Water Suitability in Shellfish Hatcheries and Nurseries:

Results, Problems, and Potential Solutions

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Sea Grant

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Parameters Examined
FL Clam Seed Production Facilities

- Hatchery and/or Nursery source water sampled once per year
- Timed with production schedules, periods of high rainfall, runoff, and aerial pest control spraying
- Parameters examined:
  - Full suite of ions
  - Harmful metals
  - Regulated inorganic chemicals (IOC),
  - Volatile organic chemicals (VOC),
  - Herbicides - Glyphosate
  - Pesticides

What do my report values mean?

- Acceptable values or recommended ranges have not been established
- Project resource guides provide:
  - Comparison of observed values to your water supply source or incoming tank water values
  - Troubleshooting procedures and comments
  - Additional references
- Year 1 and 2 Reports available on website
  - Facilities are identified by codes for anonymity

Scan to view project reports

Chemical Composition

- Ions
- Harmful metals
- Regulated inorganic chemicals (IOC)

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CHEMICAL COMPOSITION OF CULTURE WATER AT FLORIDA CLAM SEED PRODUCTION FACILITIES (n=12) DURING 2020-2022[1] IN COMPARISON WITH SALTWATER COMPOSITION[3]

Parameter Measured (Symbol)	Definition	Unit	Midwest Lab Report Limit [1,2]	Saltwater (35 ppt) Composition[3]	Year 1 (2020-21)			Year 2 (2021-22)		
					Average	Min	Max	Average	Min	Max
Antimony (Sb)	Metalloids	mg/L	0.0005	0.00033	0.0009	< 0.0005	0.0019	<0.0005	<0.0005	<0.01
Arsenic (As)	Heavy Metal	mg/L	0.0005	0.0026	0.0381	0.0231	0.0486	0.0302	0.0173	0.061
Barium (Ba)	Heavy Metal	mg/L	0.005	0.021	0.014	0.006	0.039	0.018	0.009	0.044
Beryllium (Be)	Alkaline earth metals	mg/L	0.0005	6E-07	0.0067	0.0025	0.0109	0.0038	0.0007	0.009
Bicarbonate (CaCO3)	Non-metal	ppm	10	145	137	117	200	147	114	248
Boron (B)	Metalloids	ppm	0.05	4.45	3.25	2.81	3.87	3.42	2.82	4.36
Cadmium (Cd)	Heavy Metal	mg/L	0.002	0.00011	0.007	0.003	0.011	0.003	0.002	0.003
Calcium (Ca)	Alkaline earth metals	ppm	0.10	411	316	269	410	285	250	326
Carbonate ($CaCO_3$)	Non-metal	ppm	0.5	-	1.1	0.5	1.8	1.5	0.6	3.1
Chloride (Cl)	Minerals, salts, mineral salts	ppm	500	19,400	16255	12400	19300	16600	14500	18400
Chromium (Cr)	Heavy Metal	mg/L	0.01	0.0002	< 0.01	< 0.01	< 0.01	<0.01	<0.01	0.01
Copper (Cu)	Heavy Metal	mg/L	0.01	0.0009	0.01	< 0.01	0.01	0.02	0.01	0.02
Fluoride (F)	Minerals, salts, mineral salts	mg/L	0.10	1	3	< 0.1	<5	<10	< 0.1	<10
Iron (Fe)	Heavy Metal	ppm	0.05	0.0034	1.08	< 0.05	2.14	0.65	<0.05	1.37
Lead (Pb)	Heavy Metal	mg/L	0.0005	0.00003	0.001	< 0.0005	0.0011	0.0009	<0.0005	9E-04
Magnesium (Mg)	Alkaline earth metals	ppm	0.10	1290	925	734	1120	869	790	967
Manganese (Mn)	Heavy Metal	ppm	0.005	0.0004	0.04	< 0.005	0.08	0.03	<0.005	0.048
Mercury (Hg)	Heavy Metal	mg/L	0.0004	0.00015	0.0004	< 0.0004	0.0004	<0.0004	<0.0004	<0.0004
Nickel (Ni)	Heavy Metal	mg/L	0.01	0.0066	0.03	< 0.01	0.03	0.01	< 0.01	0.01
Phosphorus (P)	Non-metal	ppm	0.05	0.088	0.28	< 0.05	0.64	0.24	0.09	0.68
Potassium (K)	Alkali metals	ppm	0.50	392	278	230	324	298	266	343
Selenium (Se)	Non-metal	mg/L	0.001	0.0009	0.040	0.009	0.098	0.029	0.018	0.048
Sodium (Na)	Alkali metals	mg/L	0.10	10,800	8145	6430	9760	8730	7520	9860
Sodium absorption ratio (SAR)	Alkali metals	None	0.1	-	51.8	45.5	59.4	57.6	52.2	62.4
Sulfate (SO_4^{2-})	Minerals, salts, mineral salts	mg/L	100	2701	2241	1740	2630	2347	2030	2620
Thallium (Tl)	Heavy Metal	mg/L	0.0005	-	< 0.0005	< 0.0005	< 0.0005	<0.0005	<0.0005	<0.01
Total dissolved solids (TDS)	Water Chemistry	mg/L	10	-	28418	21500	33300	29820	25500	33500
Zinc (Zn)	Heavy Metal	ppm	0.01	0.005	0.02	0.01	0.04	0.02	0.01	0.02

[1] Culture waters were analyzed by Midwest Laboratories, Omaha, Nebraska, https://midwestlabs.com/.
[2] The smallest amount or lowest concentration of a parameter that Midwest Laboratories can determine following established EPA analytical procedures. Note mg/L=ppm.
[3] Source: Turekian, K.K. (1968). Oceans (Foundations of Earth Science Series). Prentice-Hall, New York. http://www.seafriends.org.nz/oceano/seawater.htm#composition

Heavy Metals

HEAVY METAL PARAMETERS FOR SHELLFISH

Measured Parameter (Symbol) Unit	Midwest Lab Report Limit†, 12	Saltwater (35 ppt) Composition[8]	FDA Action Level*, 5	Removal	Comments
Arsenic (As) mg/L	0.0005	0.0026	86.0	• Biological filtration • Biosorption removal (94%) with powdered raw avocado seed [4]	• High accumulation by phenomenon [9] • EDTA may increase b yields [10]
Barium (Ba) mg/L	0.005	0.021		• Precipitation, metal chelators, ion exchange, coagulation, flocculation, and biological processes such as microbial metal uptake [16]	• Normal embryoni and sea urchins a
Cadmium (Cd) mg/L	0.002	0.00011	4.0	• Addition of 1 mg/mL EDTA (metal chelator) improved survival of D-larvae blue mussels [10]	• Retail manila cl international s • Levels of cadr Atlantic due • Levels relati in scallops
Chromium (Cr) mg/L	0.01	0.0002	13.0	• Addition of 1 mg/mL EDTA improved survival of D-larvae blue mussels [10]	• Pearlshell tested in • Elevated
Copper (Cu) mg/L	0.01	0.0009		• Using L-threonine-modified palygorskite [4] • Addition of 1 mg/mL EDTA improved survival of D-larvae blue mussels [10]	• Veneru mortal • Cupric 56 pp mor • Cop pa • Al Is •
Iron (Fe) ppm	0.05	0.0034		• Filtration after oxidation with air, potassium permanganate, or chlorine [17] • Adsorption: *Eucalyptus globulus* leaf powder • Addition of 1 mg/mL EDTA improved survival of D-larvae blue mussels [10]	• Shrimp: >20 mg/L can lead to iron hydroxide formation. Precipitate can settle on eggs and damage or kill them [1] • Blue mussel: Toxic shellfish levels are not known. Oxidative stress caused by iron could contribute to reduced embryo survival rates [11]
Lead (Pb) mg/L	0.0005	0.00003	1.7	• EDDS (biodegradable metal chelator) at concentrations of 3 and 12 µM works as effectively as EDTA [11] • Coagulation/filtration, granulated activated carbon, lime softening [15]	• Black clams: chronic toxicity value of 0.64 mg/L. Concentrations of 10 and 100 µg/L induced cellular damage. Pb content decreased at the end of the depuration period (14 days) by 1.7% and 41% in the gills and 59% and 39% in the digestive gland [14]
Mercury (Hg) mg/L	0.0004	0.00015	1.0		• *Mercuric chloride*: Oyster larvae - 12.0 ppb for 50% and 20.7 ppb for 95% mortalities; Clam larvae - 14.7 ppb for 50% and 25.4 ppb for 95% mortalities [2] • EDTA may increase bioavailability, lowering healthy D-larvae yields [10]
Nickel (Ni) mg/L	0.01	0.0066	80.0	• Precipitation, metal chelators, ion exchange, coagulation, flocculation; and biological processes such as microbial metal uptake [16]	• *Nickle chloride*: Oyster larvae - 1,200 ppb for 50% and 2,500 ppb for 95% mortalities; Clam larvae - 4,700 ppb for 50% and 10,300 ppb for 95% mortalities [2]
Thallium (Tl) mg/L	0.0005		80.0	• Precipitation, metal chelators, ion exchange, coagulation, flocculation; and biological processes such as microbial metal uptake [16]	• No data available on the accumulation in shellfish [18]
Zinc (Zn) ppm	0.01	0.005		• Addition of 1 mg mL/ EDTA improved survival of D-larvae blue mussels [10] works as effectively as non-degradable EDTA [11]	• *Zinc chloride*: Clam larvae - 195 ppb for 50% and 341 ppb for 95% mortalities [2] • Zinc is a vital metal for several biological processes including shell formation, but can be toxic for mussels in high concentration [13]

† The smallest amount or lowest concentration of a substance that Midwest Laboratories can determine following established EPA analytical procedures.
* Action levels represent limits at or above which the US Food & Drug Administration (FDA) will take legal action to remove adulterated products, including shellfish, from the market. Established based on the unavoidability of the poisonous or deleterious substance and do not represent permissible levels of contamination where it is avoidable.

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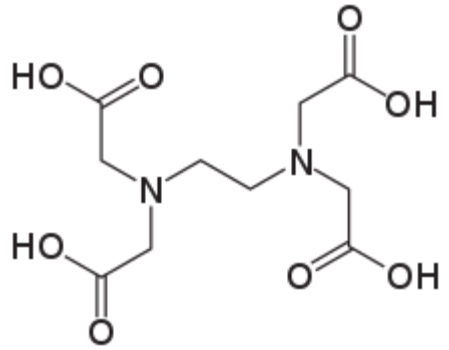
EDTA
Ethylenediaminetetraacetic acid

- **Metal chelator** - binds with divalent cations that are in solution, making them less toxic to the sensitive stages (eggs and larval) of aquatic animals
  - Examples: cadmium, chromium, copper, lead, zinc
- Routinely used in penaeid shrimp hatcheries
  - 3 to 10 mg/l (ppm)
- Sometimes used in bivalve hatcheries.
  - Auburn University: 1 ppm of culture volume (1 grams per 1,000-liter culture tank)
- Could EDTA benefit your clam hatchery?
  - Reagent grade and Commercial Grade “Versine” available
  - Experiment with application rate in a smaller culture tank using a similar tank as a control without the chelator



Volatile Organics (VOC)

- High vapor pressure
- Low water solubility
- Man-made chemicals
  - Paints
  - Pharmaceutical
  - Refrigerants

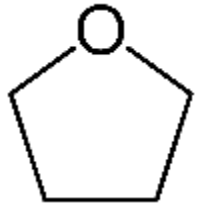
EPA 8260 WATER

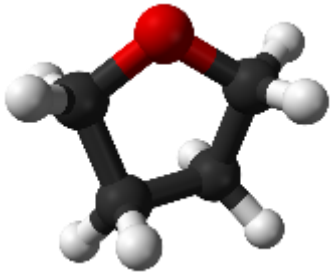
Midwest Laboratories analyzed 80 VOCs

1,1,1,2-Tetrachloroethane	1,2-Dichloropropane	Bromochloromethane	Dichlorodifluoromethane	p-Isopropyltoluene
1,1,1-Trichloroethane	1,3,5-Trimethylbenzene	Bromodichloromethane	Ethyl Ether	sec-Butylbenzene
1,1,2,2-Tetrachloroethane	1,3-Dichlorobenzene	Bromoform	Ethyl Methacrylate	Styrene
1,1,2-Trichloro-1,1,2-trifluoroethane	1,3-Dichloropropane	Bromomethane	Ethylbenzene	tert-Butylbenzene
1,1,2-Trichloroethane	1,4-Dichlorobenzene	Carbon disulfide	Hexachlorobutadiene	Tetrachloroethene
1,1-Dichloroethane	2,2-Dichloropropane	Carbon Tetrachloride	Iodomethane	Tetrahydrofuran
1,1-Dichloroethene	2-Butanone	Chlorobenzene	Isopropylbenzene	Toluene
1,1-Dichloropropene	2-Chlorotoluene	Chloroethane	m,p-Xylenes	Total Trihalomethanes
1,2,3-Trichlorobenzene	2-Hexanone	Chloroform	Methyl Acrylate	Total Xylenes
1,2,3-Trichloropropane	4-Chlorotoluene	Chloromethane	Methyl Methacrylate	trans-1,2-Dichloroethene
1,2,4-Trichlorobenzene	4-Methyl-2-pentanone	Chloroprene	Methyl tert-Butyl Ether	trans-1,3-Dichloropropene
1,2,4-Trimethylbenzene	Acetone	cis-1,2-Dichloroethene	Methylene Chloride	trans-1,4-Dichloro-2-butene
1,2-Dibromo-3-Chloropropane	Acrylonitrile	cis-1,3-Dichloropropene	Naphthalene	Trichloroethene
1,2-Dibromoethane	Allyl Chloride	cis-1,4-Dichloro-2-butene	n-Butyl Benzene	Trichlorofluoromethane
1,2-Dichlorobenzene	Benzene	Dibromochloromethane	n-Propyl Benzene	Vinyl acetate
1,2-Dichloroethane	Bromobenzene	Dibromomethane	o-Xylene	Vinyl chloride

Volatile Organics (VOC) - Tetrahydrofuran

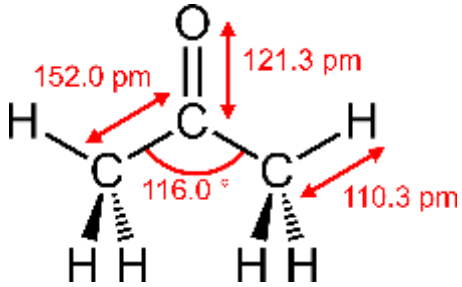
- Year 1 (2020-21)
- 9 of 10 facilities had values less than the reporting limits (RL)
- **Tetrahydrofuran**
  - 1 facility recorded value of 25 ug/L (RL: 20.0 ug/L)
  - Used to make a plastics, rubbers, adhesives, and PVC pipes
  - Not expected to build up in tissues of fish or other wildlife

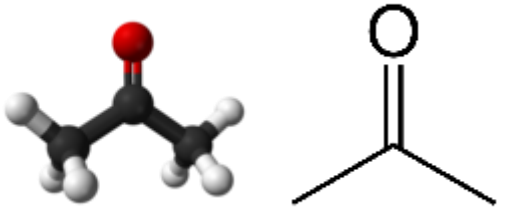




Volatile Organics (VOC) - Acetone

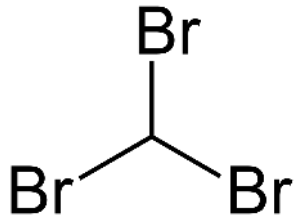
- Year 2 (2021-22)
- 9 of 10 facilities had values less than the reporting limits (RL)
- **Acetone**
  - 1 facility recorded value of 51.4 ug/L (RL: 30.0 ug/L)
  - Common industrial solvent
  - Used to clean surfaces, remove dirt, grease, stains, waxes, resins, and paint from metals, PVC and other surfaces

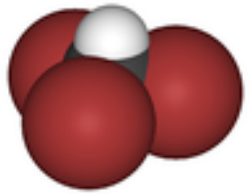




Volatile Organics (VOC) - Bromoform

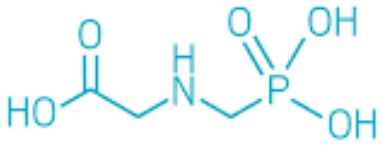
- Year 2 (2021-22)
- 9 of 10 facilities had values less than the reporting limits (RL)
- **Bromoform**
  - 1 facility recorded value of 8.4 ug/L (RL: 1.0 ug/L)
  - Colorless liquid with a chloroform-like odor
  - Used as a disinfectant and solvent for waxes, greases, and oils





Herbicides

- Georgia Waters Agricultural Lab
- **Glyphosate**
  - Kills certain weeds and grasses.
  - Blocks enzyme essential for plant growth
  - Agriculture, forestry, lawn and garden care
- All facilities values less than reporting limit of 10 ppb in both years



Glyphosate

Pesticides

- Year 2 (2021-22)
- Contact local mosquito control departments
- **Naled -** active ingredient sprayed near 2 nursery facilities
  - Both facilities had reported values less than the reporting limit of 1.0 ug/L for pesticides
- **Permethrin -** active ingredient sprayed near other nursery facilities
  - Analytical labs contacted could not test water samples for this pesticide

EPA 8141 (ORGANOPHOSPHOROUS PESTICIDES)

Midwest Laboratories analyzed 20 Pesticides

Azinphos Methyl	Demeton-S	Ethoprop	Methyl Parathion	Ronnel
Bolstar	Diazinon	EPN	Mevinphos	Sulfotep
Chlorpyrifos	Dichlorvos	Fenthion	Naled	Tetrachlorovinphos
Coumaphos	Dimethoate	Malathion	Parathion	Tokuthion
Demeton-O	Disulfoton	Merphos	Phorate	Trichloronate

Laboratories

Midwest Laboratories

- **W2-irrigation suitability**: Sodium, Chloride, Phosphorus, Calcium, Conductivity, Potassium, Magnesium, Sulfate, Boron, Iron, Nitrate Nitrogen, SAR, Copper, pH, Total Dissolved Solids (by calculation), Manganese, Carbonate, Zinc, Bicarbonate
- **Regulated Inorganic Chemicals (IOC):** Antimony, Copper, Nitrate Nitrogen, Arsenic, Fluoride, Selenium, Barium, Lead, Sodium, Beryllium, Mercury, Sulfate, Cadmium, Nickel, Thallium, Chromium, Nitrite Nitrogen
- **EPA 8260-Water Volatile Organics (VOC):** 80 VOCs
- **EPA 8141-Organophosphorus Pesticides:** 20 pesticides

Website: https://midwestlabs.com/contact-us

Waters Agricultural Lab

- **Glyphosate**: Herbicide analysis

Website: https://watersag.com/

Additional Information

- Project Reports - Year 1 and 2 Results
- Resources - Project Guides
- Problem Solving Tree - Troubleshooting Procedures

Scan to visit website
https://shellfish.ifas.ufl.edu/clam-seed-project-2020-22/