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A statewide survey of pharmaceutical exposure: **Red drum across 9 Florida Estuaries**

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Pharmaceuticals

>5000 prescription medications that keep us **healthy**

100s Pharmaceuticals detected in **aquatic environments** & pose a risk to **aquatic biota**



Pharmaceutical pollution poses a global threat



Assessment of
258 rivers



104 countries

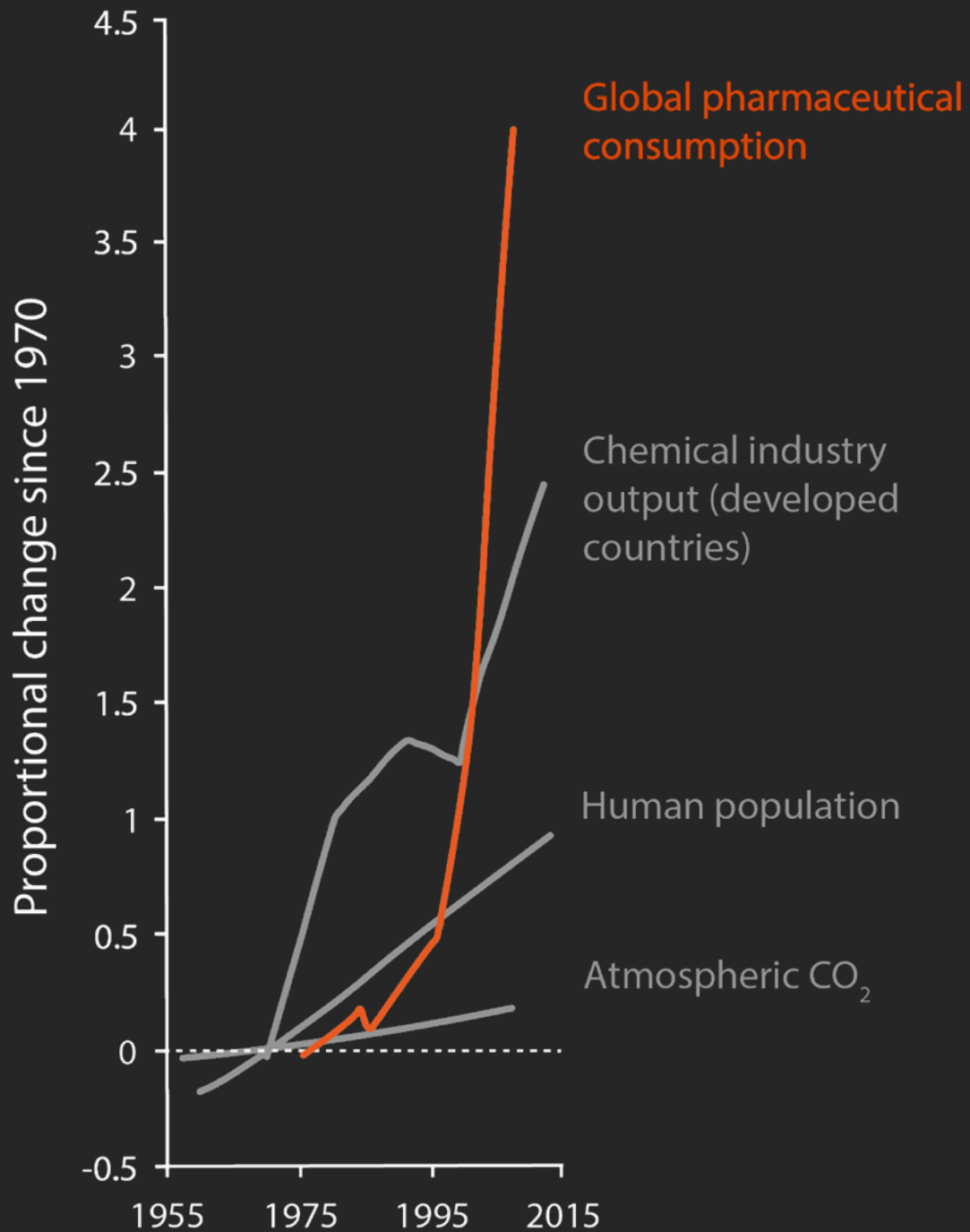


Only **2 rivers** had
no detections



25 % had **harmful**
levels of
pharmaceuticals

Rate of **production & release** far outpacing ability to **assess safety**



Bernhardt et al. 2017 Front Ecol Env

Americans consume
50% of
world's



18 prescriptions/yr

6.4 billion
prescriptions in 2021

Florida ranks 3rd



1. Is pharmaceutical pollution a **Florida problem**?

2. Do we see evidence of **human exposure**?



Redfish

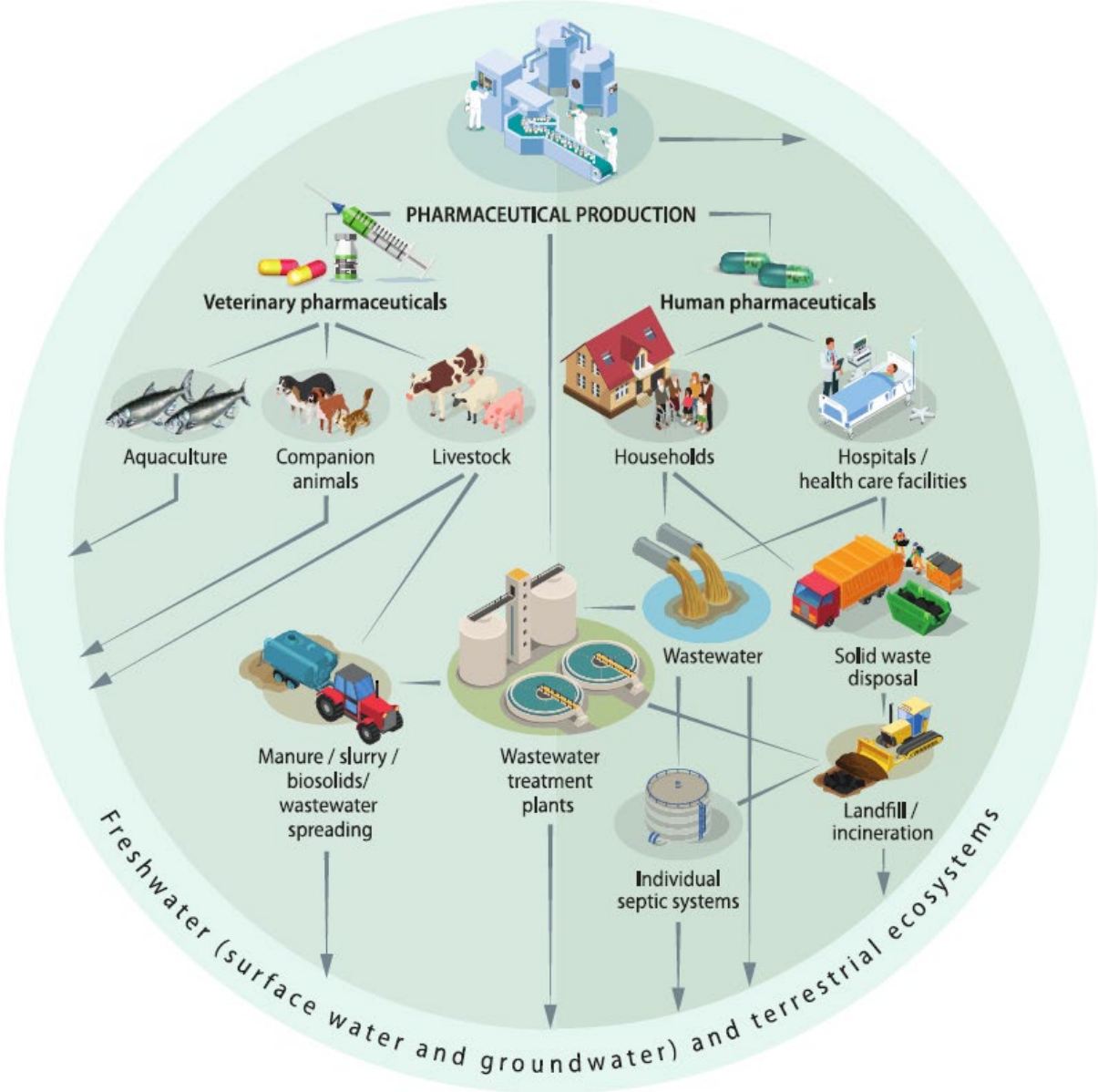
- Statewide distribution in **inshore habitats** (near pollution sources)

- Popular **recreational & food** fishery

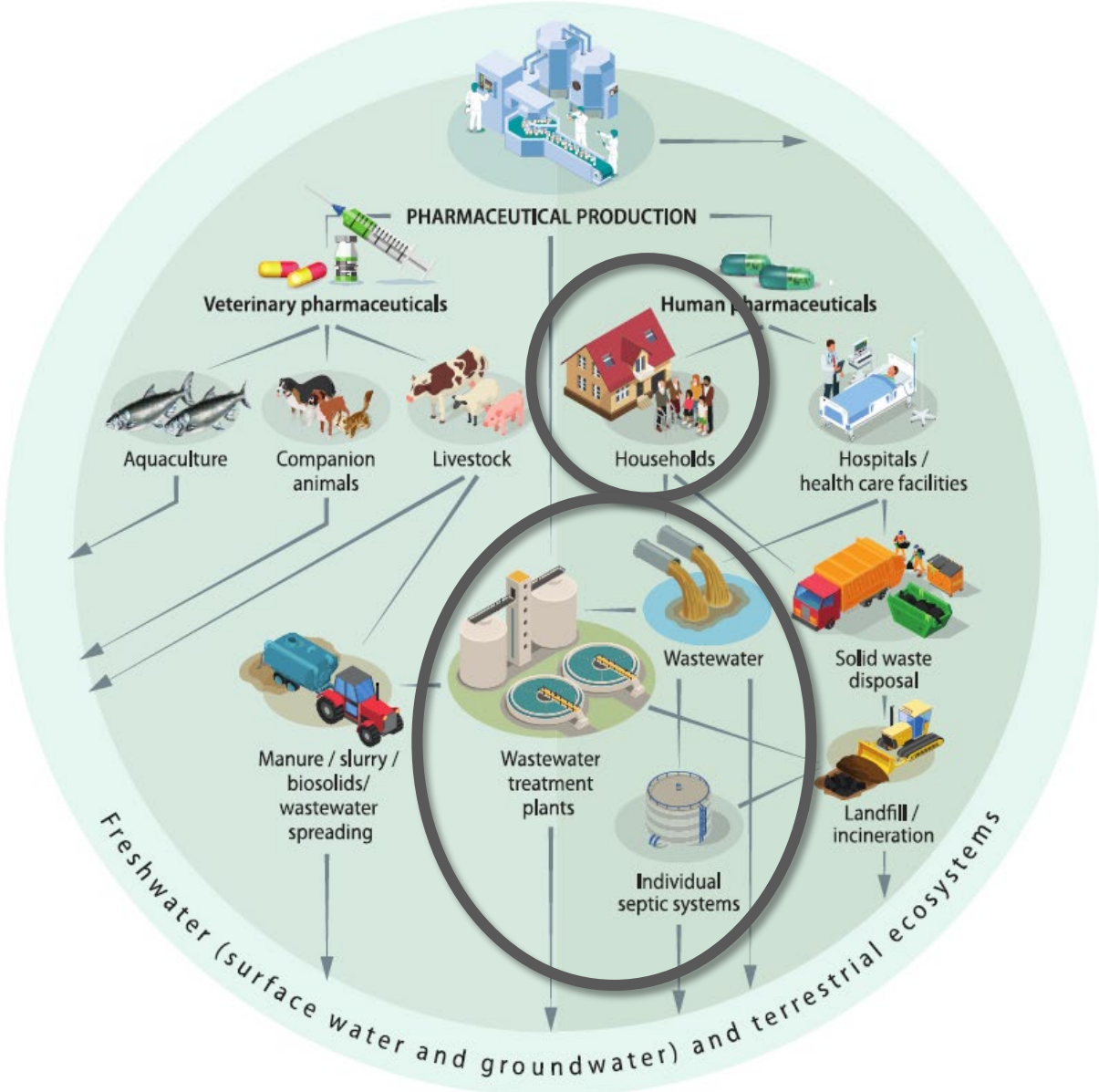
- New regional management that considers **habitat metrics**



How do **pharmaceuticals** end up in ?



How do **pharmaceuticals** end up in

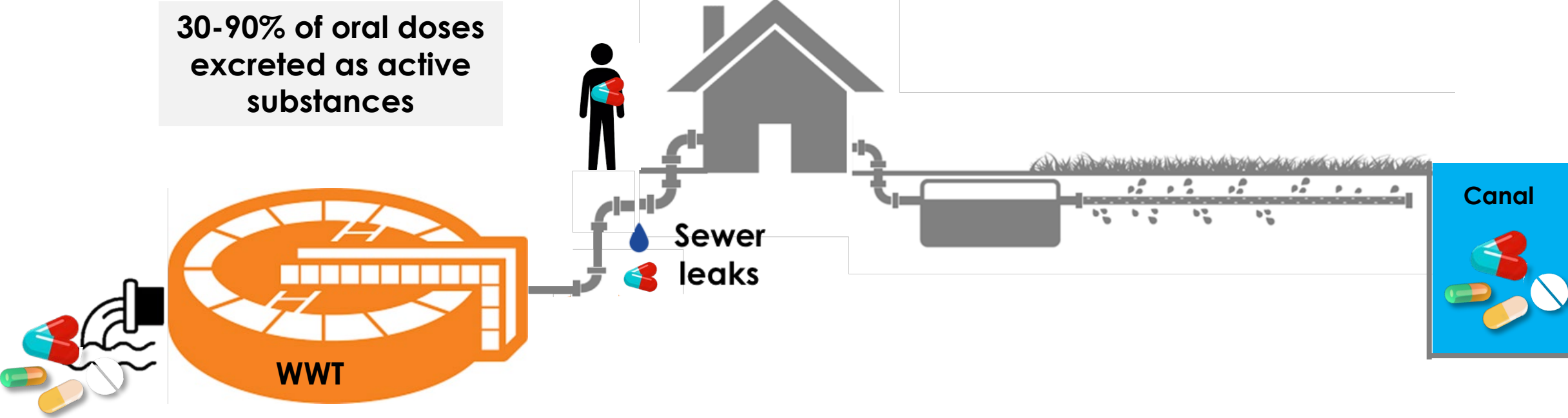


Urban waste discharge is dominant pathway

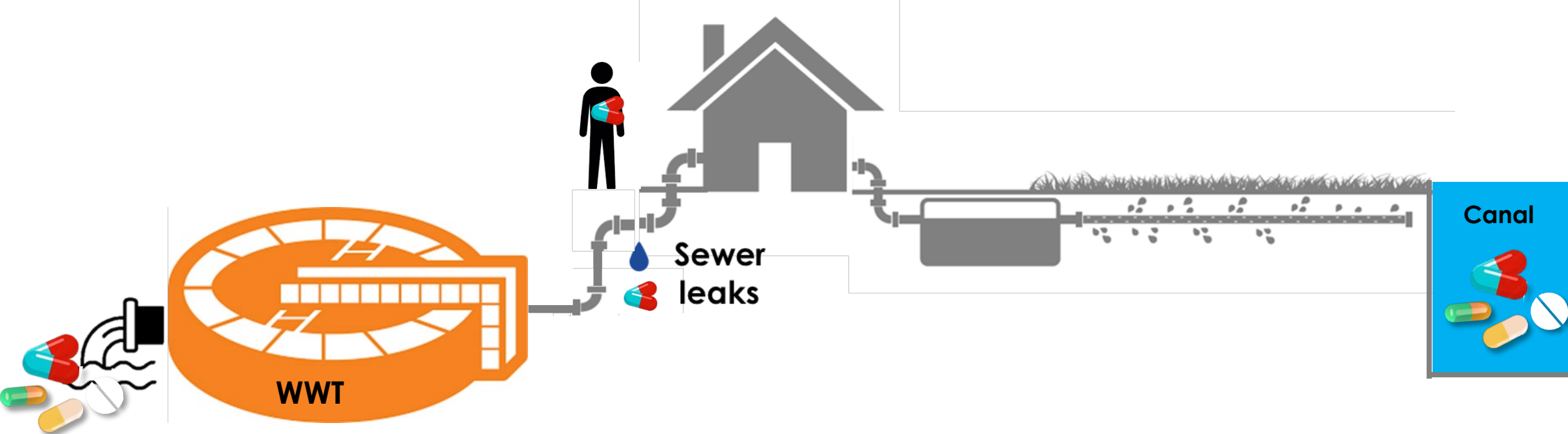
How do **pharmaceuticals** end up in ?

Red Drum

30-90% of oral doses excreted as active substances



How do **pharmaceuticals** end up in



2/3
Sewer
systems

**Pharmaceuticals
are not
Removed**

0-97% - beta blocker 30%

1/3
Septic
systems

Wastewater is the main pathway to



Wastewater is the main pathway to



Constant
supply



90% lack
toxicity data



No regulations
for safe levels

Effects on fish:
70% shared
systems



Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?



Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?



Capt Pack, Tampa

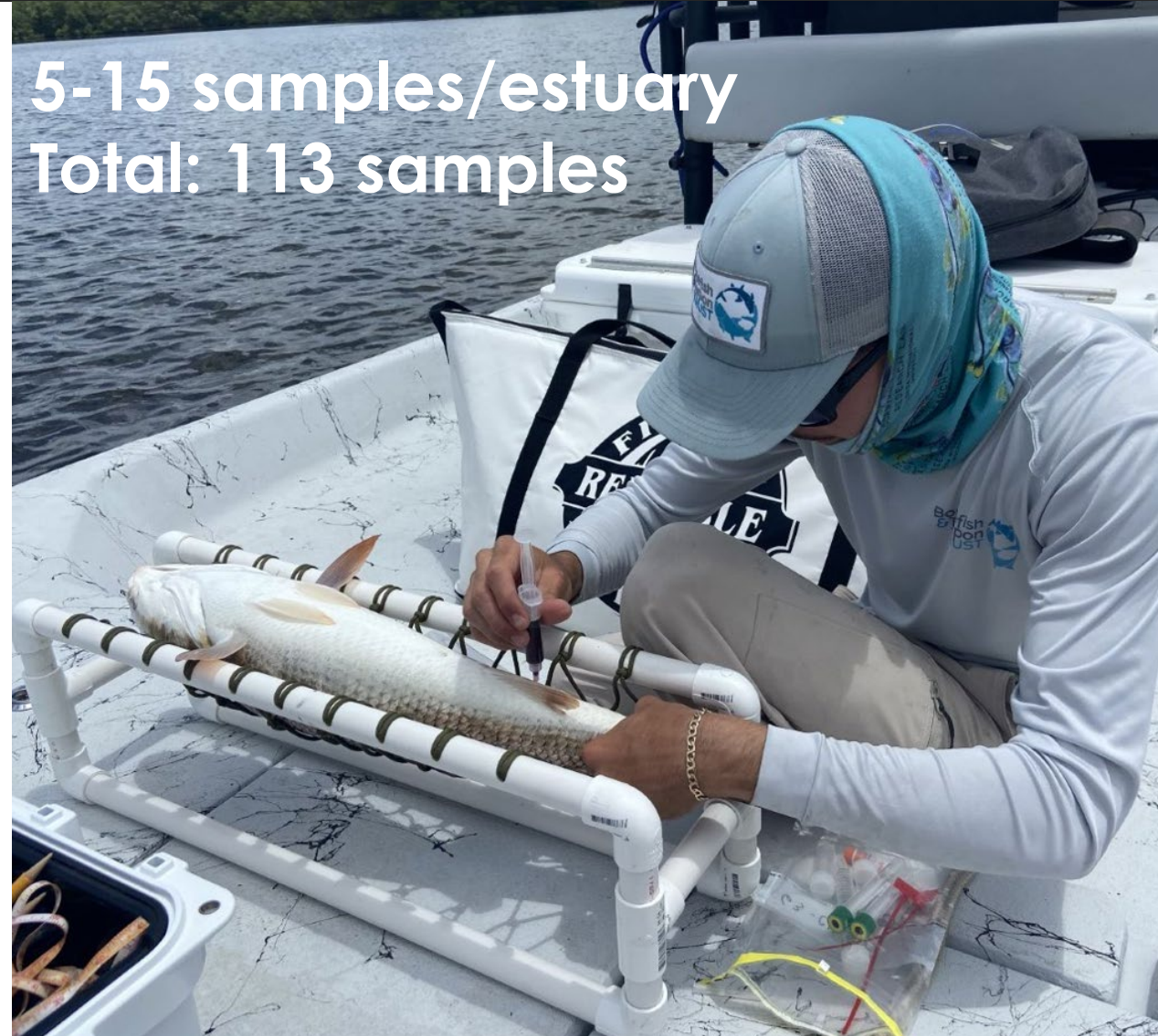


Capt Danny Allen, Cedar Key

Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?

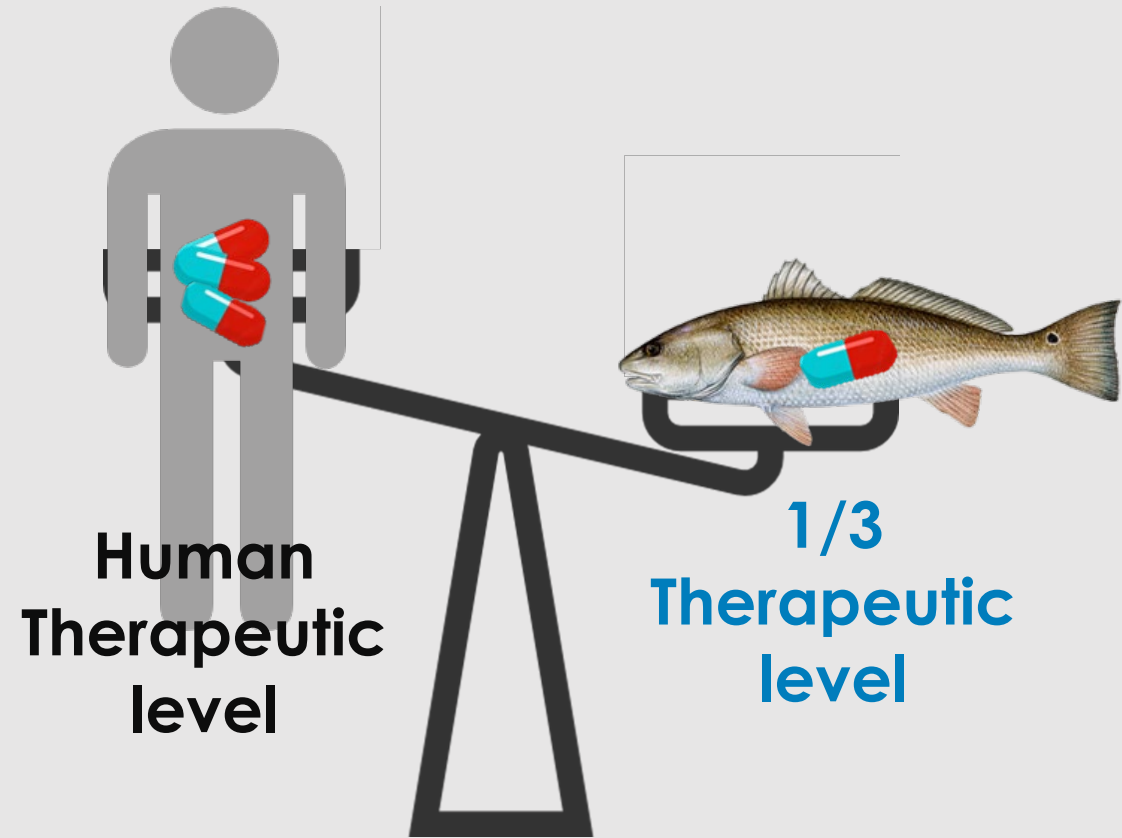
5-15 samples/estuary
Total: 113 samples



Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?

2. Are levels concerning?



If $> 1/3$ = fish expected to experience **drug effects**

Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?

2. Are levels concerning?

3. What are concerning drugs?

Tested for **95**
pharmaceuticals
in **13** categories

#	Pharmaceutical Type	# of Pharmaceuticals
1	Psychoactive	31
2	Cardiovascular	21
3	Antibiotic	12
4	Antihistamine	9
5	Opioid	5
6	Antifungal	4
7	Antiparkinson	4
8	Diabetes	4
9	Endocrine	3
10	Muscle Relaxant	3
11	Corticosteroid	2
12	Neuroactive Pain Reliever	2
13	Anti-inflammatory	1

Is pharmaceutical pollution a **Florida problem**?

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Therapeutic group	Examples of Pharmaceutical	Impact and effected organisms
Analgesics	Diclofenac, Ibuprofen	Organ damage, reduced hatching success (fish) Genotoxicity, neurotoxicity and oxidative stress (mollusk) Disruption with hormones (frog)
Antibiotics	-	Reduced growth (environmental bacteria, algae and aquatic plants)
Anti-cancer	Cyclophosphamide ¹ , mitomycin C, fluorouracil, cisplatin, doxorubicin	Ecotoxicity, genotoxicity
Antidiabetics	Metformin	Potential endocrine-disrupting effects (fish)
Anti-convulsants	Carbamazepine, phenytoin, valproic acid	Reproduction toxicity (invertebrates), development delay (fish)
Antifungals	Ketoconazole, clotrimazole, triclosan	Reduced growth (algae, fish), reduced algae community growth, disruption of hormones (rats)
Antihistamines	Hydroxyzine, fexofenadine, diphenhydramine	Behaviour changes, growth and feeding rate (fish) Behaviour changes and reproduction toxicity (invertebrates)
Antiparasitics	Ivermectin	Growth and reduced reproduction (invertebrates)
Beta blockers	Propranolol	Reproduction behaviour (fish), reproduction toxicity (invertebrates)
Endocrine active pharmaceuticals	E2, EE2, levonorgestrel	Disruption with hormones causing reproduction toxicity (fish, frogs)
Psychiatric drugs	Fluoxetine, sertraline, oxazepam, citalopram, chlorpromazine	Behaviour changes - feeding, boldness, activity, sociality (fish) Disruption with hormones (fish) Behaviour changes - swimming and cryptic (invertebrates) Reproduction toxicity and disruption with hormones (invertebrates)

Is pharmaceutical pollution a **Florida problem**?

1. Are pharmaceuticals everywhere?
2. Are levels concerning?
3. What are concerning drugs?
4. Is there human exposure?

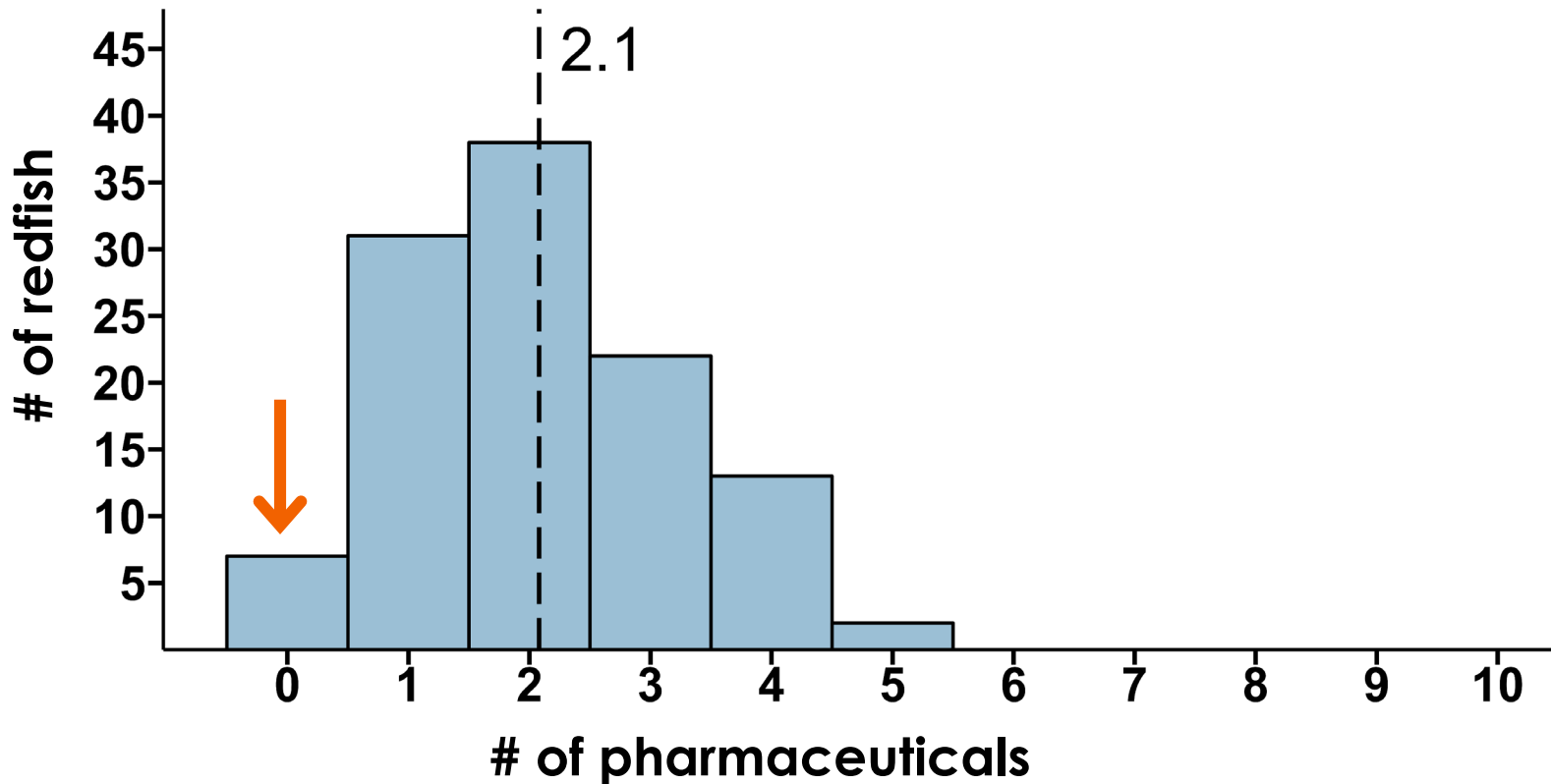


5 Findings



1. Pharmaceutical were found in **every estuary**

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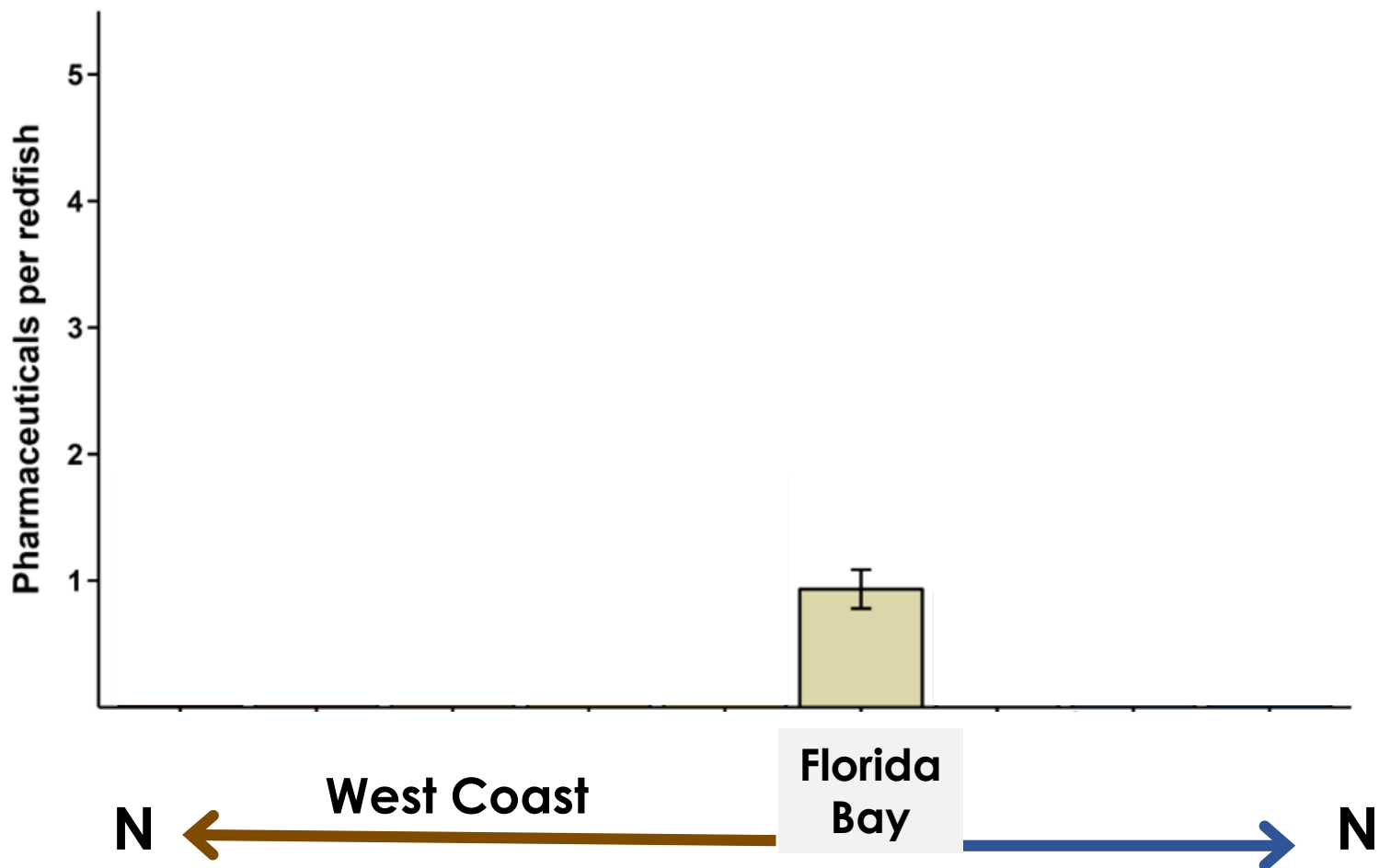
- **94%** had at least 1
(7 zeros/113 fish)

- Average = **2.1**

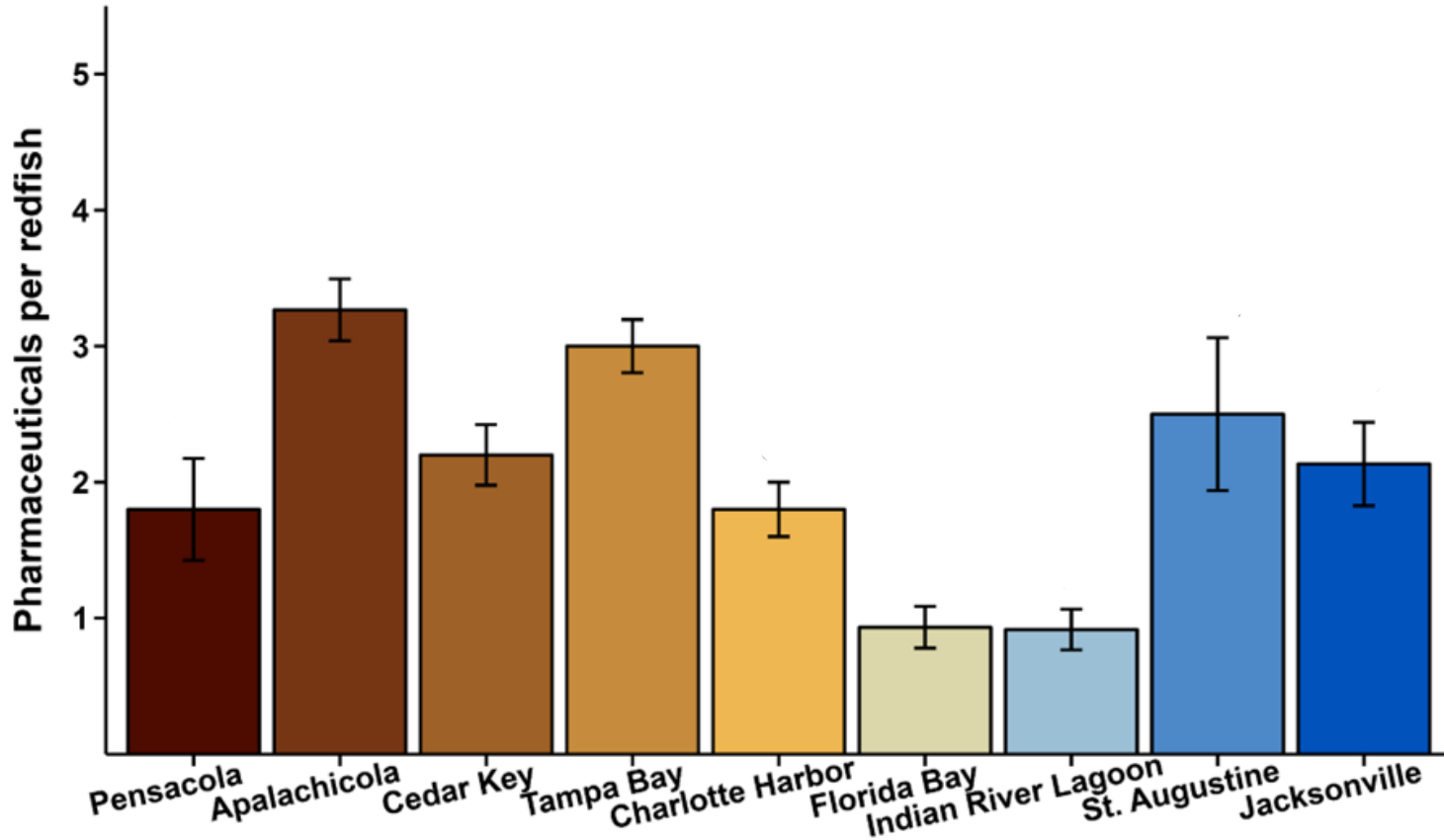
17 pharmaceuticals
detected

2. **Estuaries** varied in exposure

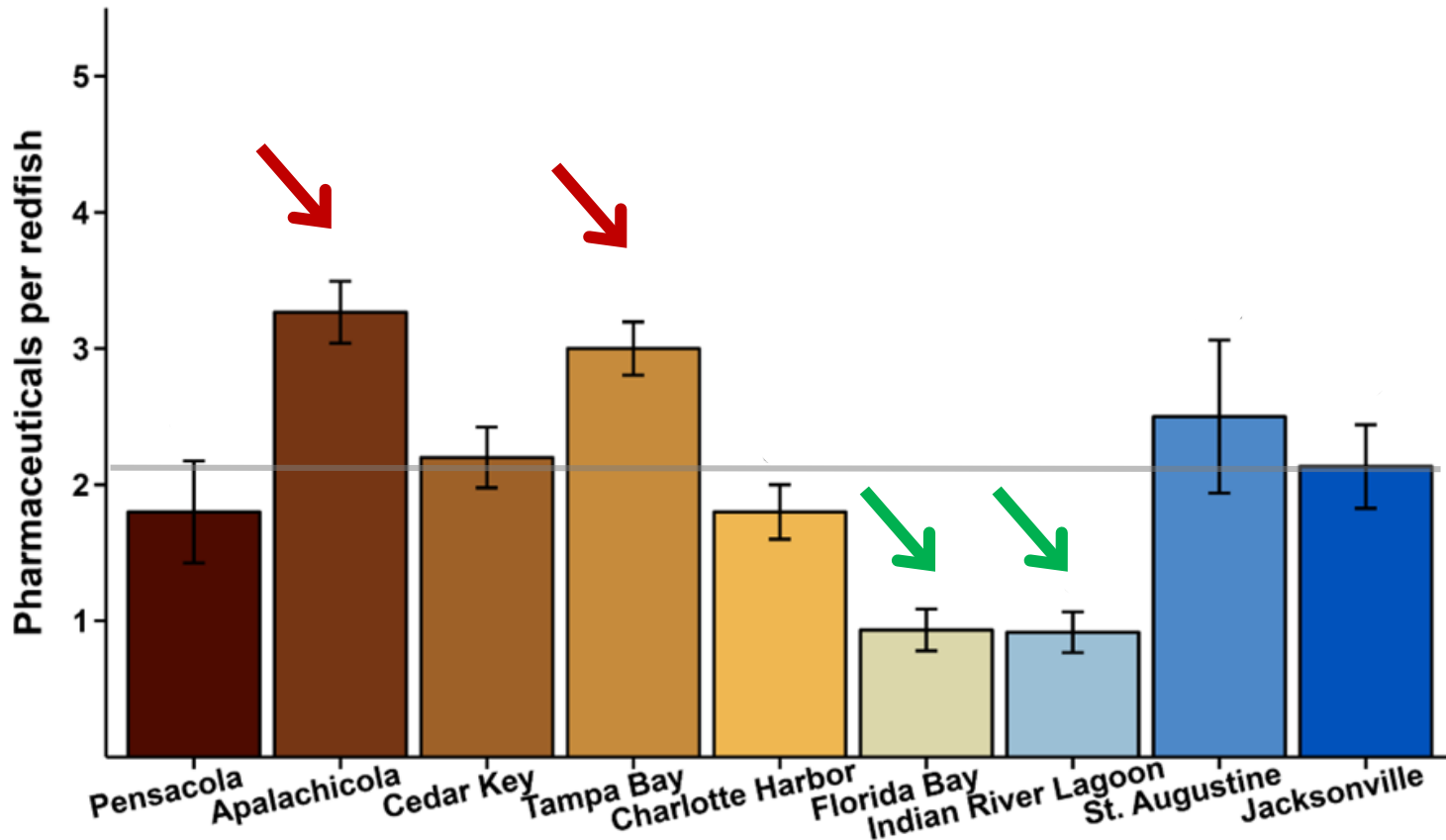
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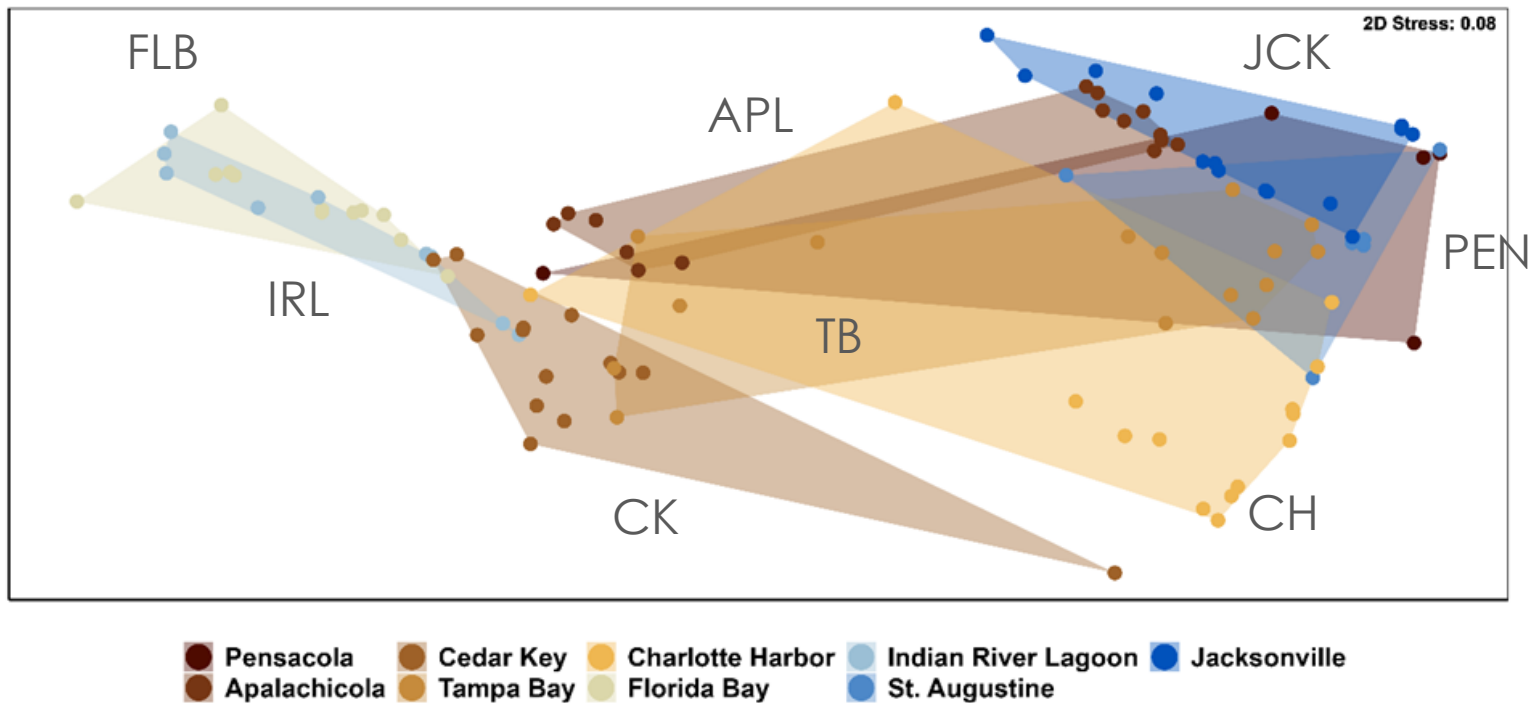
2. Estuaries varied in exposure



TAMPA BAY & APALACHACOLA are highest
> 3 pharmaceuticals/fish

FLORIDA BAY & INDIAN RIVER LAGOON are lowest
= 1 pharmaceuticals/fish

2. Estuaries varied in exposure

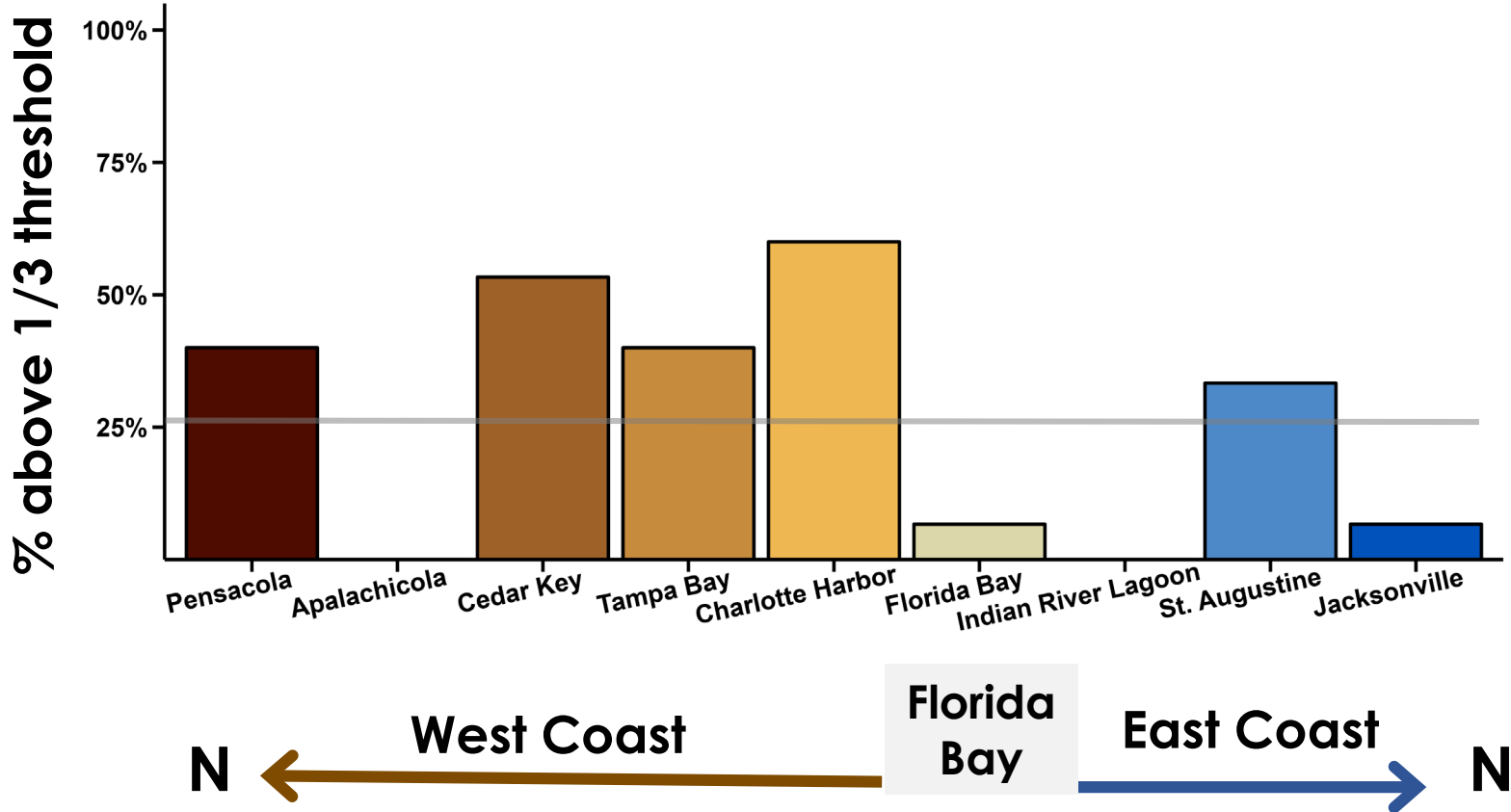


Pharmaceuticals
varied across regions

More variable
assemblages in
WEST Florida

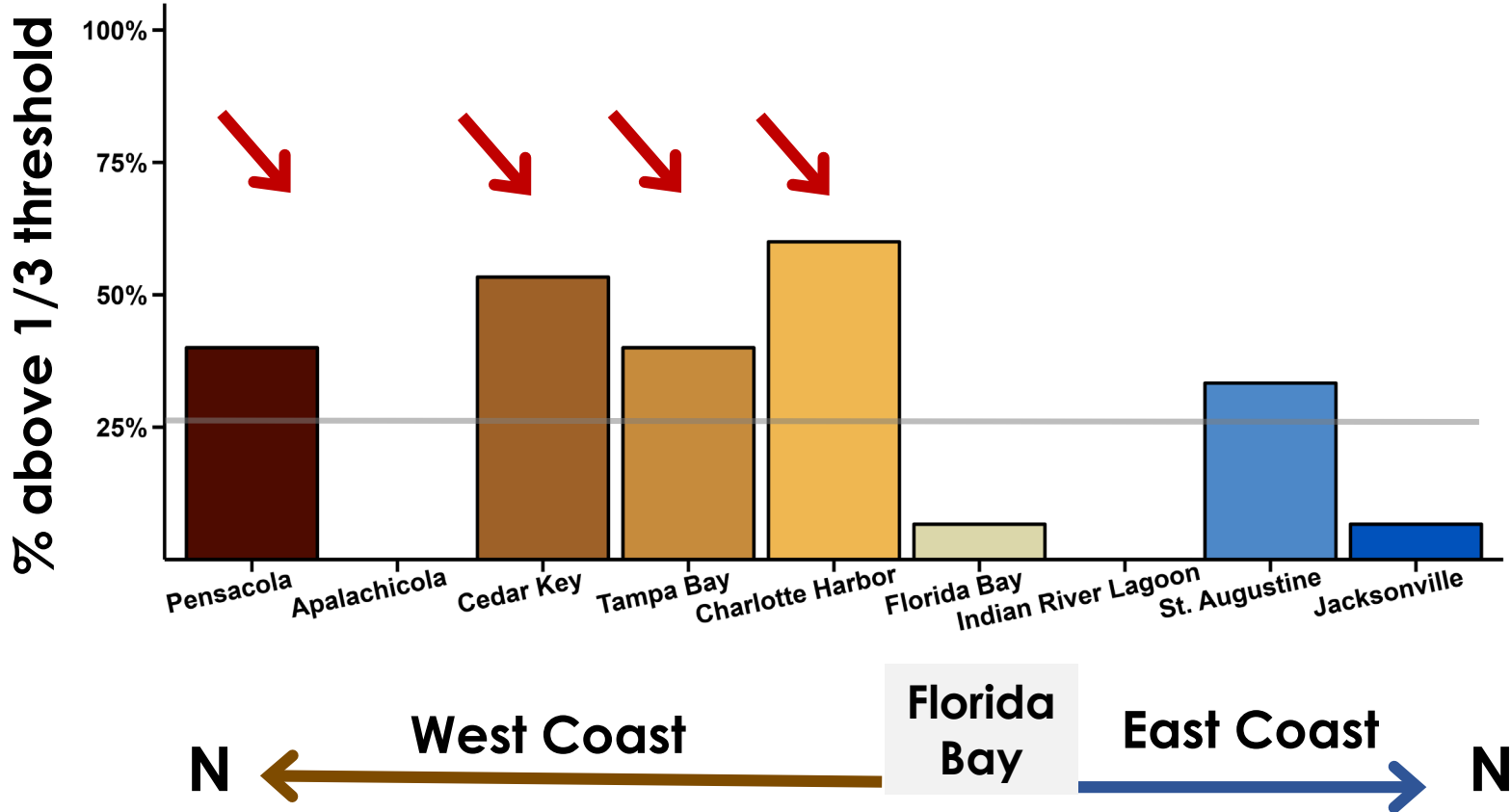
3. 1 in 4 **redfish** should feel effects

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25.7% of **113 redfish** above 1/3 threshold

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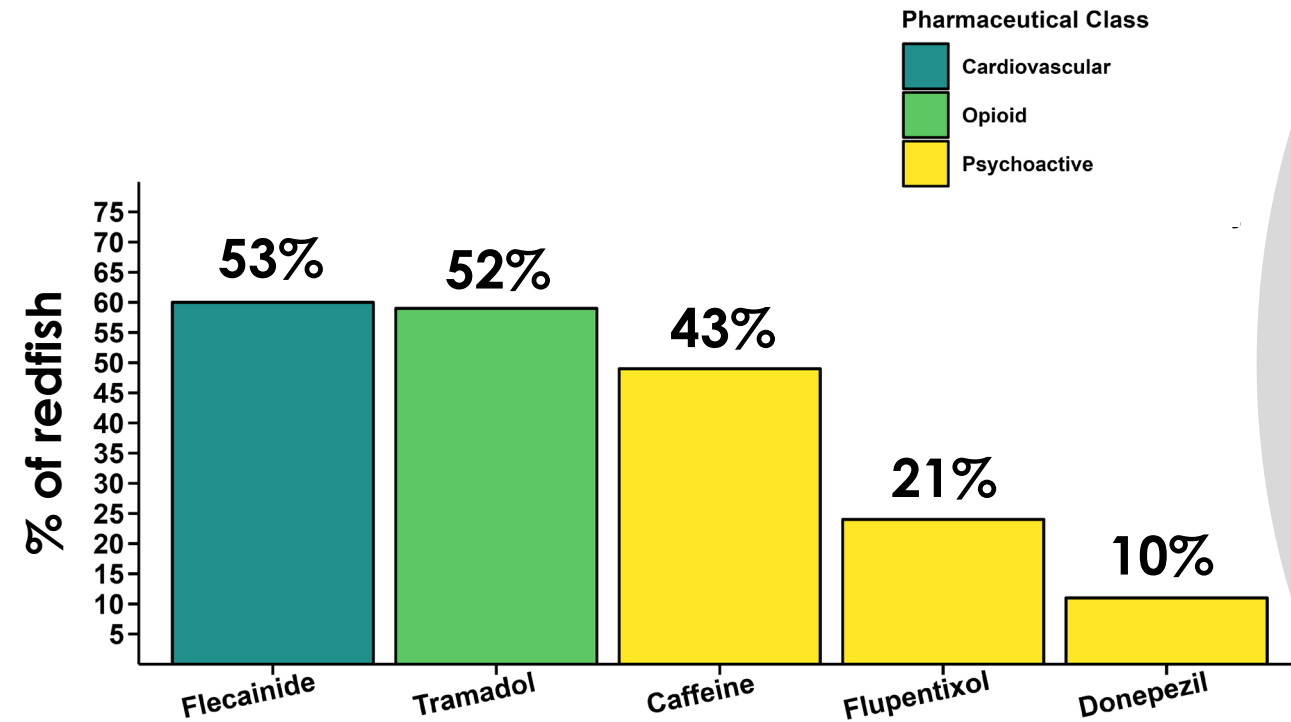
25.7% of **113 redfish** above 1/3 threshold

Higher in **west coast estuaries**

4. **5 pharmaceuticals** were most concerning

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85% of detections



Flecainide: Antiarrhythmic agent

Tramadol: Opioid pain reliever

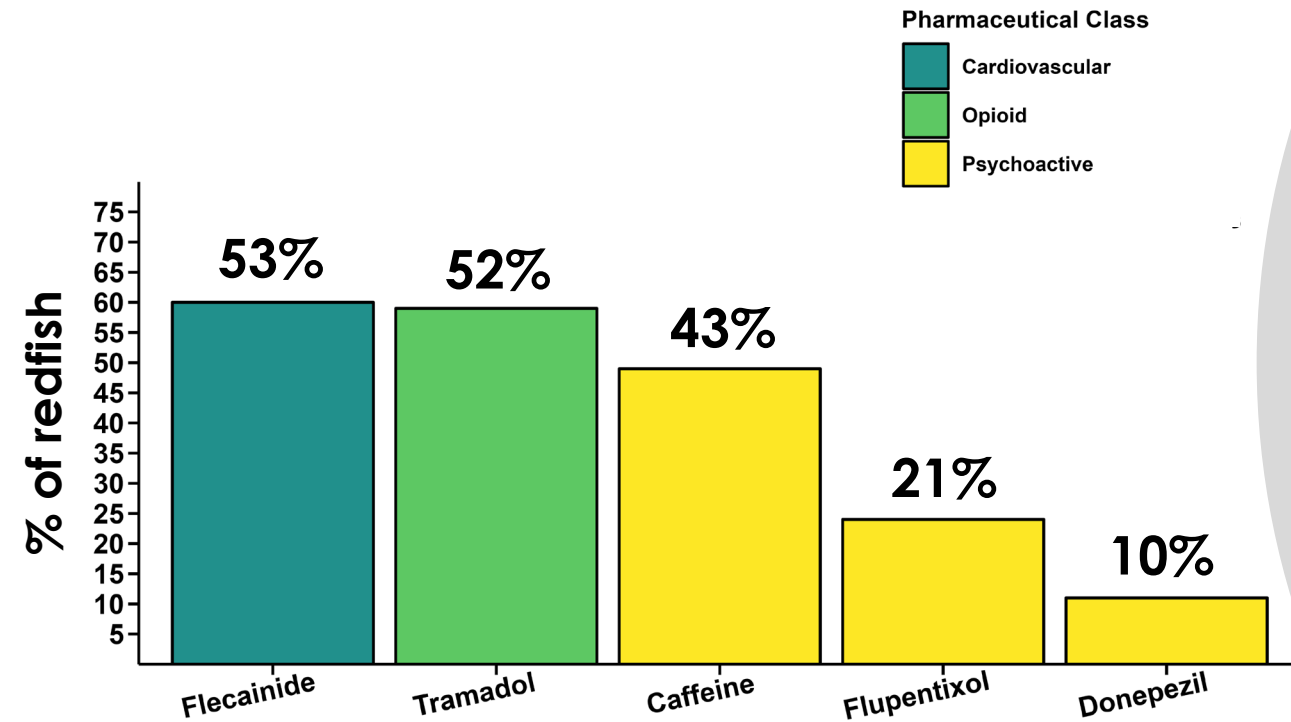
Caffeine: Stimulant

Flupentixol: Schizophrenia & antidepressant

Donepezil: Alzheimer's dementia

4. 5 pharmaceuticals were most concerning

85% of detections



Flecainide: unknown

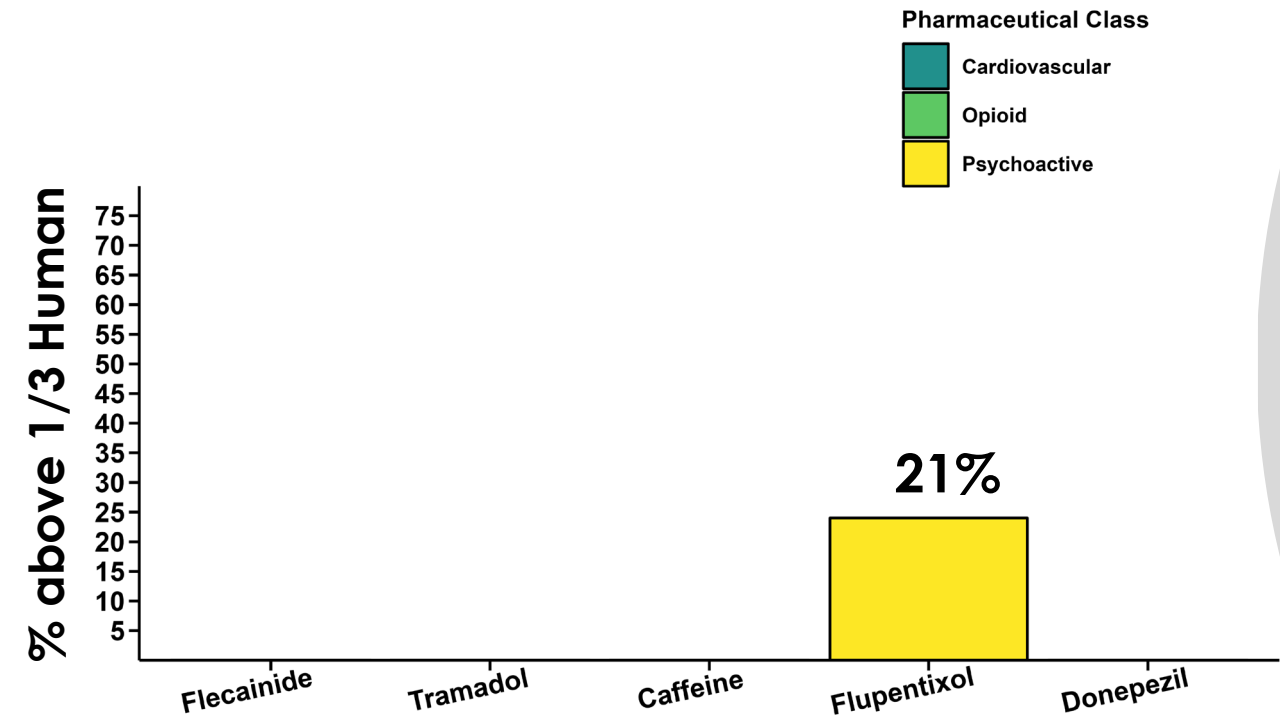
Tramadol: gill/liver damage, - activity + boldness/+ asocial, delayed hatching, withdraw

Caffeine: anxiety-like effects, erratic mov delayed response, cell/DNA damage

Flupentixol: unknown/Canada

Donepezil: aggression, muscle weakness, anxiety effects

4. 5 pharmaceuticals were most concerning



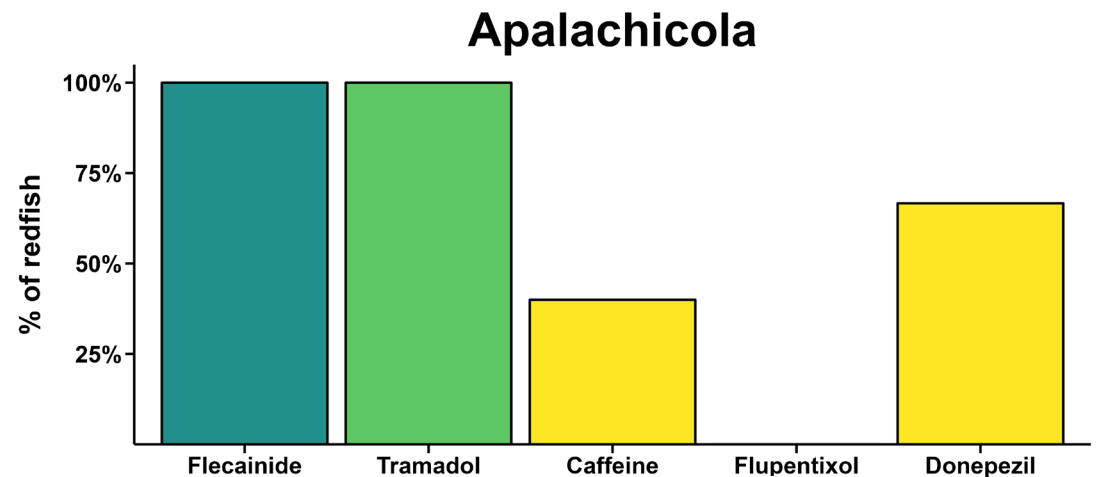
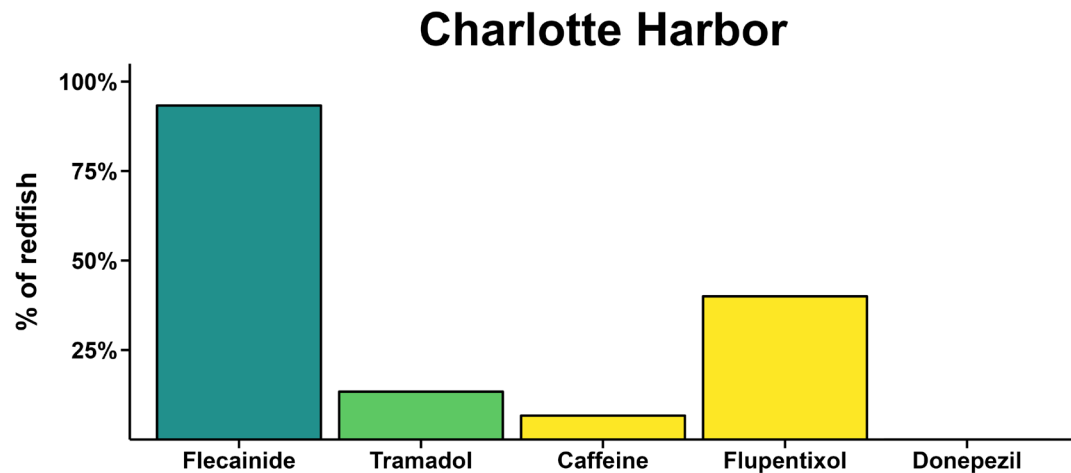
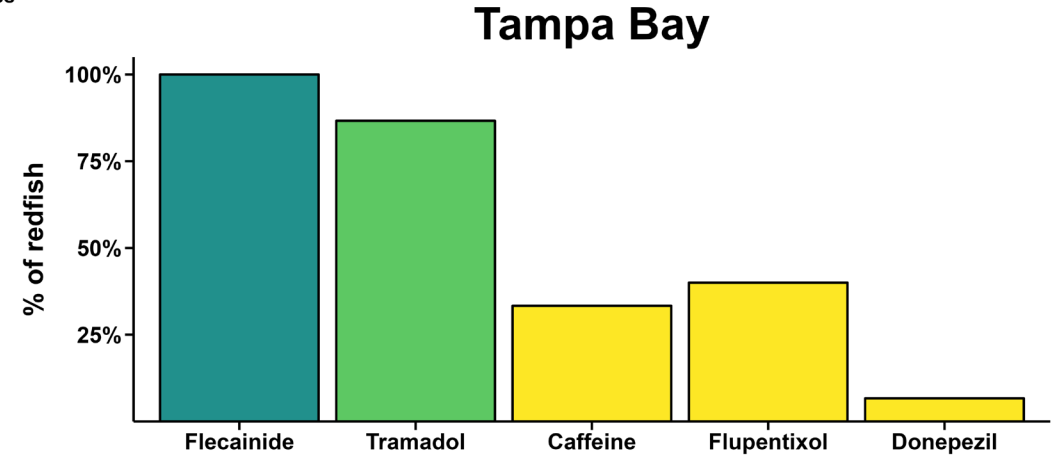
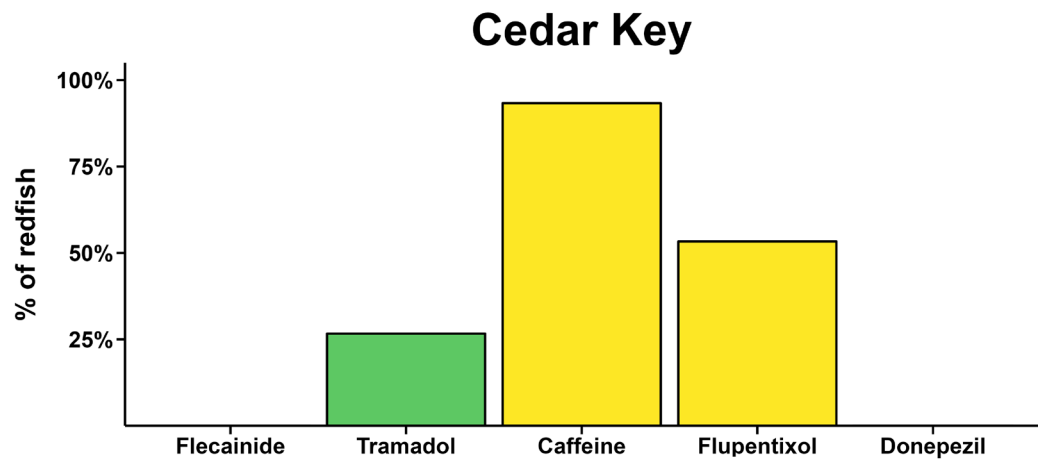
Flupentixol = schizophrenia & antidepressant

Every detection in an exceedance

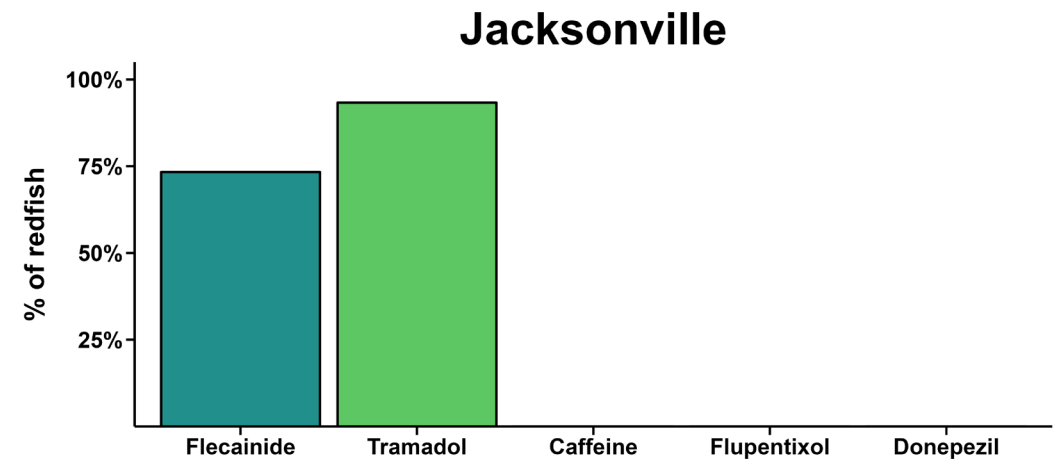
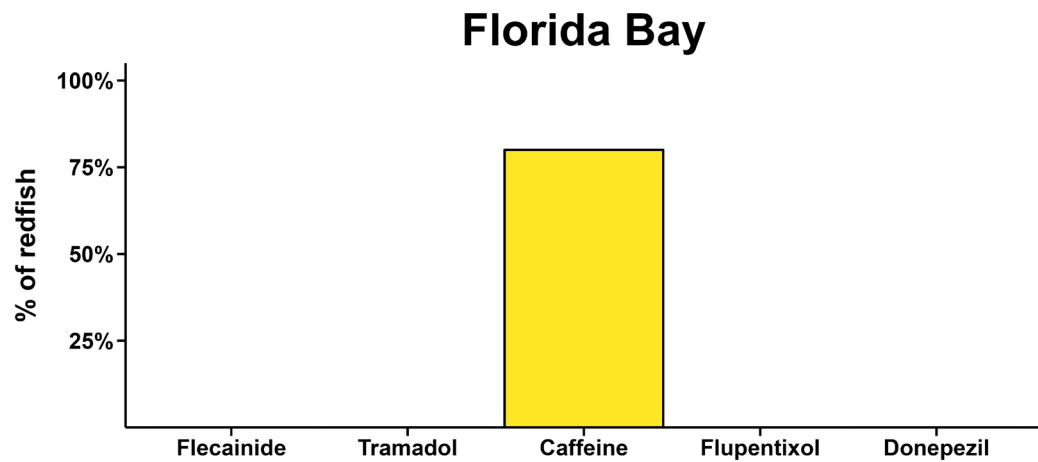
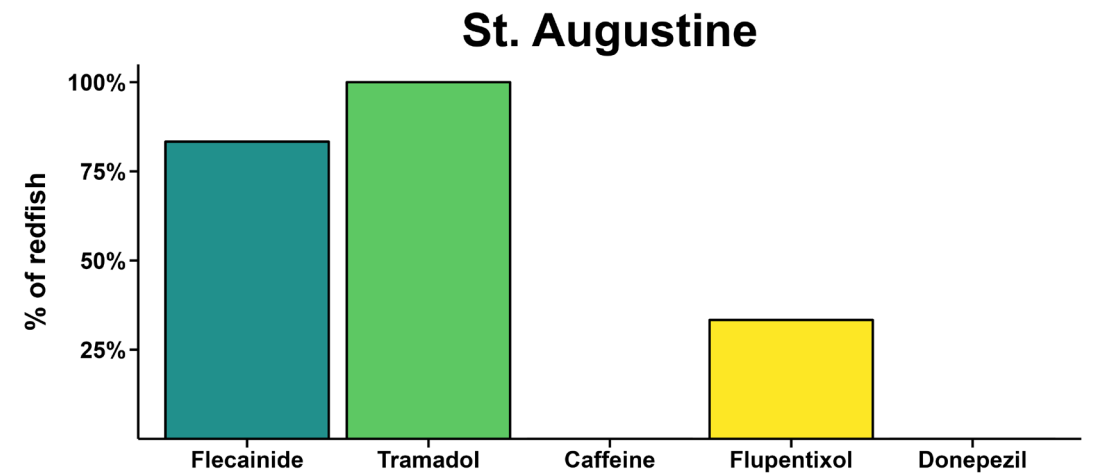
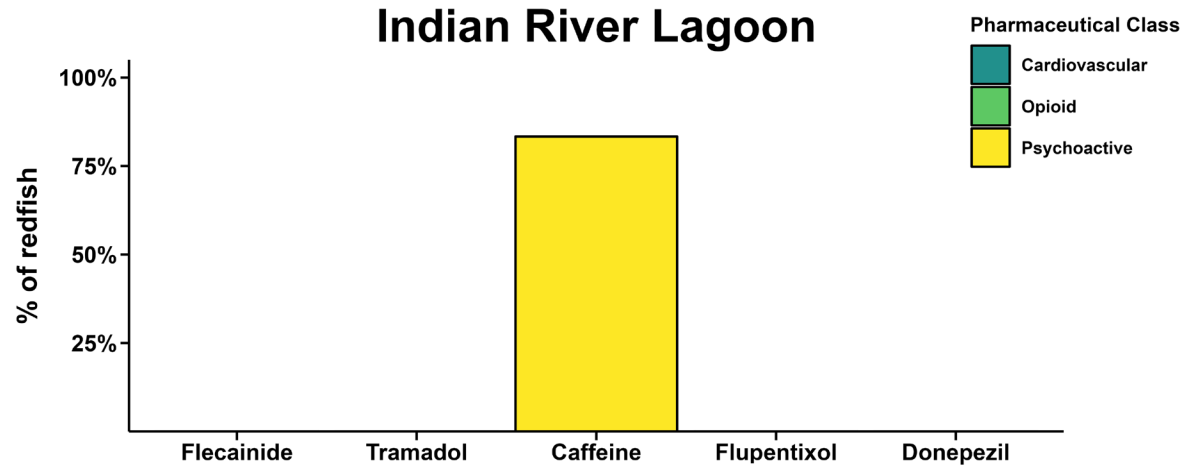
Detect at high levels in Czech Rep

High risk of effects

4.5 pharmaceuticals: West coast

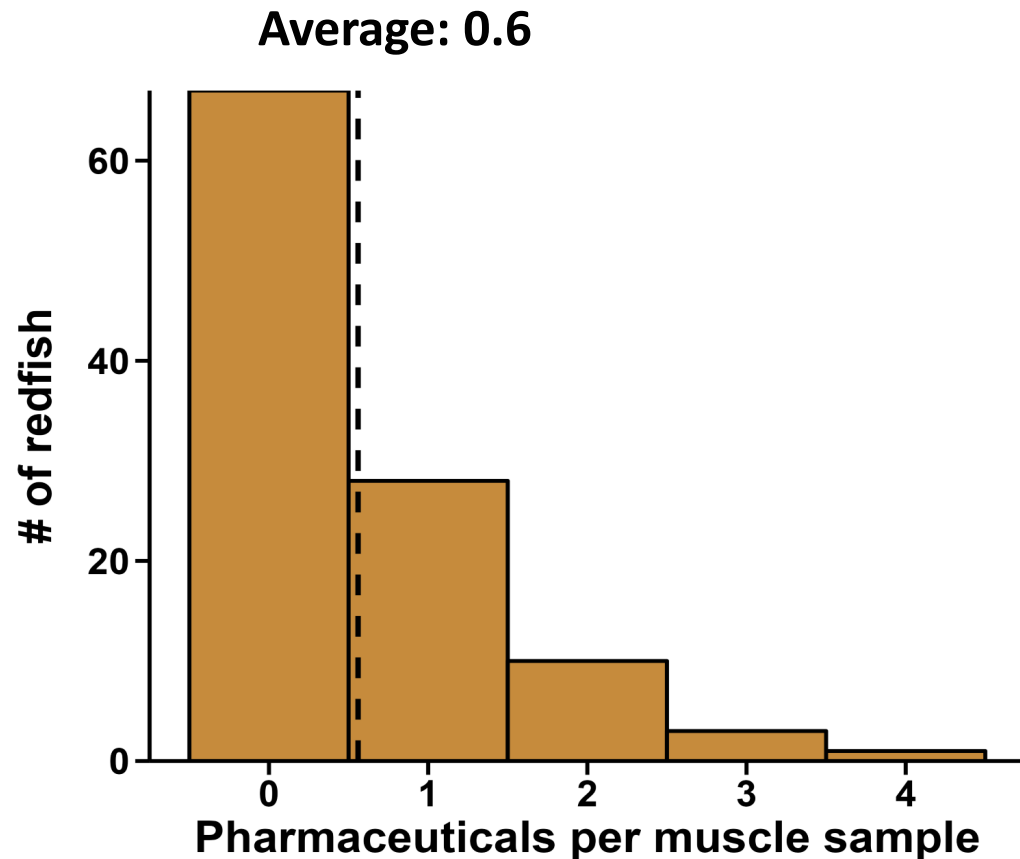


4.5 pharmaceuticals: East coast



5. Exposure **via consumption...**very low levels

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Detected in 38.5% of muscle

11 pharmaceuticals

52% of detections were
Flecainide & Tramadol

5. Very low exposure **via consumption**



At most 0.002% of dose/serving

48,000 servings for full dose

No acute risk but allergies*

Part of other exposure, so **real exposure** is unknown

Chronic risk to mixtures at low levels
is **unknown**

5. Exposure **via consumption...**next steps



We propose to **examine potential PFAS contaminants** in redfish

PFAS pose more risk than pharmaceuticals via consumption

Pharmaceutical pollution IS a Florida problem





Pharmaceutical pollution IS a Florida problem

1. **Widespread** exposure across estuaries
 - Both large & small cities
2. Exposure to a **few pharmaceuticals**
3. But **high concentrations**
 - **25% of fish** with expected effects

Our **Wastewater** issues are
statewide

This can be **fixed**

1. SOURCE:

2. USER:

3. END OF PIPE:



This can be **fixed**

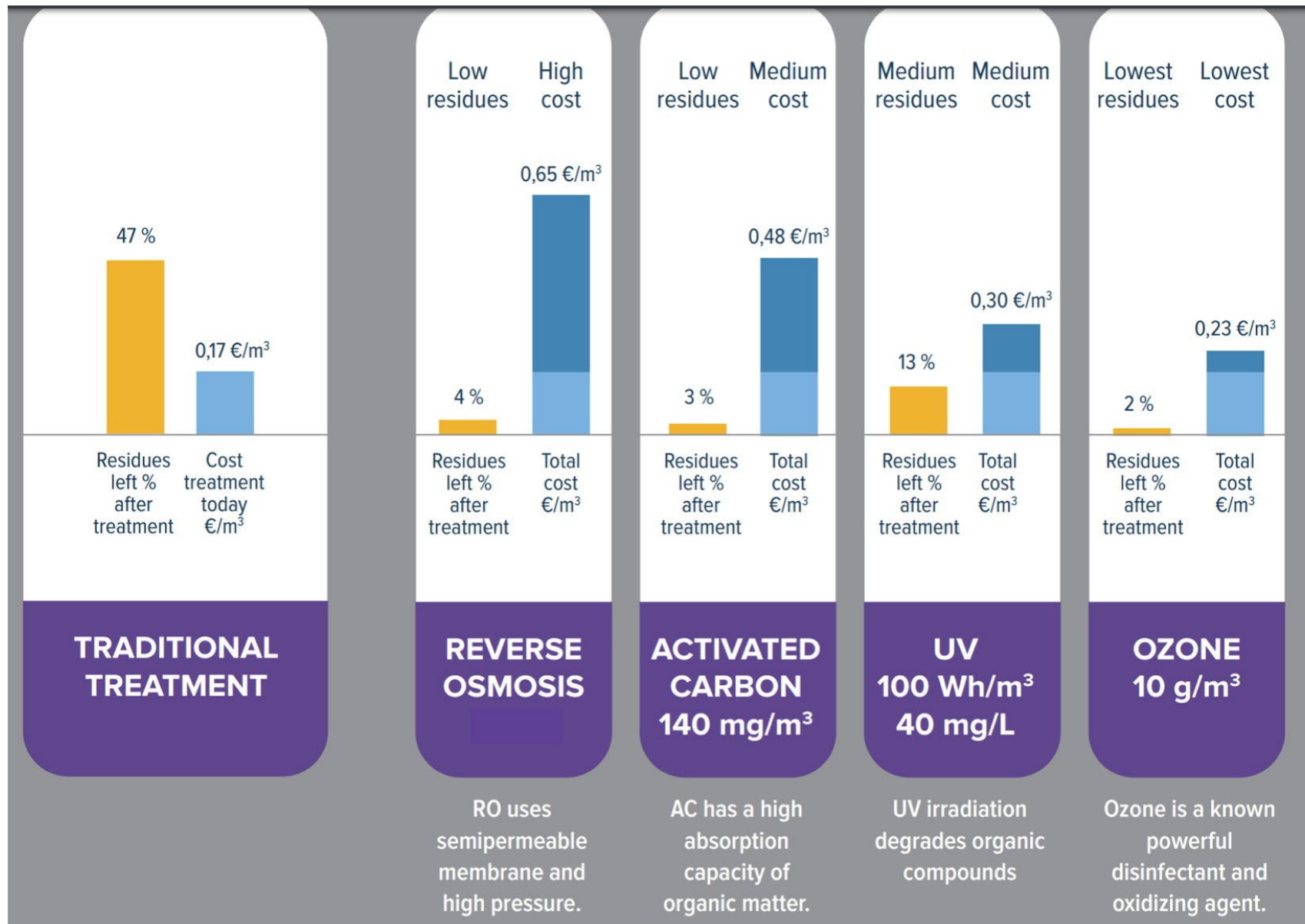
1. SOURCE: - Insert **env risk assessment** into pharmaceutical authorization process
- Production of **green pharmaceuticals** (eco-labeling)

2. USER: - Reduce **need** & optimize **use**
- Best practices for **disposal** (human & vet purposes)

3. END OF PIPE: - **Upgrade WWT** for removal
- Best practices for use & removal of **biosolids**



WWT Upgrade: Sweden, Switzerland, Netherlands & Germany



Ozonation is most cost effective

35% more costly than conventional treatment

Need to rethink
wastewater: Too valuable
& damaging

Move to **recycle**
wastewater

Wastewater
becomes a safe source of
energy, fertilizer
& **100% clean water**





This is an opportunity for Florida to lead

FIU Institute of Environment
FLORIDA INTERNATIONAL UNIVERSITY



COASTAL FISHERIES RESEARCH LAB
FLORIDA INTERNATIONAL UNIVERSITY



SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES



UMEÅ UNIVERSITY





**David Vales,
Indian River Lagoon**

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**Capt Rami Ashouri,
Jacksonville**



**Anthony Morgan,
Pensacola**



**Capt Nick Castillo,
Florida Bay**



**Capt Jim Brown,
Apalachicola**



**JoEllen Wilson,
Charlotte Harbor**



**Capt Josh Greer,
Charlotte Harbor**



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Questions?

Thank you!

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