Potential impacts to lobsters and lobster habitat from chlorinated sewage outfall effluent

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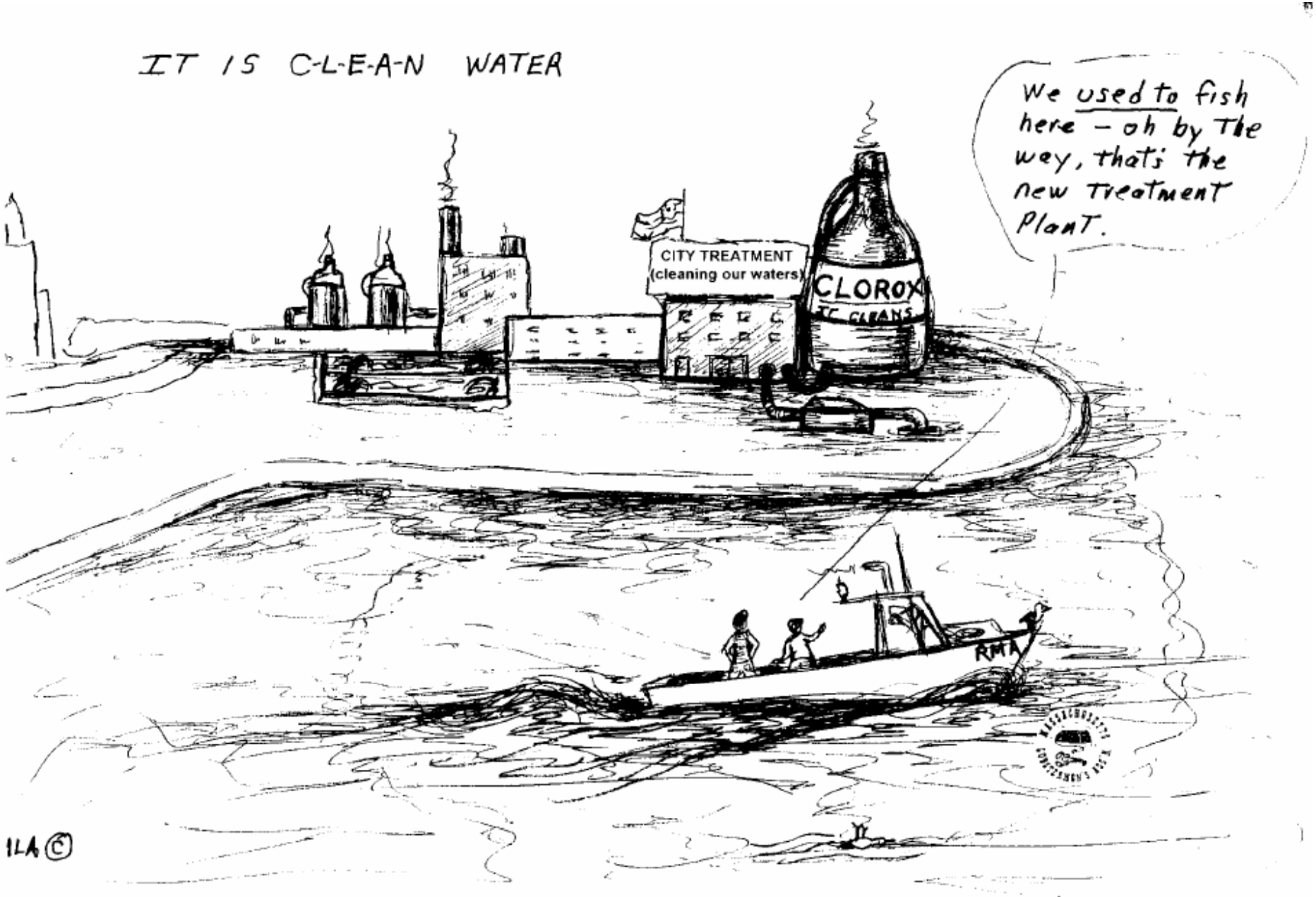
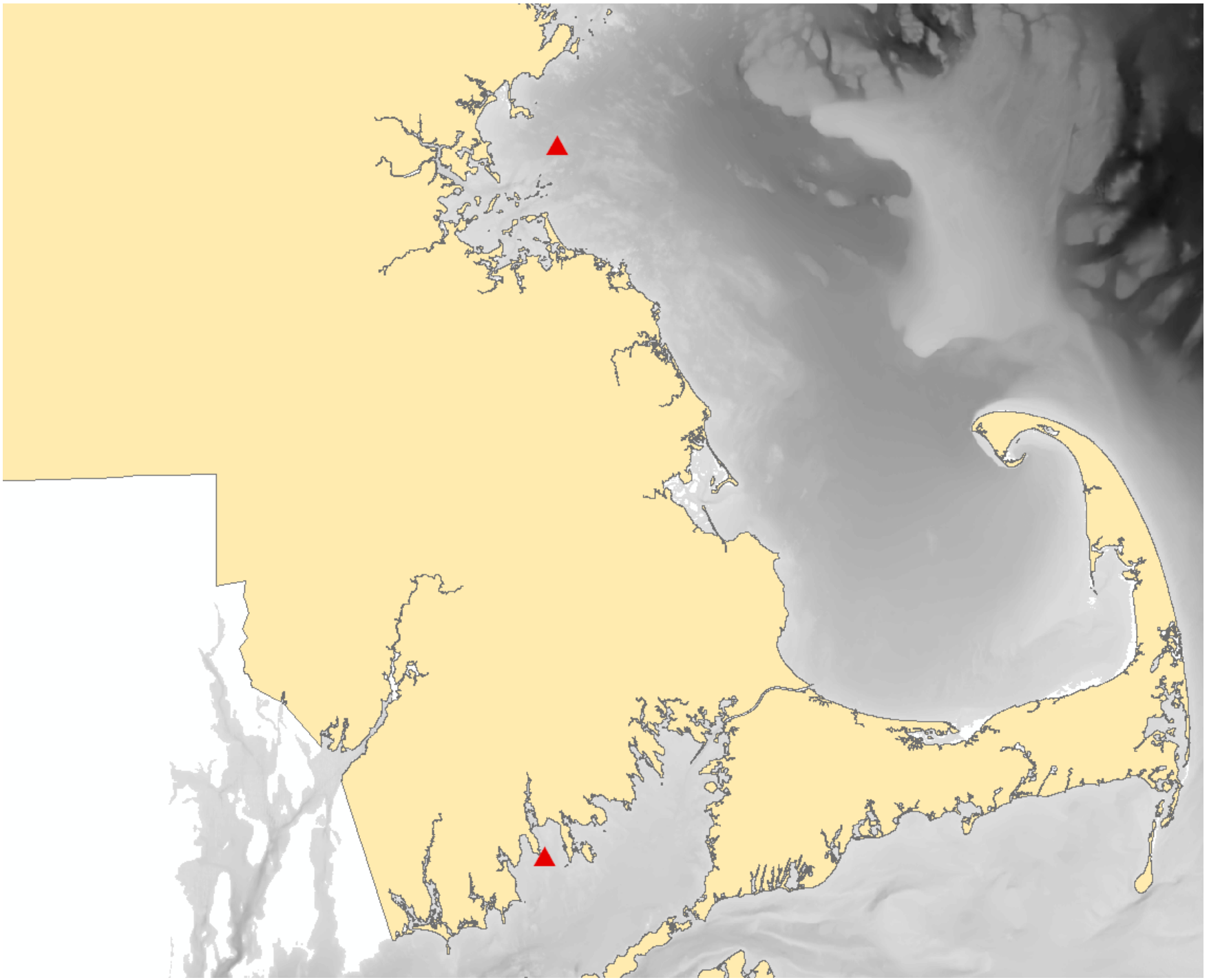
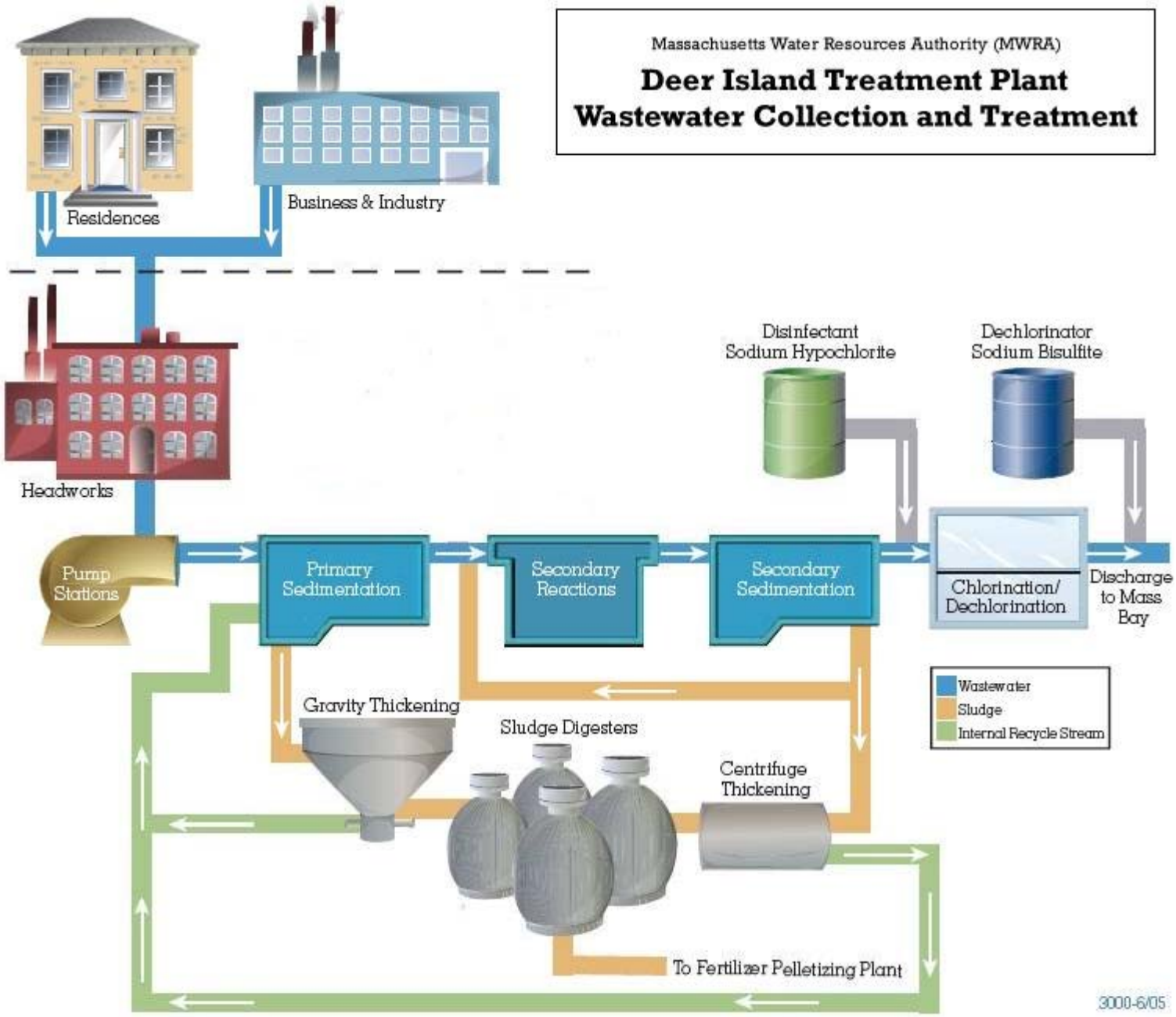

IT IS C-L-E-A-N WATER
We used to fish here – oh by the way, that's the new treatment plant.
CITY TREATMENT
(cleaning our waters)
CLOROX
TC CLEANS
RMA
ILA ©

Overview of sewage treatment

- Primary = settlement
  - Floatables and sinkables get removed
  - Very high organic load—dramatically alters ecosystem in receiving waters
- Secondary = settlement + bacterial digestion
  - Floatables and sinkables get removed
  - Liquid undergoes bacterial digestion
  - Liquid gets chlorinated and dechlorinated then discharged




Massachusetts Water Resources Authority (MWRA)
Deer Island Treatment Plant
Wastewater Collection and Treatment
Residences
Business & Industry
Headworks
Disinfectant
Sodium Hypochlorite
Dechlorinator
Sodium Bisulfite
Pump Stations
Primary Sedimentation
Secondary Reactions
Secondary Sedimentation
Chlorination/ Dechlorination
Discharge to Mass Bay
Wastewater
Sludge
Internal Recycle Stream
Gravity Thickening
Sludge Digesters
Centrifuge Thickening
To Fertilizer Pelletizing Plant
3000-6/05

Why chlorinate?

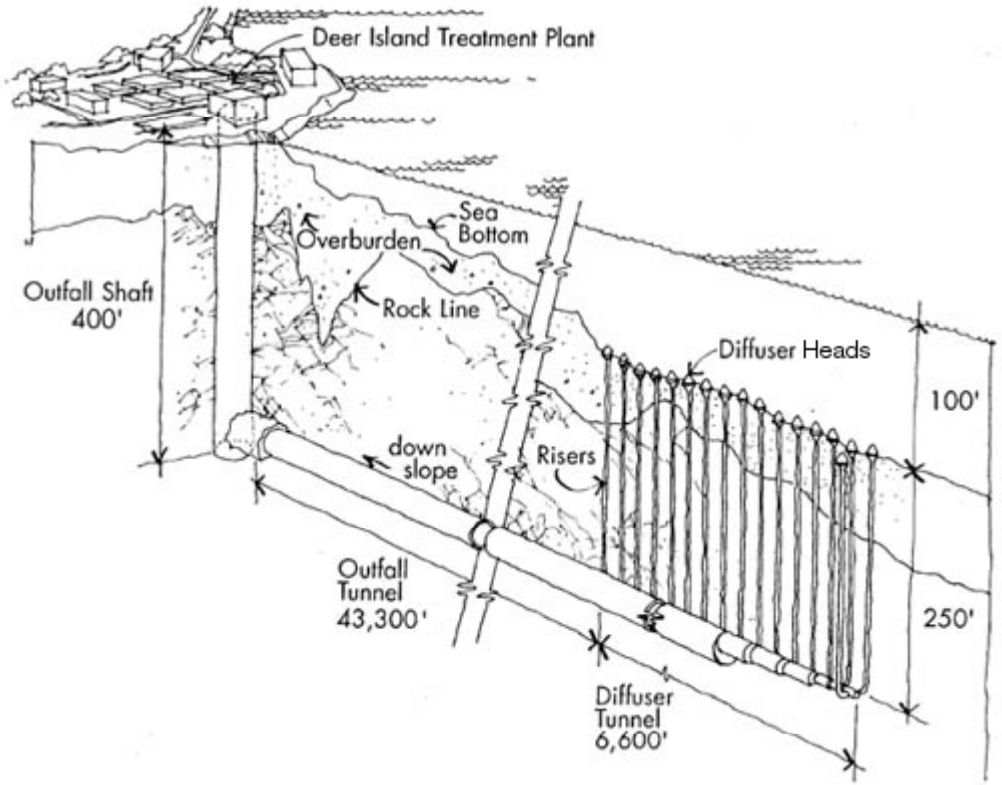
- Effluent is very dangerous to human health; many disease-causing organisms
- Chlorination is a well-known, inexpensive, and very effective method to kill these organisms
- Disadvantage: chlorinating the natural aquatic environment
- Therefore,treated effluent is chemically dechlorinated after disinfection

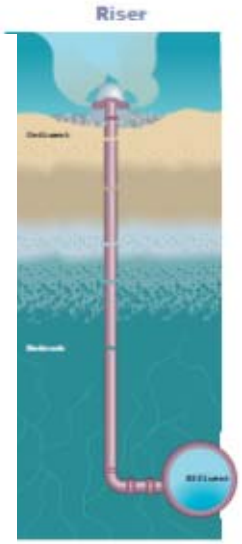
INFECTIOUS AGENTS IN UNTREATED DOMESTIC WASTEWATER

Bacteria	**Illness**
Escherichia coli	Gastroenteritis
Leptospira (spp.)	Leptospirosis
Salmonella typhi	Typhoid fever
Salmonella	Salmonellosis
Shigella (4 spp.)	Shigellosis (bacillary dysentery)
Vibrio cholerae	Cholera
Protozoa	
Balantidium coli	Balantidiasis
Cryptosporidium parvum	Cryptosporidiosis
Entamoeba histolytica	Amebiasis (amoebic dysentery)
Giardia lamblia	Giardiasis
Parasitic worms (Helminths)	
Ascaris lumbricoides	Ascariasis
T. solium	Taeniasis
Trichuris trichiura	Trichuriasis
Viruses	
Enteroviruses (72 types, e.g., polio, echo, and coxsackie viruses)	Gastroenteritis, heart anomalies, meningitis
Hepatitis A virus	Infectious hepatitis
Norwalk agent	Gastroenteritis
Rotavirus	Gastroenteritis

Source: Crites and Tchobanoglous, 1998

MASS BAY: 365 million gallons per day





Diffuser head schematic

Actual diffuser head

50 risers over last 6600 feet of the pipe.

http://www.mwra.state.ma.us/harbor/html/outfall_update.htm

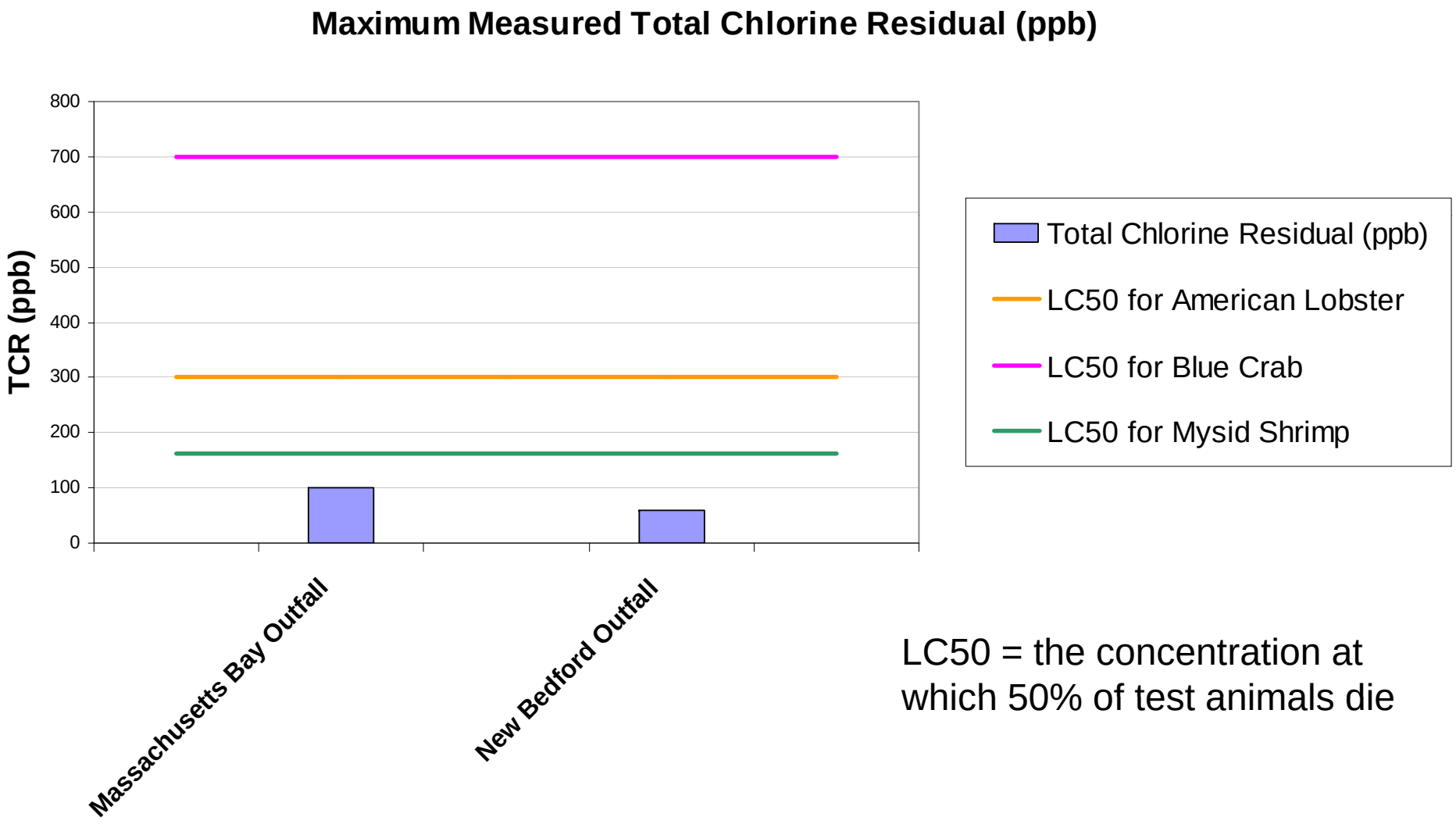
NEW BEDFORD: 25 million gallons per day

Picture of 72” (6’) pipe in Bergen County, NJ

http://www.concrete-pipe.org/pdf/2010-Project-Achievement-Award-application.pdf

1. Are chlorine levels released in sewage effluent responsible for killing lobsters?

How much chlorine hurts lobsters



LC50 = the concentration at which 50% of test animals die

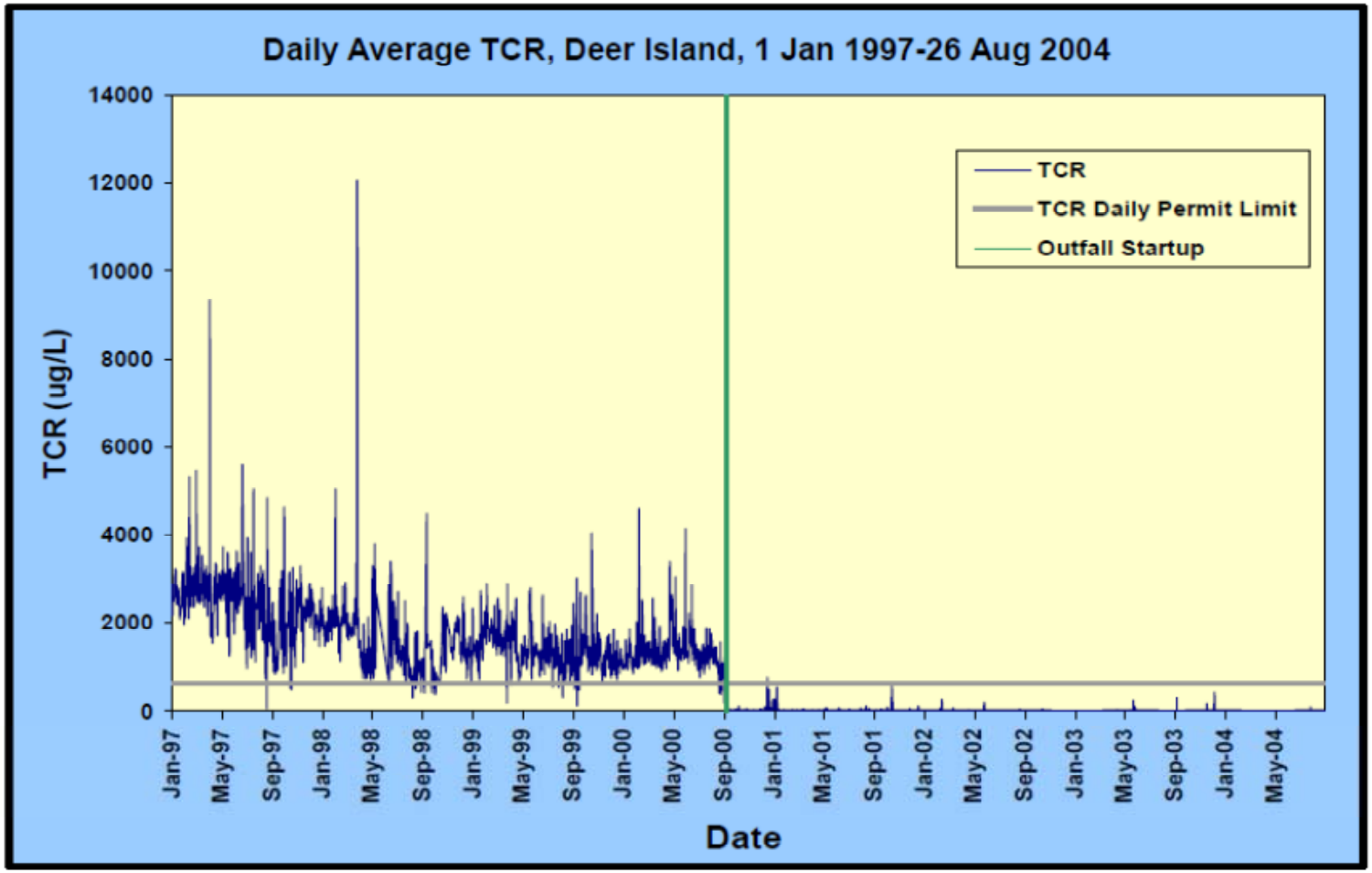


Figure 2. Daily average total chlorine residual (TCR) 1997 – 2004. Green line depicts transfer of effluent discharge from Boston Harbor to Mass Bay.(figure copied from Werme and Hunt 2004).

Egg bearing lobster population not affected by rising chlorine levels

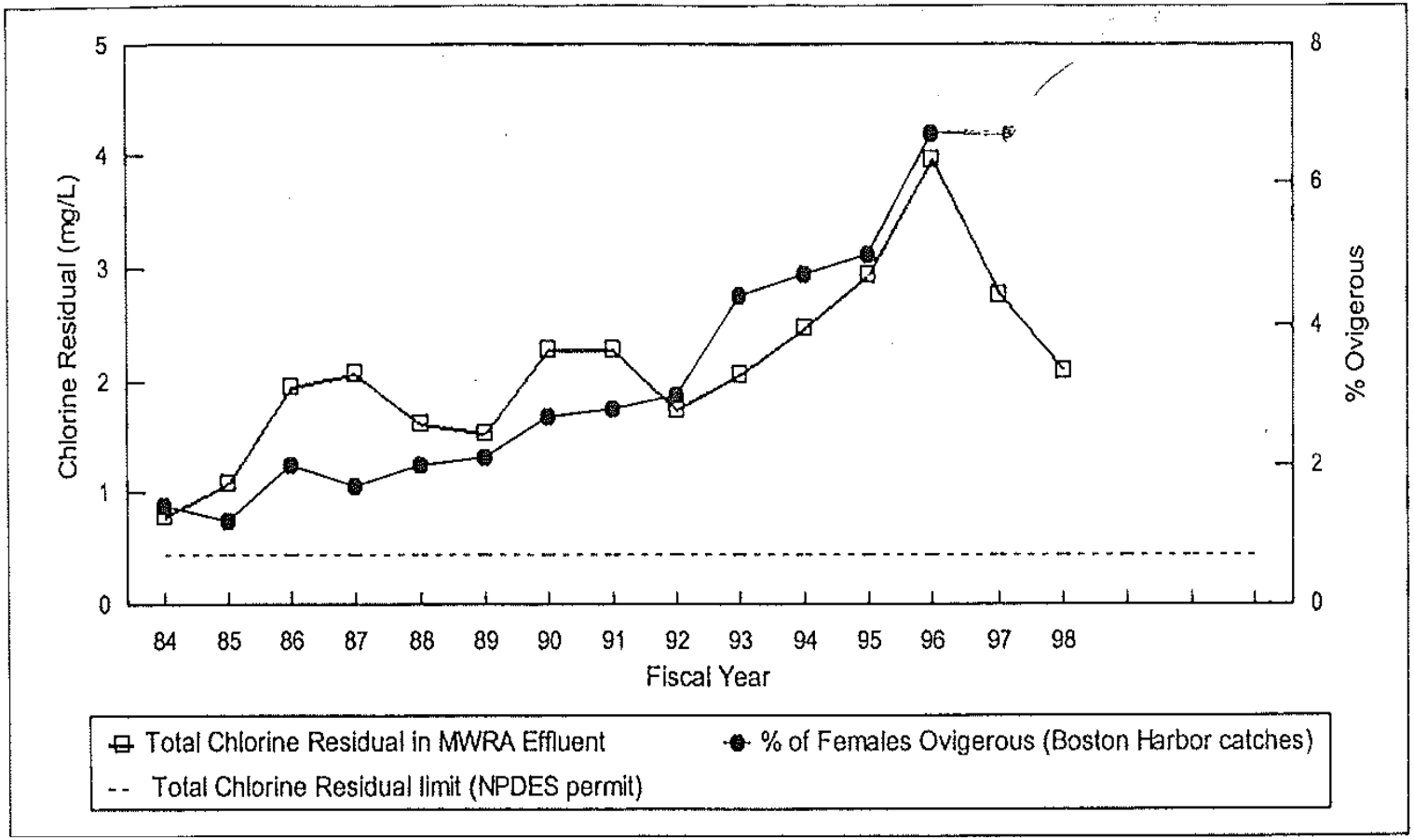


Figure 2: Comparison of annual chlorine residual in MWRA effluent discharged at Deer Island (MWRA NPDES reporting) with the percent of egg-bearing females from lobster caught in Boston Harbor as part of Massachusetts Division of Marine Fisheries lobster population monitoring (figure copied from Mitchell et al 1998).

Boston Harbor

- Greatly improved water quality
- More oxygen
- Better sediment quality

Are lobsters outcompeted and have moved somewhere else to feed?

Is something else eating larval/young lobsters that couldn't live in the Harbor before?

Impact of chlorine on lobsters has been very well studied for a very long time

- Major reports
  - Biology of the lobster in Massachusetts Bay (Mitchell et al 1998)
  - Abundance of juvenile lobsters at the new outfall site: comparison with inshore abundances and discussion of potential impacts on lobster populations (Lavalli and Kropp 1998)
  - Comparison of two analytical methods for measurement of chlorinated pesticides and PCB congeners in biological tissue – Trends in Boston Harbor lobster tissue. (Lefkovitz et al 2001)
  - Changes in contaminants in winter flounder, lobster, and caged mussels in Massachusetts and Cape Cod Bays and Boston Harbor: 1995-2006. (Kane-Driscoll et al 2008)
  - 1 modeling study for Salem Sound (Krahforst et al 2001)
- Major workshops
  - New England Aquarium, included toxicity researchers

There is confidence in this assessment

1. Are chlorine levels released in sewage effluent responsible for killing lobsters?

No evidence of this effect

2. Can chlorine concentration levels around sewage outfalls be consistently high enough to be detectable on the surface by lobstermen during fishing ?

- Effluent is diluted >100 times and does not contain Cl_2 (chlorine gas)
- Cl_2 is formed in reaction with acids. The pH of seawater is slightly basic
- No reporting of this phenomenon has been done through the regular channels, so it's unsubstantiated

Very unlikely

Something very wrong is happening if chlorine is being detected in air near the outfalls. It is important to report such events.

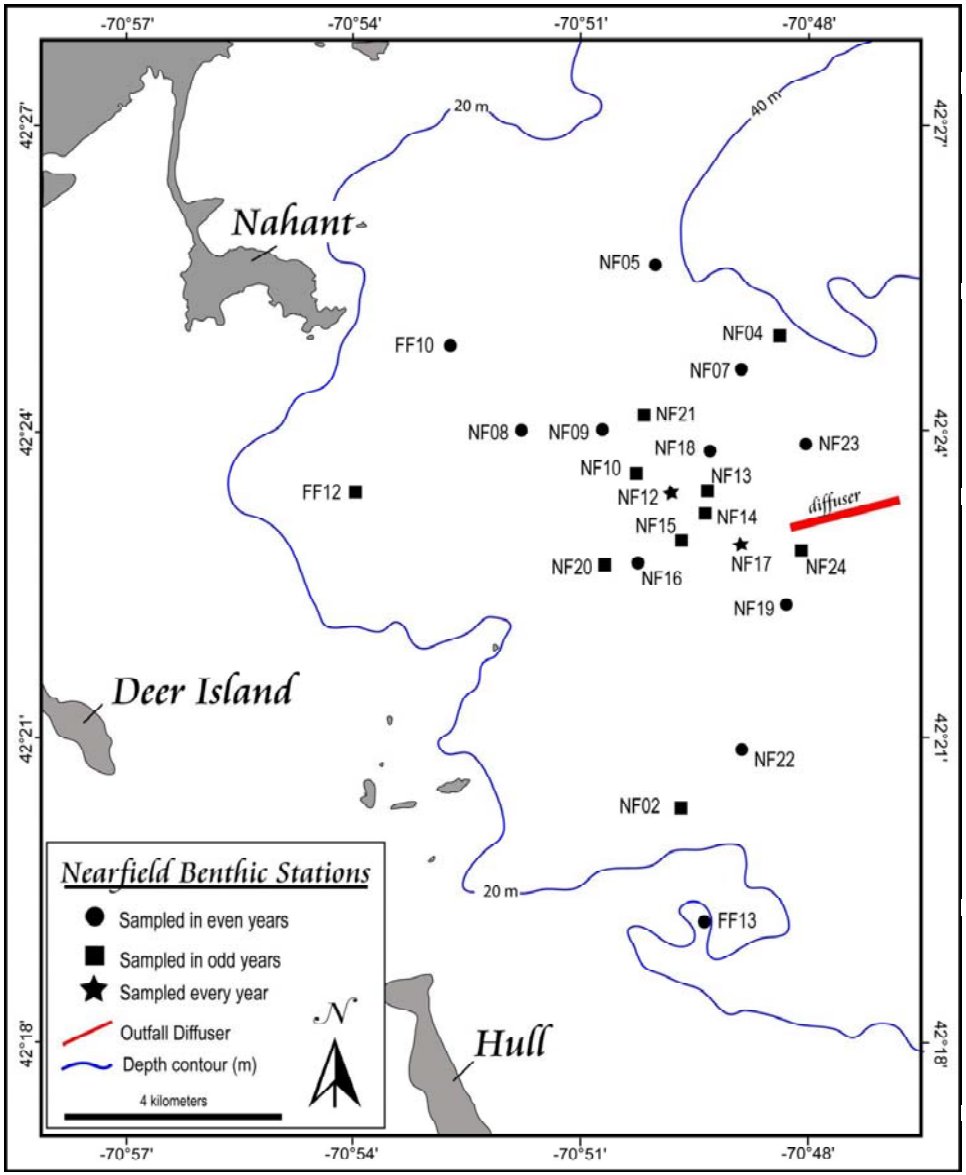
- Channel 16: Coast Guard
- Emergency Response section at MassDEP at the toll-free 24-hour statewide number: **1-888-304-1133**
- MWRA Emergency Contact: **617-305-5940**

3. Are chronic effluent discharges damaging habitats near outfalls (i.e. moonscapes)?

- Moonscape = lifeless seafloor

  "looks like an oil spill, and it has been happening for years" (Rose pers comm 2010)

- Monitoring around MWRA outfall shows increases in crustaceans since the outfall has gone online
- Seafloor images do not show oil-like residue



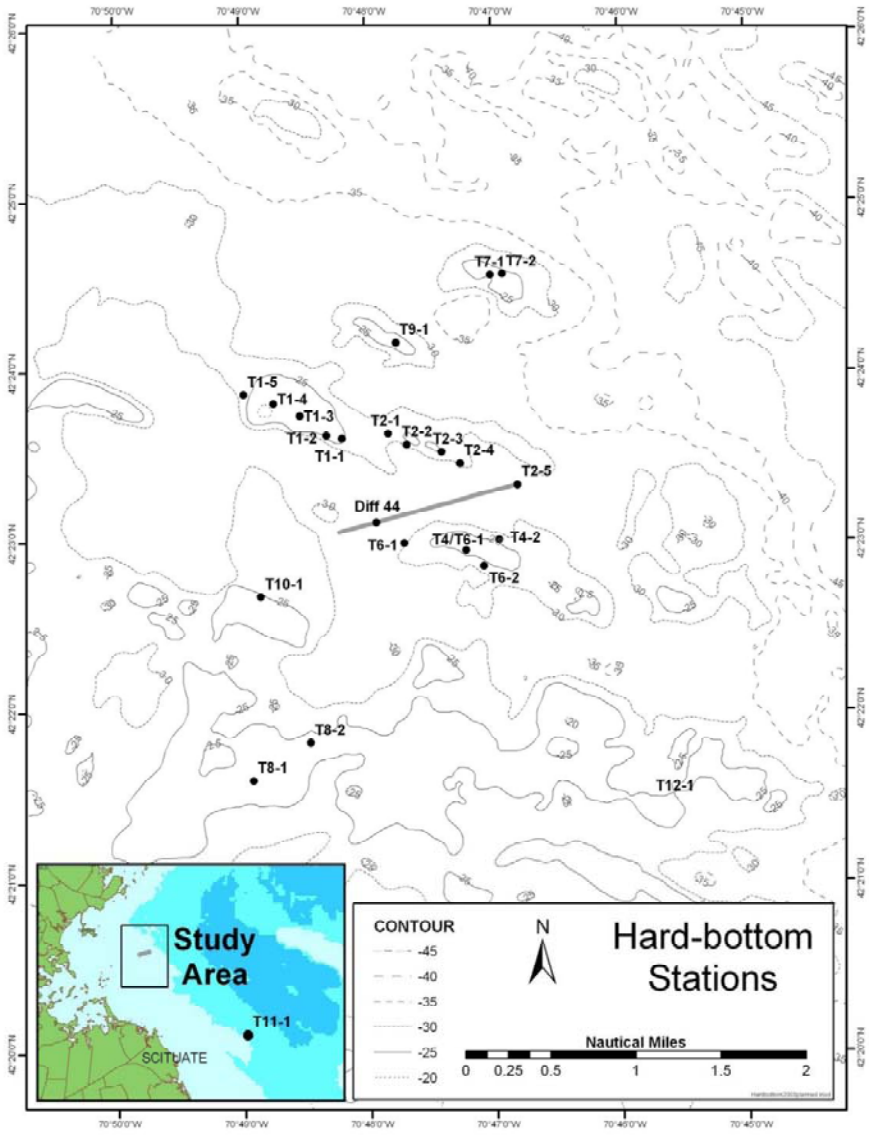


Figure copied from Maciolek 2009

Soft bottom

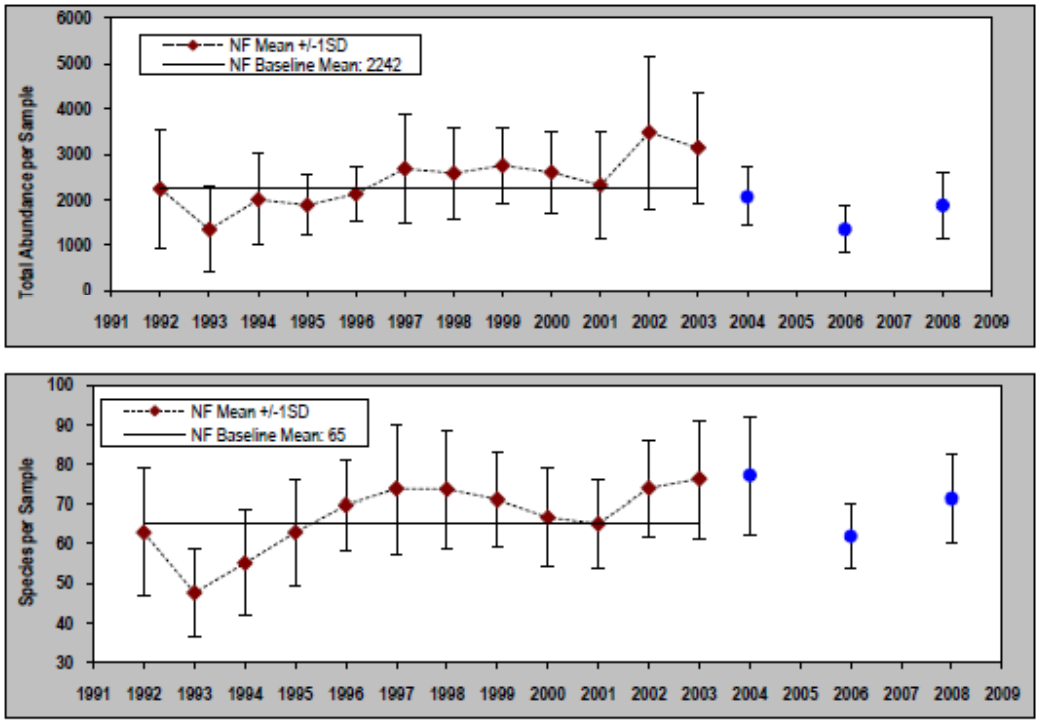


Figure 14. Mean total abundance and species per sample for 21 nearfield samples.

- Samples collected in the post-diversion period (2001–2008) have not indicated any discernable impact of the discharge on the infauna.

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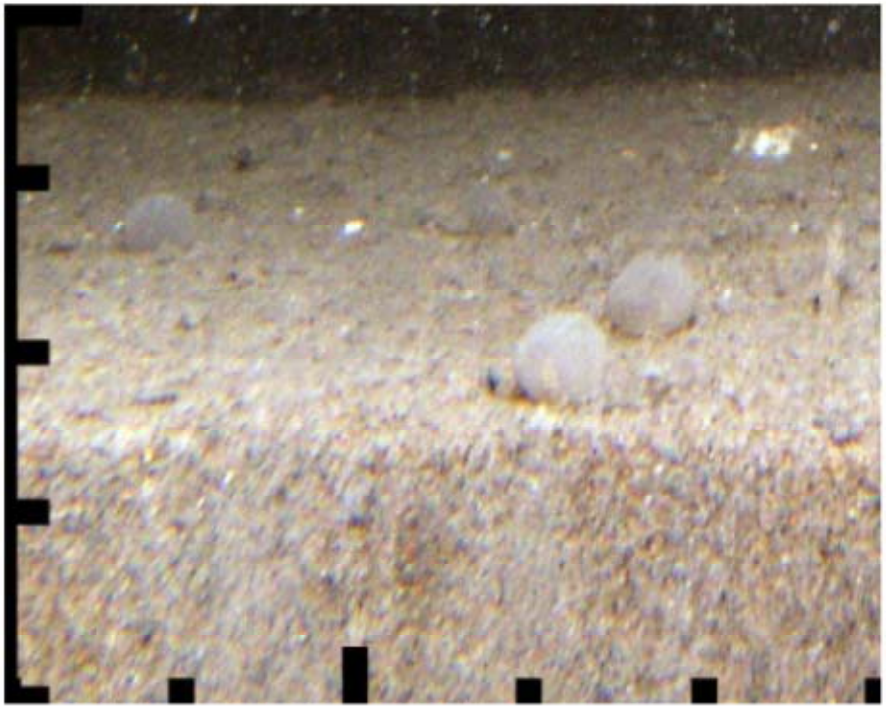

Figure 13. Egg cases of a lumbrinerid polychaete on fine-medium sand at NF13-4. Scale is in cm units.

Photo taken in 2008

Figure copied from Maciolek 2009

Hard bottom

Table 7. Number of individuals of selected species observed during the nearfield hard-bottom surveys, adjusted to include only stations that were surveyed in all 12 years (with the exception of two stations added after 1996).

	Baseline					Post-diversion							
	1996*	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Video													
Minutes of video	438	487	439	422	444	448	495	469	454	466	419	440	443
Cancer spp. (rock crab)	6	3	4	15	92	123	168	144	115	67	81	108	12
Gadus morhua (cod)	-	6	12	22	11	41	53	10	52	64	59	40	64
Homarus americanus (lobster)	6	2	11	4	18	21	31	33	12	10	35	36	28
Still Photographs													
Number of photographs	534	622	635	551	635	583	672	661	675	664	666	661	661
Strongylocentrotus droebachiensis	444	339	282	299	157	180	249	90	113	82	145	116	55
Cancer spp. (rock crab)	4	1	4	6	14	44	63	47	16	22	56	49	12
Gadus morhua (cod)	-	-	2	3	-	9	12	-	3	17	5	19	16
Homarus americanus (lobster)	1	-	3	3	5	4	13	6	5	9	19	15	2

* did not include T9-1 and T10-1

- *Cancer* crabs, cod (*Gadus morhua*), and lobster (*Homarus americanus*) all appear to be more abundant during the post-diversion period than during the pre-diversion period.

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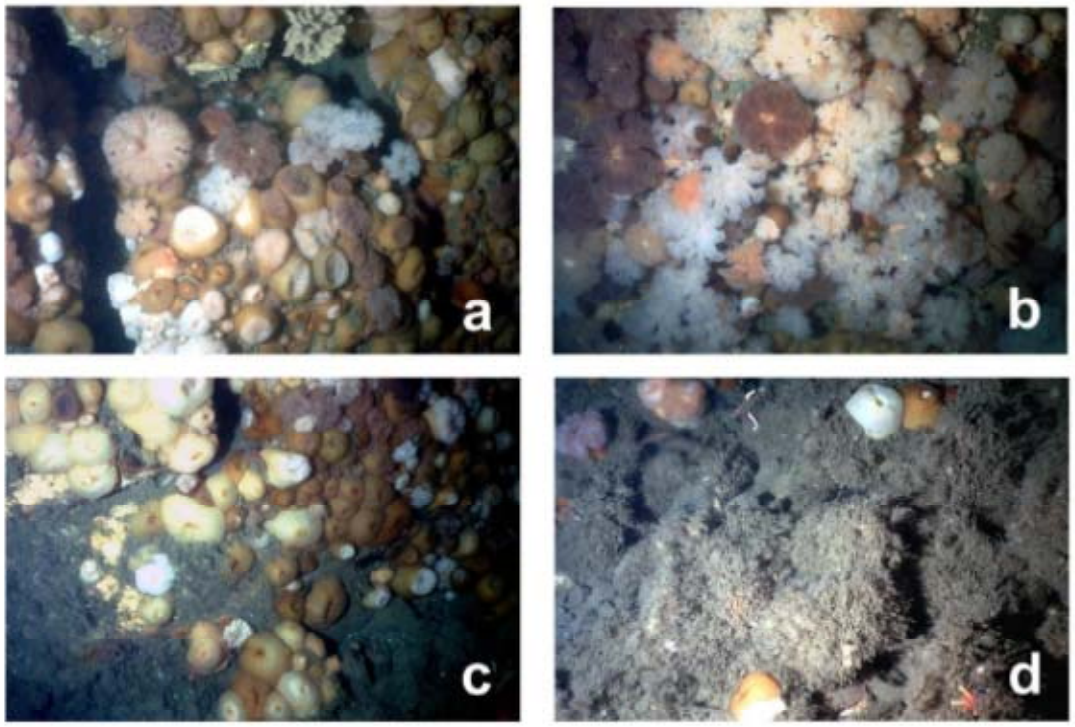

Figure 20. Photographs taken in 2008 showing colonization of the head of active Diffuser #2 at site T2-5. The top and sides (a, b, and c) of the diffuser are colonized by a dense population of *Metridium senile*. The riprap near the base of the diffuser (d) is also being colonized by *M. senile* and some encrusting taxa.

Photos taken in 2008

Figure copied from Maciolek 2009

3. Are chronic effluent discharges damaging habitats near outfalls (i.e. moonscapes)?

No evidence of this effect

4. Can the outfalls clean lobster pots?

- 1 lobsterman told us he used to clean his traps at the Buzzards Bay outfall, but stopped out of fear of being caught
- Because effluent is mostly freshwater, it is possible that the material on the traps died and was washed off (but there is a lot of dilution)
- This is not caused by chlorine
- More investigation needed

Unlikely

Summary

1. Is chlorine at outfalls killing lobsters? *No evidence. This specific question has been studied with multiple studies and workshops. Also, the indicator organism used is more sensitive than lobsters to chlorine. Lastly, the permit limits are very conservative for lobsters.*
2. Is chlorine gas being released from the water near outfalls? *Very unlikely.*

   Permit requirements are conservative, chemical reactions to cause the effect are unlikely.
3. Are outfalls causing moonscapes? *No evidence.*

   No evidence of this effect.
4. Do outfalls clean traps? *Possible.*

   Due to freshwater flow, traps may be cleaned by the effluent. There is little evidence of this effect, however.