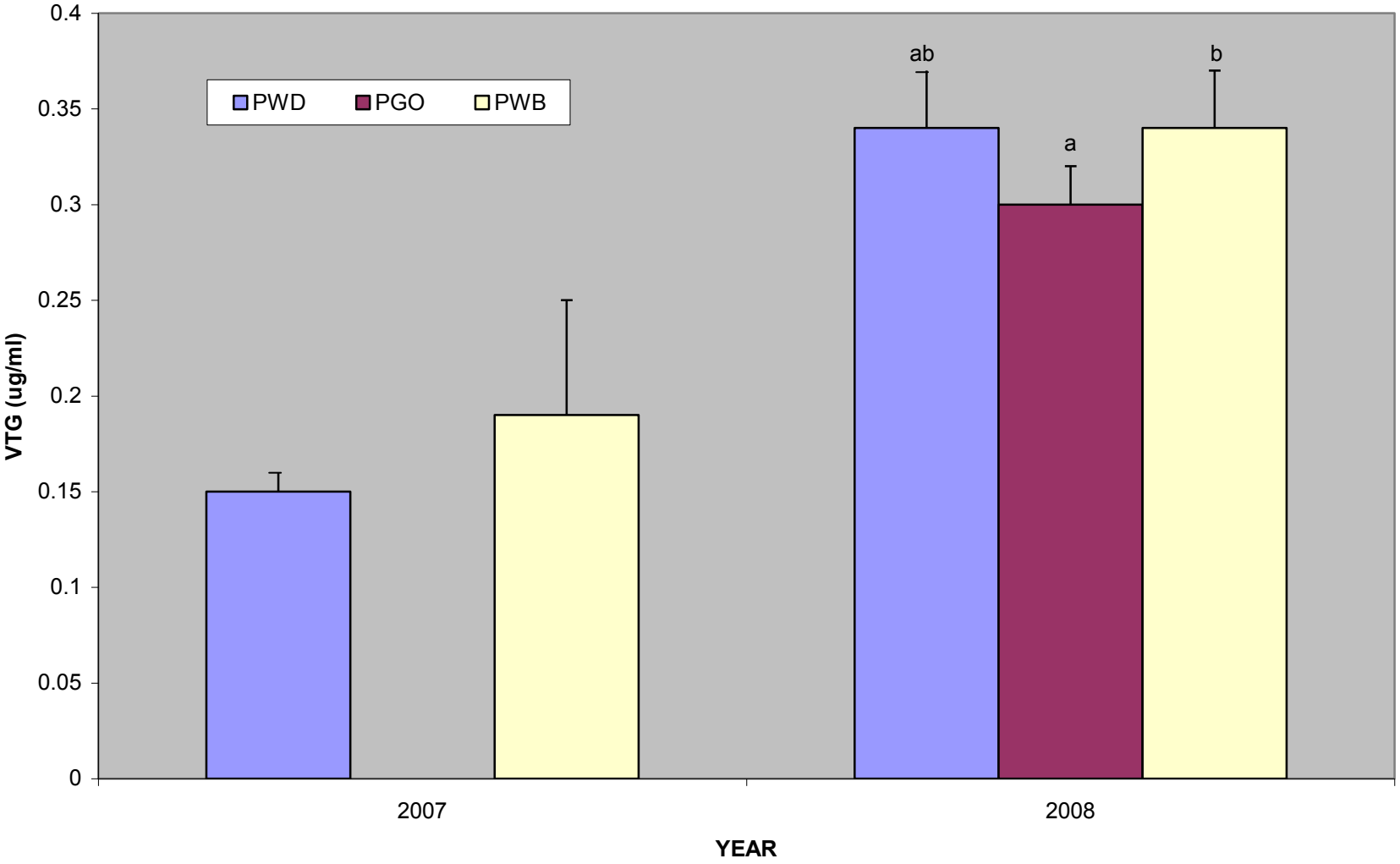


Table 3.3.2. Catch rates (CPUE) of white sucker from the Presumpscot River above (PWD, PGO) and below (PWB) Westbrook, 2007-2009				
STATION	SEX	2007 CPUE #/d/1000ft	2008 CPUE #/d/1000ft	2009 CPUE #/d/1000ft
PWD	F	28	15	9
PGO	F		28	14
PWB	F	6	17	3
PWD	M	19	16	6
PGO	M		14	10
PWB	M	1	14	1


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

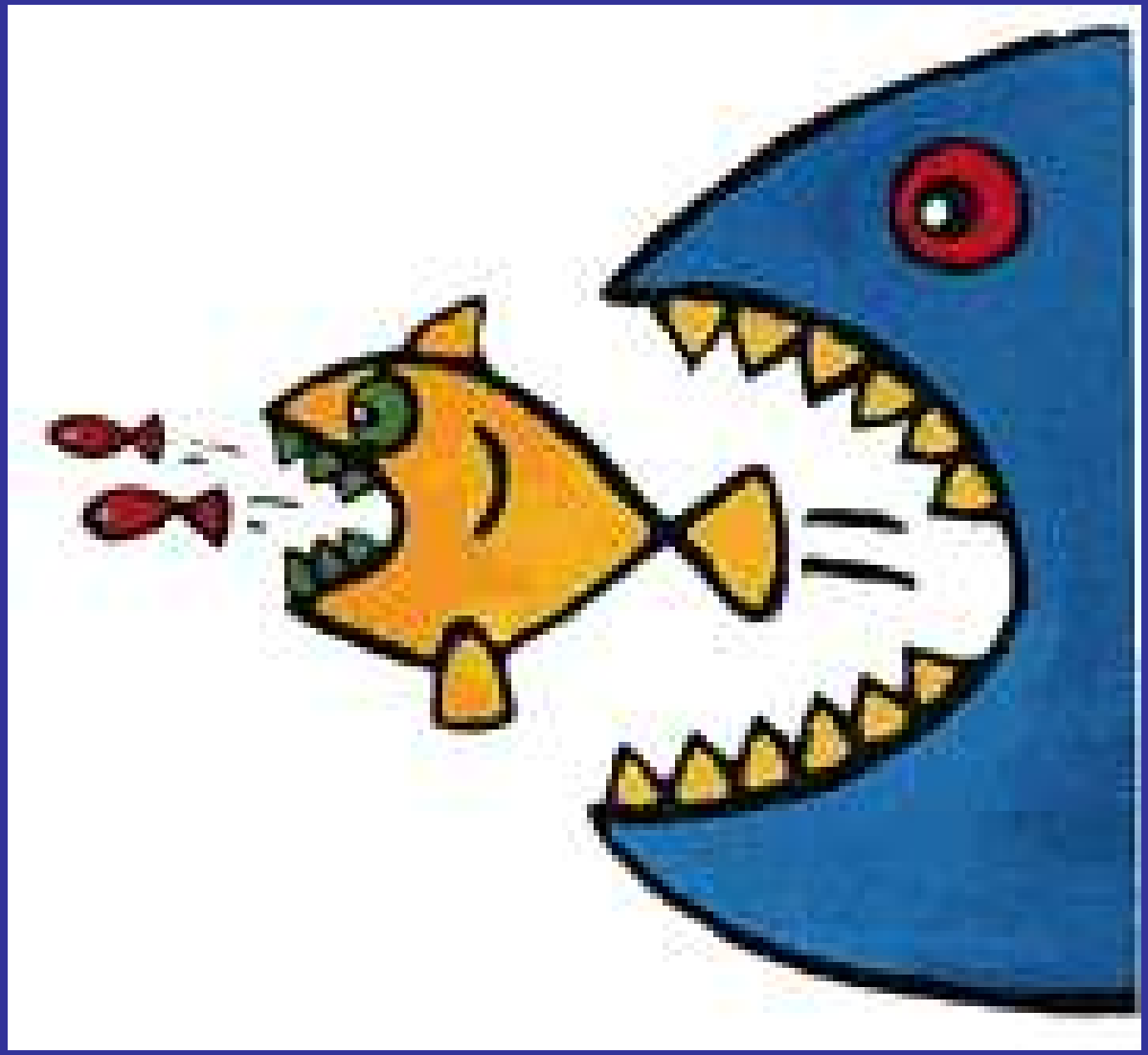
[1] mean monthly for 2007-2008

[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?