Emerging Contaminant Surveillance: PFAS in Surface Water and Fish

Results from Cape Cod Pilot Study
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Recreational Waterbody Focus

- Recreational waterbodies that are used for swimming as public and semi-public beaches are regulated by MDPH.

- Two types of "beaches" included in MDPH regulations:
  1. Public — open to general public (e.g., town and state beaches)
  2. Semi-public — open to individuals through a common access (e.g., hotels, condo associations, camps)




40 PFAS Analytes Included in this Assessment

Perfluorobutanoate (PFBA)
Perfluoropentanoate (PFPeA)
Perfluorohexanoate (PFHxA)
Perfluoroheptanoic acid (PFHpA)
Perfluorooctanoate (PFOA)
Perfluorononanoate (PFNA)
Perfluorodecanoate (PFDA)
Perfluoroundecanoate (PFUnA)
Perfluorododecanoate (PFDoA)
Perfluorotridecanoate (PFTrDA)
Perfluorotetradecanoate (PFTeDA)
Perfluorobutanesulfonate (PFBS)
Perfluoropentanesulfonate (PFPeS)
Perfluorohexanesulfonate (PFHxS)
Perfluoroheptanesulfonate (PFHpS)
Perfluorooctanesulfonate (PFOS)
Perfluorononanesulfonate (PFNS)
Perfluorodecanesulfonate (PFDS)
Perfluorododecanesulfonate (PFDoS)
4:2 fluorotelomersulfonate (4:2 FTS)

6:2 fluorotelomersulfonate (6:2 FTS)
8:2 fluorotelomersulfonate (8:2 FTS)
N-Methylperfluorooctanesulfonamidoacetic acid (N-MeFOSAA)
N-Ethylperfluorooctanesulfonamidoacetic acid (N-EtFOSAA)
Perfluorooctanesulfonamide (PFOSA)
N-Methylperfluorooctanesulfonamide (N-MeFOSA)
N-Ethylperfluorooctanesulfonamide (N-EtFOSA)
N-Methylperfluorooctanesulfonamidoethanol (N-MeFOSE)
N-Ethylperfluorooctanesulfonamidoethanol (N-EtFOSE)
Perfluoro-2-propoxypropanoate (HFPO-DA)
4-dioxa-3H-perfluorononanoate (ADONA)
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate (9Cl-PF3ONS)
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate (11Cl-PF3OUdS)
3:3 perfluorohexanoic acid (3:3 FTCA)
5:3 perfluorooctanoic acid (5:3 FTCA)
7:3 perfluorodecanoic acid (7:3 FTCA)
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)
Perfluoro-4-methoxybutanoate (PFMBA)
Perfluoro-3-methoxypropanoate (PFMPA)
Perfluoro-3,6-dioxaheptanoate (NFDHA)

PFAS concentrations evaluated in surface water

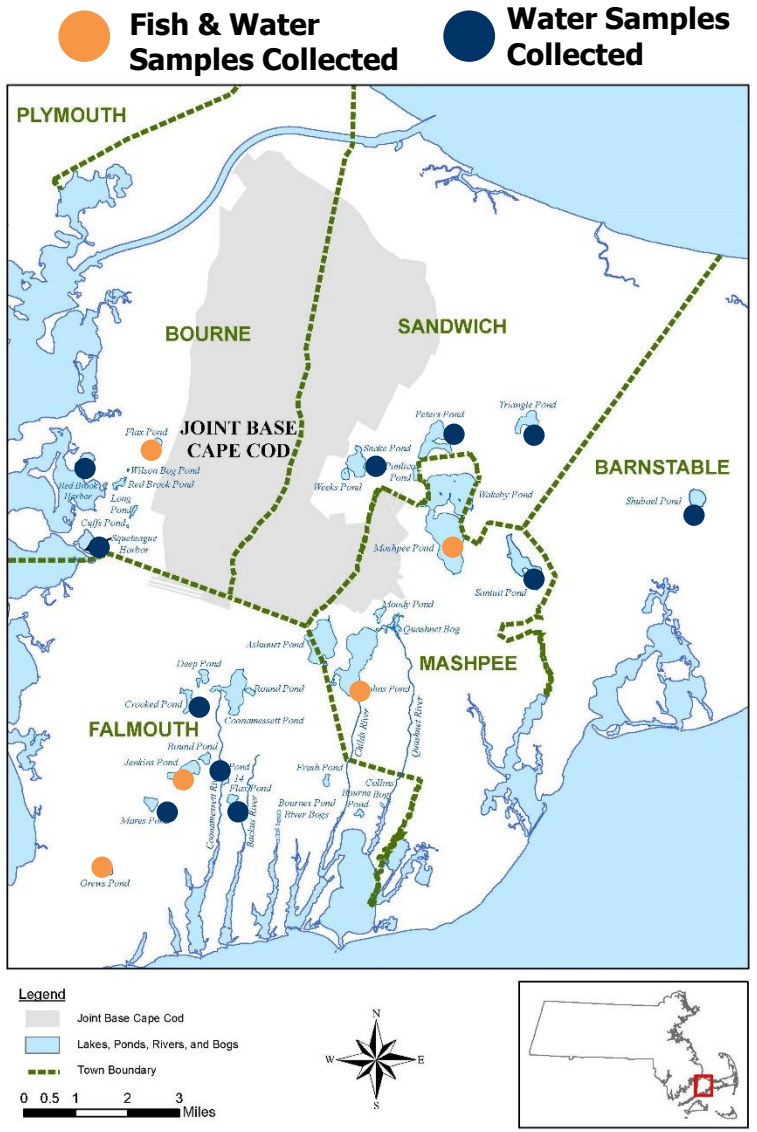
PFAS concentrations evaluated in fish

Collection of Surface Water and Fish Samples on Cape Cod

- Permitted public or semi-public bathing beaches (n = 16)

Sampling Locations

Location	Waterbody	# of Water Samples	# Fish Samples
Barnstable	Shubael Pond	1	-
Bourne	Squeteague Harbor	1	-
	Hen Cove	1	-
	Flax Pond (Picture Lake)	1	9
Sandwich	Snake Pond	1	-
	Peter's Pond	2	-
	Triangle Pond	1	-
Mashpee	Santuit Pond	1	-
	Mashpee-Wakeby Pond	2	16
	Johns Pond	1	17
Falmouth	Crooked Pond	1	-
	Round Pond	1	-
	Flax Pond	1	-
	Jenkins Pond	2	5
	Mares Pond	1	-
	Grews Pond	1	4



Surface Water Collection & Analysis

DPH conducted surface water sampling at 16 waterbodies on Cape Cod (May 2021)

- Waterbodies selected based on having permitted public or semi-public bathing beaches in area where PFAS contamination was previously identified and DPH asked to prepare annual recreational use of waterbody fact sheet
- A total of 20 surface water samples collected (grab method, depth 1 to 1.5 feet) and analyzed for 40 PFAS.

Sampling conducted using PFAS-specific sample collection and handling protocol

- Only PFAS-free materials used at all points of sample collection and decontaminated sampling equipment prior to mobilization and between sampling sites
- Samples collected in HDPE containers
- Collected two field duplicate samples and two field blanks per field day
- Completed and tracked chain-of-custody forms and stored and shipped samples on ice

Samples analyzed by SGS AXYS Analytical Services (British Columbia, Canada)

- SGS AXYS Method MLA-110 Rev. 02 Ver. 08, targets all PFAS from EPA Method 537.1 and Method 533 (Reporting Limit = 0.4-1.6 ng/L water).

Surface Water Results: PFAS Analytes
(ng/L)

Analyte Short Name	Frequency of Detection	Min	Max	Average
PFAS6 Sum*	100%	0.57	168.20	20.27
PFBA	30%	<RL	5.30	0.89
PFPeA	65%	<RL	12.70	2.28
PFHxA	100%	0.46	17.00	2.84
PFHpA	90%	<RL	9.57	1.79
PFOA	90%	<RL	18.40	3.14
PFNA	30%	<RL	24.90	2.58
PFDA	10%	<RL	0.46	<RL
PFUnA	0%	<RL	<RL	<RL
PFDoA	0%	<RL	<RL	<RL
PFTrDA	0%	<RL	<RL	<RL
PFTeDA	0%	<RL	<RL	<RL
PFBS	85%	<RL	5.48	1.30
PFPeS	10%	<RL	6.06	0.59
PFHxS	80%	<RL	55.30	5.93
PFHpS	10%	<RL	1.02	<RL
PFOS	75%	<RL	64.30	6.79
PFNS	0%	<RL	<RL	<RL
PFDS	0%	<RL	<RL	<RL
PFDoS	0%	<RL	<RL	<RL

Analyte Short Name	Frequency of Detection	Min	Max	Average
4:2 FTS	0%	<RL	<RL	<RL
6:2 FTS	5%	<RL	3.14	<RL
8:2 FTS	0%	<RL	<RL	<RL
PFOSA	5%	<RL	0.45	<RL
N-MeFOSA	0%	<RL	<RL	<RL
N-EtFOSA	0%	<RL	<RL	<RL
MeFOSAA	0%	<RL	<RL	<RL
EtFOSAA	0%	<RL	<RL	<RL
N-MeFOSE	0%	<RL	<RL	<RL
N-EtFOSE	0%	<RL	<RL	<RL
HFPO-DA	0%	<RL	<RL	<RL
ADONA	0%	<RL	<RL	<RL
9Cl-PF3ONS	0%	<RL	<RL	<RL
11Cl-PF3OUdS	0%	<RL	<RL	<RL
3:3 FTCA	0%	<RL	<RL	<RL
5:3 FTCA	0%	<RL	<RL	<RL
7:3 FTCA	0%	<RL	<RL	<RL
PFEESA	0%	<RL	<RL	<RL
PFMPA	0%	<RL	<RL	<RL
PFMBA	0%	<RL	<RL	<RL
NFDHA	0%	<RL	<RL	<RL

Analysis used accredited SGS AXYS Method MLA-110 Rev. 02 Ver. 08, which targets all PFAS from EPA Method 537.1 and Method 533; Reporting Limit (RL) = 0.4-1.6 ng/L water

PFAS compared to DPH screening value

Surface Water Results: PFAS Sum6 per Waterbody (ng/L)

Waterbody	PFHpA	PFOA	PFNA	PFDA	PFHxS	PFOS	PFAS6 Sum
Crooked Pond	0.744	1.25	<RL	<RL	0.461	<RL	2.46
Flax Pond	<RL	0.622	<RL	<RL	0.626	<RL	1.25
Grews Pond	1.08	2.12	0.621	<RL	<RL	0.538	4.36
Hen Cove	<RL	<RL	<RL	<RL	1.08	3.48	4.56
Jenkins Pond (N)	0.554	1.45	<RL	<RL	0.497	0.510	3.01
Jenkins Pond (NE)	0.736	1.19	<RL	<RL	0.499	0.624	3.05
	0.742	1.56	<RL	<RL	0.561	0.676	3.54
Johns Pond (NE)	9.57	17.40	24.9	<RL	55.3	51.8	159.0
Johns Pond (SE)	8.90	18.40	24.2	<RL	52.4	64.3	168.2
	8.82	15.50	24.4	<RL	52.9	53.7	155.3
Mares Pond	0.568	<RL	<RL	<RL	<RL	<RL	0.568
Mashpee-Wakeby Pond (S)	0.703	0.757	<RL	<RL	0.711	0.591	2.76
Mashpee-Wakeby Pond (SW)	0.732	0.943	<RL	<RL	0.897	0.537	3.11
Peters Pond (N)	1.54	2.17	<RL	<RL	0.636	0.578	4.92
Peters Pond (S)	1.63	2.13	0.490	0.42	0.795	1.95	7.41
	1.71	2.63	0.468	<RL	0.971	1.80	7.58
Picture Lake (Flax Pond)	1.88	4.29	<RL	<RL	1.64	1.66	9.47
Round Pond	0.725	1.26	<RL	<RL	0.599	0.616	3.20
Santuit Pond	0.562	1.46	<RL	<RL	0.947	0.542	3.51
Shubael Pond	0.916	1.79	<RL	<RL	0.733	0.484	3.92
Snake Pond	0.680	0.720	<RL	<RL	<RL	<RL	1.40
Squeteague Harbor	0.723	2.62	0.959	0.46	0.748	7.67	13.2
	0.568	2.79	1.03	0.41	0.727	8.55	14.1
Triangle Pond	3.46	2.25	0.421	<RL	<RL	<RL	6.13

Analysis used accredited SGS AXYS Method MLA-110 Rev. 02 Ver. 08, which targets all PFAS from EPA Method 537.1 and Method 533; Reporting Limit (RL) = 0.4-1.6 ng/L water

Interpretation of Surface Water Data

PFAS concentrations are evaluated using a two-step process:

1. Surface water levels are compared to **DPH's screening value of 23 ng/L**, which is used to indicate when unlimited swimming by the most sensitive person would be unsafe.
   - Screening value is calculated using reasonable maximum estimates of exposure, and the toxicity criterion for PFOS (i.e., the most potent PFAS). If the surface water concentration of PFOA, PFNA, PFHxS or PFOS exceeds this screening value, then:
2. A **risk assessment** is conducted. The assessment is based on realistic estimates of exposure such as time spent swimming, or amount of water ingested while swimming.
   - The risk assessment is conducted for all PFAS for which toxicity criteria are available.

Surface Water Results

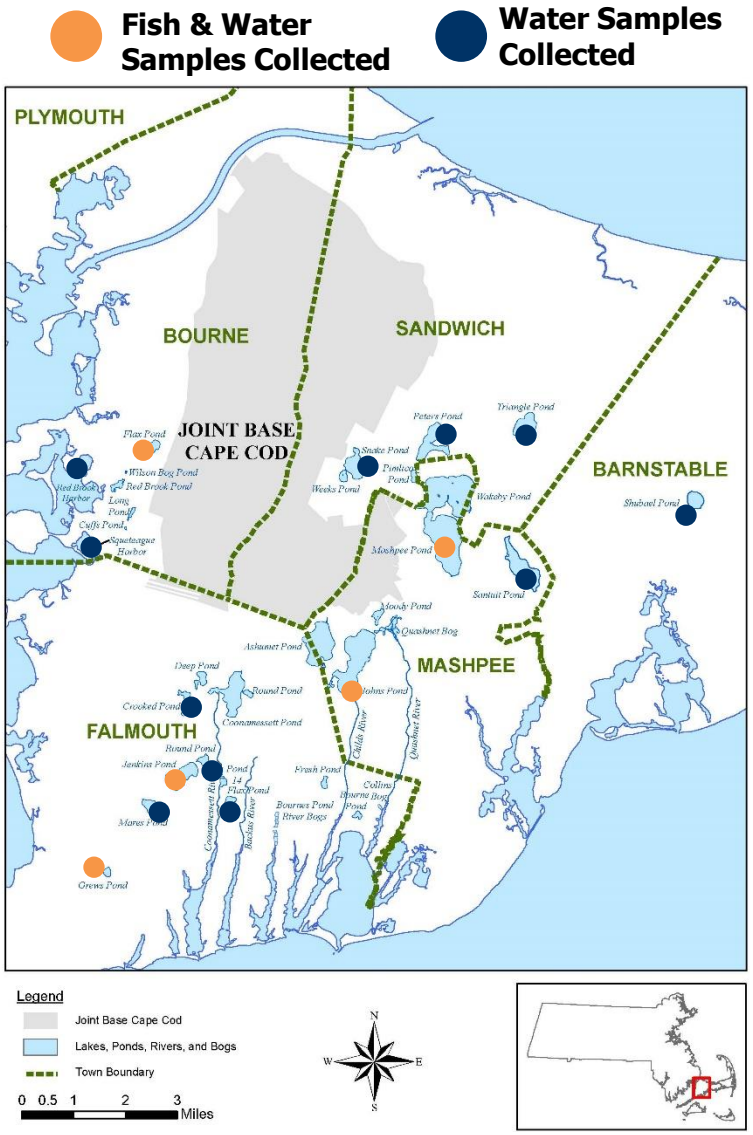
- PFAS were detected in all 16 waterbodies
- Number of PFAS analytes detected at each waterbody:
  - Average: 7 compounds
  - Range: 2 – 11 compounds
  - Max # of detections: John's Pond (11 compounds)
- Only one waterbody, John's Pond, had levels that exceeded screening value of 23 ng/L (159 and 162 ng/L) and required a risk assessment.
- Following risk assessment, all 16 waterbodies found safe for recreational activities such as swimming, wading, and boating.

Collection of Fish Samples on Cape Cod

- 5 of 16 waterbodies were sampled for fish, resulting in collection of 51 fish (total)

Sampling Locations

Location	Waterbody	# of Water Samples	# Fish Samples
Barnstable	Shubael Pond	1	-
Bourne	Squeteague Harbor	1	-
	Hen Cove	1	-
	Flax Pond (Picture Lake)	1	9
Sandwich	Snake Pond	1	-
	Peter's Pond	2	-
	Triangle Pond	1	-
Mashpee	Santuit Pond	1	-
	Mashpee-Wakeby Pond	2	16
	Johns Pond	1	17
Falmouth	Crooked Pond	1	-
	Round Pond	1	-
	Flax Pond	1	-
	Jenkins Pond	2	5
	Mares Pond	1	-
	Grews Pond	1	4



Fish Collection & Analysis

DPH sampled fish from five waterbodies (May 2021)

- Sites selected from among the 16 waterbodies where surface water sampling was conducted
- Secured Scientific Collection Permit (152.21SCF, 5/17/21) and notified waterbody operators, MA Division of Fisheries and Wildlife, local police, and environmental police.

Employed three techniques for fish collections

- Electrofishing from a motorboat (Mashpee-Wakeby Pond and Johns Pond)
- Electrofishing from a modified cartop boat (Jenkins Pond, Grews Pond, and Flax Pond)
- Hook and line angling was used to supplement electrofishing (Jenkins Pond)

Fish were packed and shipped on ice to the contracted analytical laboratory

- Whole fish were wrapped in aluminum foil, placed in a plastic bag, frozen, and shipped on wet ice.
- Field blanks, collected at each site, consisted of aluminum placed in a plastic bag.
- Prior to analysis, SGS AXYS skinned, filleted, and homogenized the fish samples.
- Analysis used SGS AXYS Method MLA-110 Rev. 02 Ver. 08 which targets all PFAS from EPA Method 537.1 and Method 533 (Reporting Limit = 0.1 µg/kg tissue)

Fish Results: PFAS Analytes
(µg/kg)

Analyte short name	Frequency of Detection	Min	Max	Average
PFBA	0%	<RL	<RL	<RL
PFPeA	0%	<RL	<RL	<RL
PFHxA	2%	<RL	0.14	<RL
PFHpA	0%	<RL	<RL	<RL
PFOA	7%	<RL	0.31	<RL
PFNA	39%	<RL	5.69	0.54
PFDA	78%	<RL	0.52	0.20
PFUnA	94%	<RL	1.45	0.39
PFDoA	89%	<RL	1.45	0.33
PFTrDA	100%	0.10	2.45	0.58
PFTeDA	89%	<RL	1.03	0.26
PFBS	0%	<RL	<RL	<RL
PFPeS	0%	<RL	<RL	<RL
PFHxS	30%	<RL	2.14	0.19
PFHpS	24%	<RL	0.42	<RL
PFOS	100%	0.33	170	32.6
PFNS	0%	<RL	<RL	<RL
PFDS	2%	<RL	0.15	<RL
PFDoS	0%	<RL	<RL	<RL

Analyte short name	Frequency of Detection	Min	Max	Average
4:2 FTS	0%	<RL	<RL	<RL
6:2 FTS	7%	<RL	17.1	0.47
8:2 FTS	0%	<RL	<RL	<RL
PFOSA	20%	<RL	0.82	<RL
N-MeFOSA	0%	<RL	<RL	<RL
N-EtFOSA	0%	<RL	<RL	<RL
MeFOSAA	0%	<RL	<RL	<RL
EtFOSAA	0%	<RL	<RL	<RL
N-MeFOSE	0%	<RL	<RL	<RL
N-EtFOSE	7%	<RL	3.30	0.11
HFPO-DA	0%	<RL	<RL	<RL
ADONA	0%	<RL	<RL	<RL
9Cl-PF3ONS	0%	<RL	<RL	<RL
11Cl-PF3OUdS	0%	<RL	<RL	<RL
3:3 FTCA	0%	<RL	<RL	<RL
5:3 FTCA	4%	<RL	7.79	0.23
7:3 FTCA	2%	<RL	9.09	0.17
PFEESA	0%	<RL	<RL	<RL
PFMPA	0%	<RL	<RL	<RL
PFMBA	0%	<RL	<RL	<RL
NFDHA	0%	<RL	<RL	<RL

Analysis used accredited SGS AXYS Method MLA-110 Rev. 02 Ver. 08, which targets all PFAS from EPA Method 537.1 and Method 533; Reporting Limit (RL) = 0.1 µg/kg tissue

PFAS compared to DPH screening value

Fish Results: Average PFAS Concentrations in Fish (µg/kg)

Waterbody	Town(s)	Fish Species (# sampled)	PFOA	PFNA	PFHxS	PFOS
Flax Pond (Picture Lake)	Bourne	Bluegill (n=8)	<RL	<RL	<RL	2.54
		Yellow perch (n=1)	<RL	0.28	<RL	3.44
		All Fish (n = 9)	**<RL**	**<RL**	**<RL**	**2.64**
Grews Pond	Falmouth	Bluegill (n=4)	<RL	<RL	<RL	0.97
		All Fish (n = 4)	**<RL**	**<RL**	**<RL**	**0.97**
Jenkins Pond	Falmouth	Largemouth Bass (n=2)	<RL	<RL	<RL	2.71
		Smallmouth bass (n=2)	<RL	<RL	<RL	4.68
		Yellow Bullhead (n=1)	<RL	<RL	<RL	0.34
		All Fish (n = 5)	**<RL**	**<RL**	**<RL**	**2.80**
Johns Pond	Mashpee	Bluegill (n=3)	<RL	0.93	0.32	144.3
		Chain Pickerel (n=1)	<RL	1.78	0.83	86.10
		Largemouth bass (n=3)	<RL	0.18	0.16	73.37
		Pumpkinseed (n=3)	0.22	2.06	1.38	45.70
		White perch (n=4)	<RL	1.29	0.13	140.3
		Yellow perch (n=3)	<RL	3.89	1.01	74.90
		All Fish (n = 17)	**<RL**	**1.65**	**0.58**	**97.76**
Mashpee-Wakeby Pond	Mashpee/Sandwich	Chain Pickerel (n=3)	<RL	<RL	<RL	0.40
		Largemouth bass (n=1)	<RL	<RL	<RL	0.91
		Pumpkinseed (n=3)	<RL	0.10	<RL	0.62
		Smallmouth bass (n=3)	<RL	<RL	<RL	1.02
		White perch (n=1)	<RL	<RL	<RL	0.87
		White sucker (n=2)	<RL	<RL	0.16	0.69
		Yellow perch (n=3)	<RL	<RL	<RL	0.55
		All Fish (n = 16)	**<RL**	**<RL**	**<RL**	**0.67**

Analysis used accredited SGS AXYS Method MLA-110 Rev. 02 Ver. 08, which targets all PFAS from EPA Method 537.1 and Method 533; Reporting Limit (RL) = 0.1 µg/kg tissue

Analysis of Fish Data

PFAS concentrations in fish tissue are evaluated in a 3-step process:

1. Concentrations in fish tissue are compared to **DPH's screening value of 0.22 µg/kg (ppb)**, designed to be protective of a sensitive individual.
    - The screening value is calculated using reasonable maximum estimates of fish consumption, for sensitive populations, and the toxicity criterion for PFOS (i.e., the most potent PFAS).

2. If the fish tissue level of PFOA, PFNA, PFHxS or PFOS exceed the screening value, then a **waterbody specific analysis** is conducted to evaluate how frequently individuals should consume fish from the waterbody.

3. Waterbody-specific **fish consumption advisories** are issued whenever the screening value is exceeded. This ensures that consumption of PFAS from fish does not exceed an estimated safe daily dose.

Fish Results: Observations

- PFAS were detected in all of the 51 fish sampled
  - Most frequently detected analytes: PFTrDA (100%), PFOS (100%), PFUNA (94%), PFTeDA (88%), PFDoA (88%), and PFDA (76%)

- Number of PFAS analytes detected in each sample:
  - Average: 7 compounds
  - Range: 2 – 11 compounds
  - Max # of detections: 11 compounds

- Highest PFAS levels were found in:
  - John's Pond (Mashpee) – PFOS concentrations as high as 170 µg/kg in Bluegill and White Perch

- PFOS levels were high enough in all fish to trigger a DPH fish consumption advisory for all five waterbodies sampled in 2021

For Additional Information

MDPH JBCC Waterbody Fact Sheet
https://www.mass.gov/doc/recreational-use-of-waterbodies-on-or-near-joint-base-cape-cod-jbcc/download

MDPH Public Health Fish Consumption Advisories
https://www.mass.gov/lists/fish-consumption-advisories

MDPH Advice on Eating fish safely in Massachusetts
https://www.mass.gov/info-details/eating-fish-safely-in-massachusetts

CDC/ATSDR PFAS and Your Health
https://www.atsdr.cdc.gov/pfas/resources/pfas-faqs.html

For additional information, contact the Environmental Toxicology Program at the:

Massachusetts Department of Public Health (MDPH)
Bureau of Environmental Health
617-624-5757 - DPHToxicology@mass.gov
https://www.mass.gov/orgs/bureau-of-environmental-health

Appendix I.
Changes to Fish Consumption Advisories at 5 waterbodies

Waterbody	Population	Current Advisory (basis of advisory)	New Consumption Advice (based on PFAS)	Recommended New Advisory (applies to all fish)	Practical Impact
Flax Pond (Picture Lake)	Sensitive	Do not eat any fish (State Guidance*)	1 meal/month	Do not eat any fish	None
	General	2 meals/week (State Guidance*)	1 meal/week	1 meal/week	Eat slightly less frequently
Grews Pond	Sensitive	Do not eat any fish (State Guidance*)	1 meal/week	Do not eat any fish	None
	General	2 meals/week (State Guidance*)	2 meals/week	2 meals/week	None
Jenkins Pond	Sensitive	Do not eat any fish (State Guidance*)	1 meal/month	None	None
	General	2 meals/week (Mercury*)	1 meal/week	1 meal/week	Eat slightly less frequently
Johns Pond	Sensitive	Do not eat any fish (Mercury)	Do not eat any fish	None	None
	General	Do not eat smallmouth bass (Mercury); Limit other species to 2 meals/month (Mercury)	1 meal/year	1 meal/year	No change for smallmouth bass; Eat other species less frequently
Mashpee-Wakeby Pond	Sensitive	Do not eat smallmouth and largemouth bass (Mercury); No advisory for other species	1 meal/week	Do not eat smallmouth and largemouth bass; Limit other species to 1 meal/week	None for smallmouth and largemouth bass; Eat other species slightly less frequently
	General	Limit of 2 meals/month for smallmouth and largemouth bass (Mercury); No advisory for other species	1 meal/week	Limit of 2 meals/month for smallmouth and largemouth bass; Limit other species 1 meal/week	None for smallmouth and largemouth bass; Consume other species slightly less frequently

*This advisory was assigned per DPH's statewide fish consumption advisory for mercury. Because this waterbody has not yet been evaluated for mercury, sensitive populations should not eat fish from this waterbody and the general population should limit consumption to 2 meals per week until more information on mercury levels is available.

Appendix II.
DPH PFOS Guidelines for Issuing Recreational Fish Consumption Advisories (FCA)

Target Population	Frequency	Meals*/ Year	PFOS Threshold (ppb)
General Population	7 meals/week, or unlimited	365	≤ 0.50
	2 meals/week	104	≤ 1.76
	1 meal/week	52	≤ 3.52
	2 meals/month	24	≤ 7.62
	1 meal/month	12	≤ 15.2
	1 meal/2 months	6	≤ 30.5
	1 meal/6 months	2	≤ 91.4
	1 meal/year	1	≤ 183
	Do Not Consume	0	>183
Sensitive Populations	7 meals/week, or unlimited	365	**≤ 0.22****
	2 meals/week	104	≤ 0.78
	1 meal/week	52	≤ 1.56
	2 meals/month	24	≤ 3.38
	1 meal/month	12	≤ 6.76
	1 meal/2 months	6	≤ 13.5
	1 meal/6 months	2	≤ 40.6
	1 meal/year	1	≤ 81.1
	Do Not Consume	0	>81.1

*Uncooked serving size is approximately 8 oz. for adults and children over 12, with smaller amounts for younger children

**This value also serves as the DPH Fish Action level (FAL). Exceeding this level would trigger a waterbody specific advisory and a FCA recommendation.