

Freshwater Mussels: Restoring Virginia's Native Bivalve Bounty



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Mussel Recovery Biologist
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DWR Region III, Marion, VA

Virginia DWR Mission Statement

Conserve and manage wildlife populations and habitat for the benefit of present and future generations.

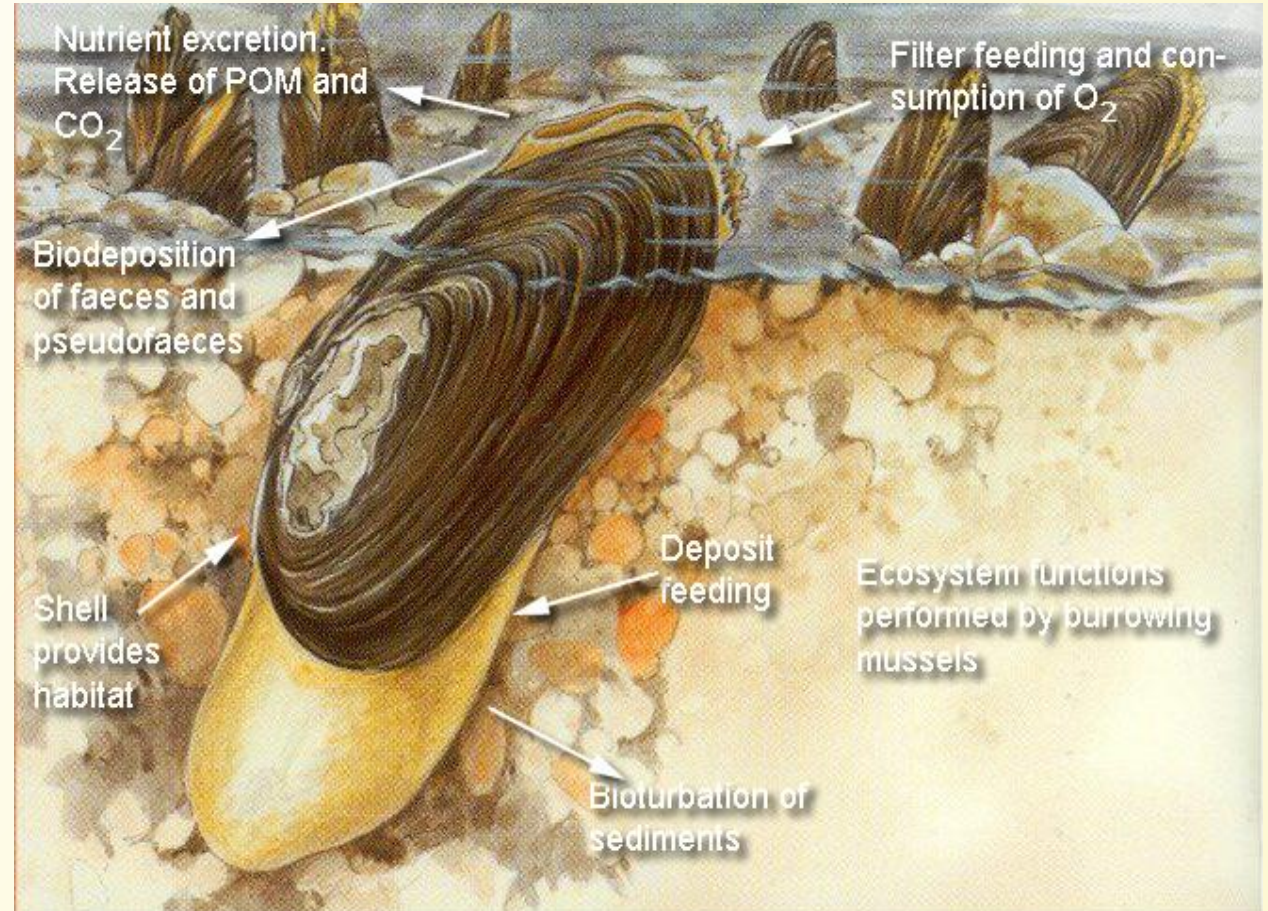
Connect people to Virginia's outdoors through boating, education, fishing, hunting, trapping, wildlife viewing, and other wildlife-related activities.

Protect people and property by promoting safe outdoor experiences and managing human-wildlife conflicts.

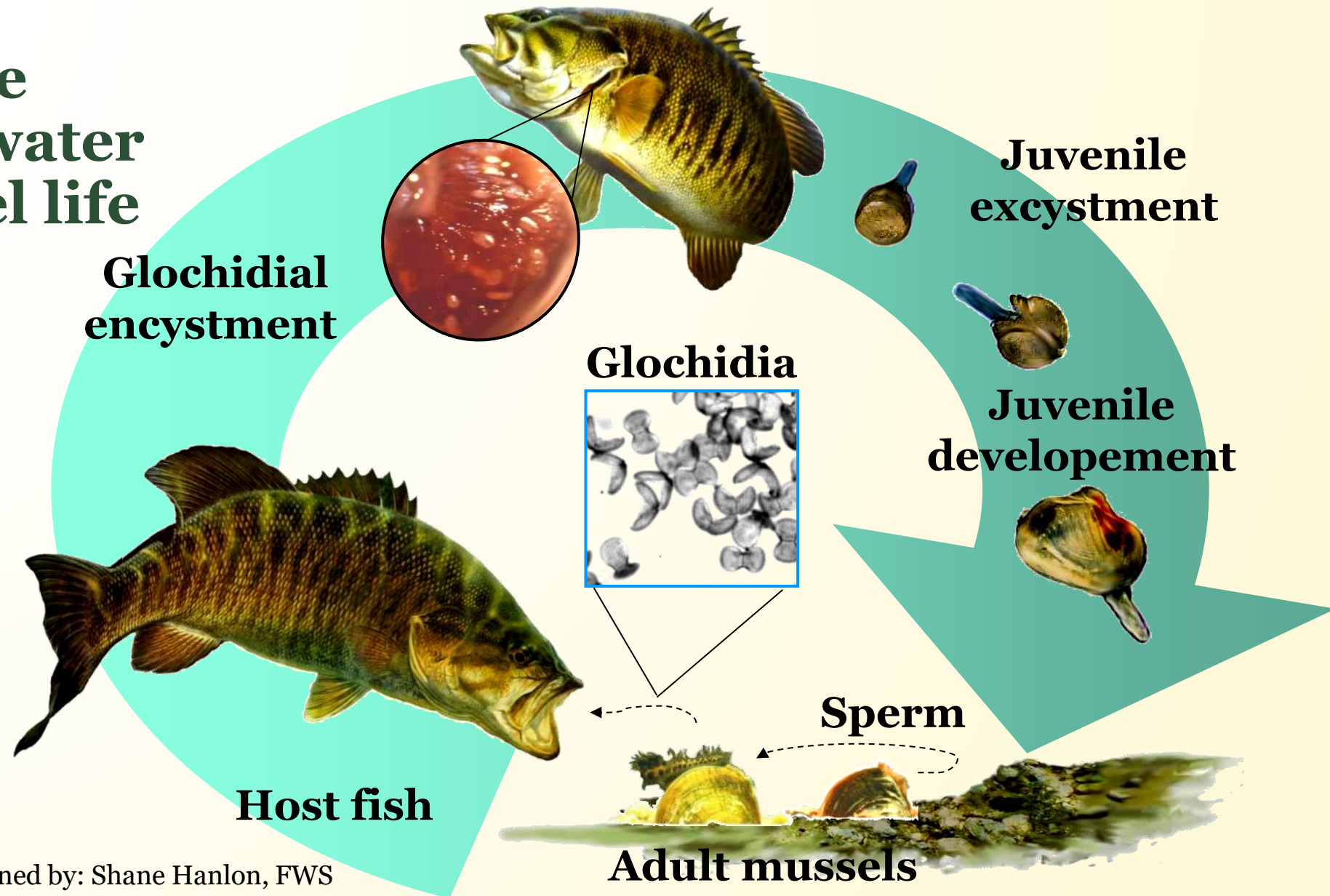


Freshwater Mussel Facts

- Soft-bodied invertebrates with 2 hard shells
- Filter feed on algae, bacteria and fine organic particulates
- Sedentary most of their lives
- Long lifespan
- Water quality indicators
- Complicated life cycle –involves many types of fish



The unique freshwater mussel life cycle



Designed by: Shane Hanlon, FWS

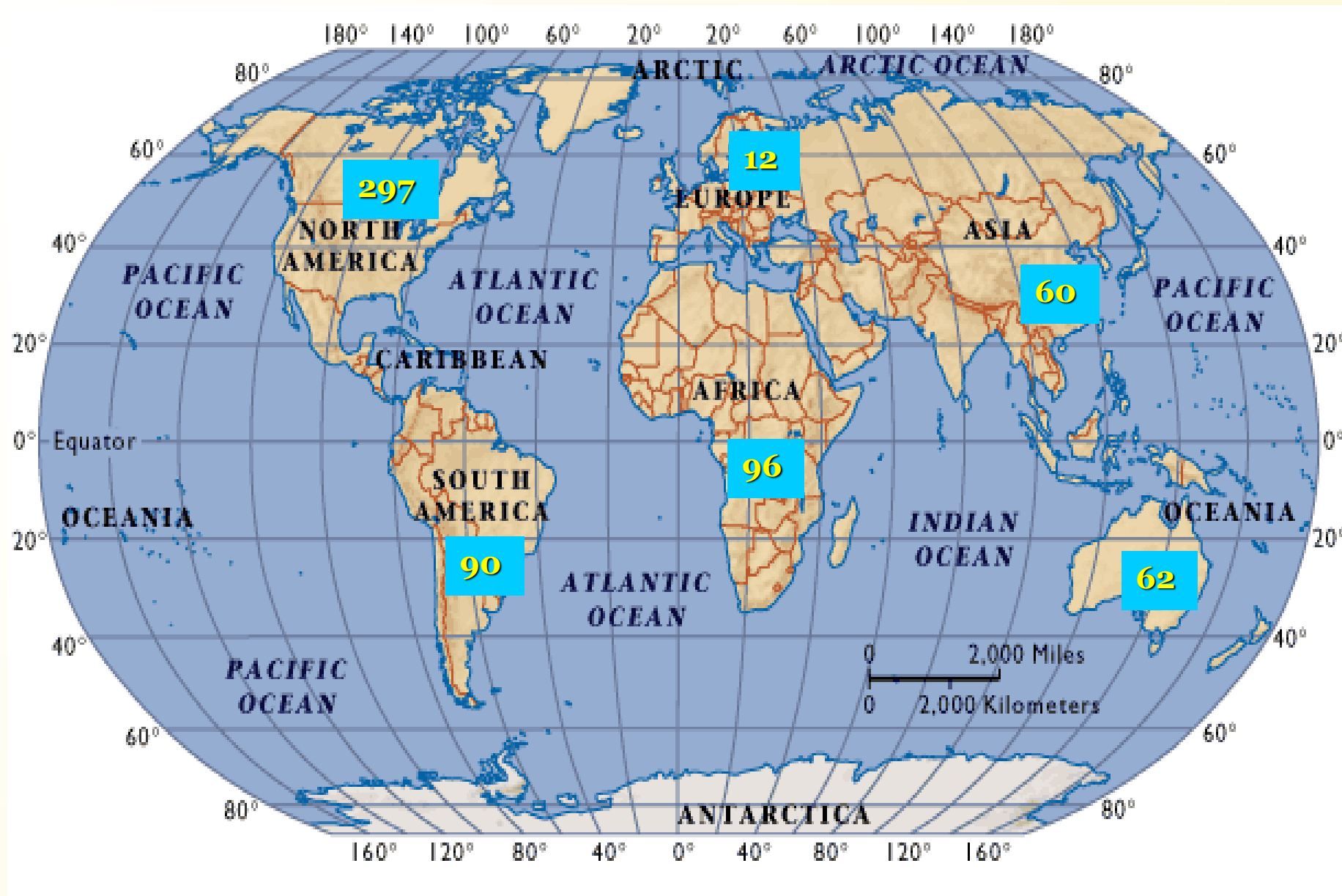


Where's the Mussel?

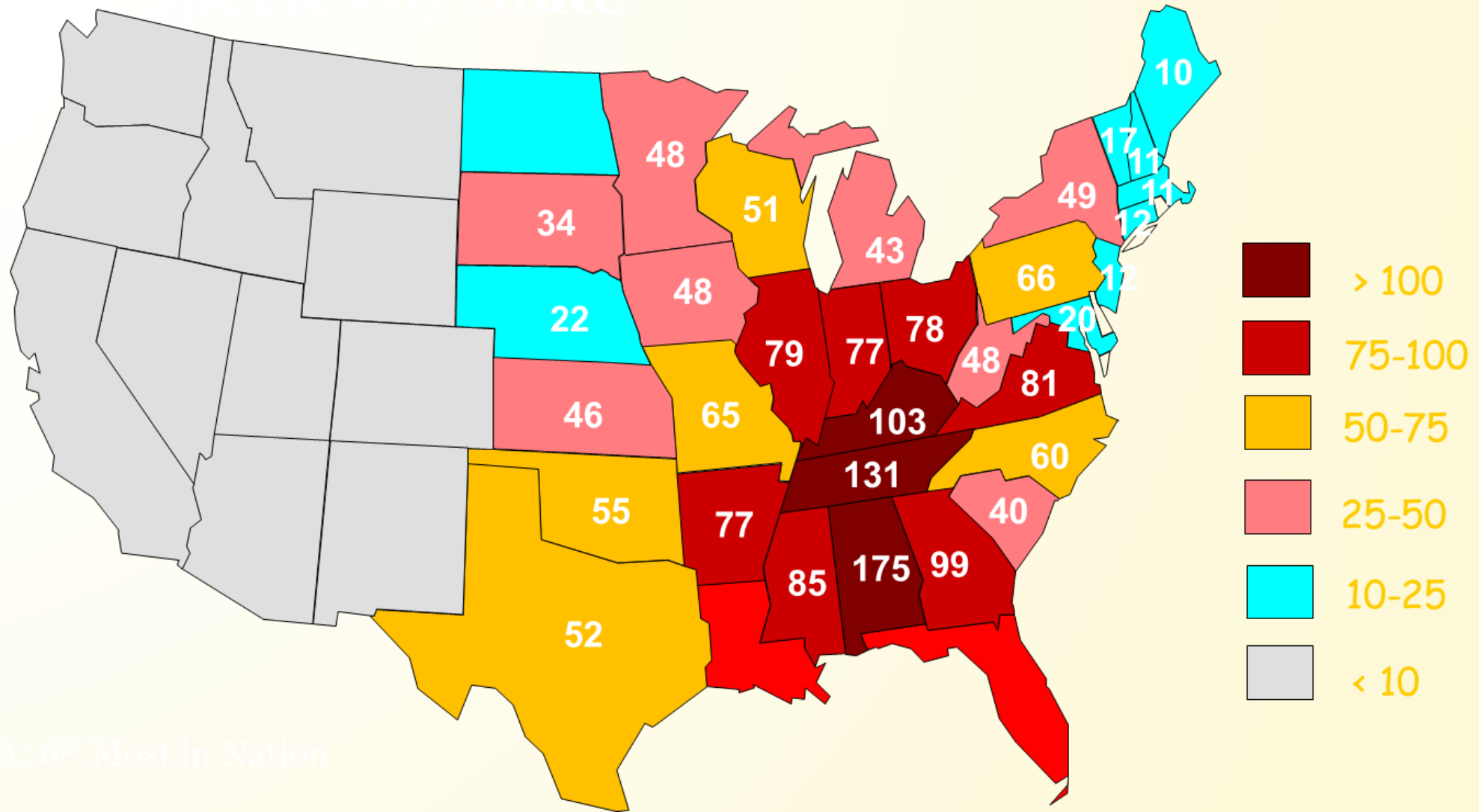


Nature's Water Purifiers: Lab Example



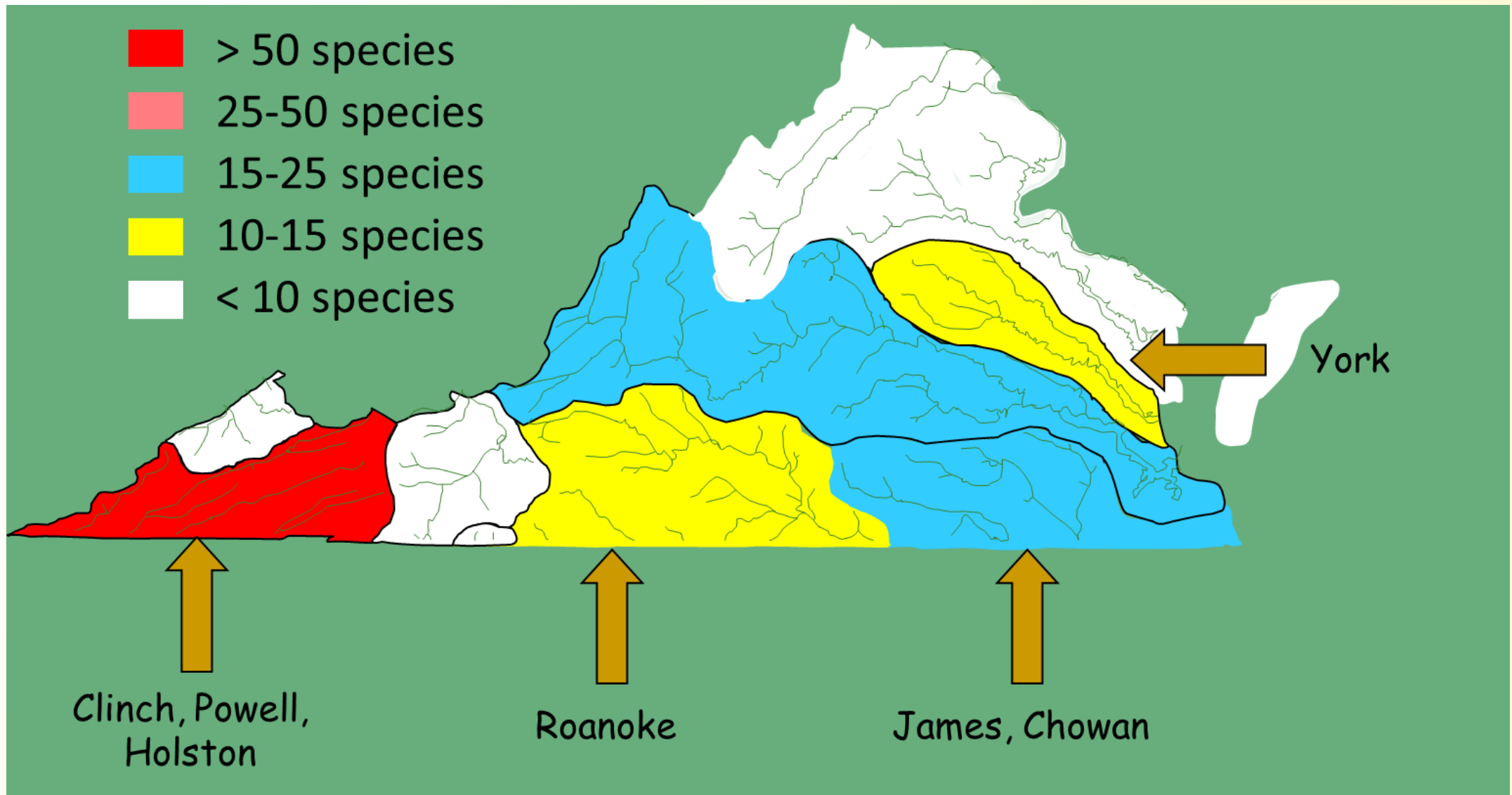


Species by State



VA: 6th Most in Nation





Mussel Diversity in Virginia



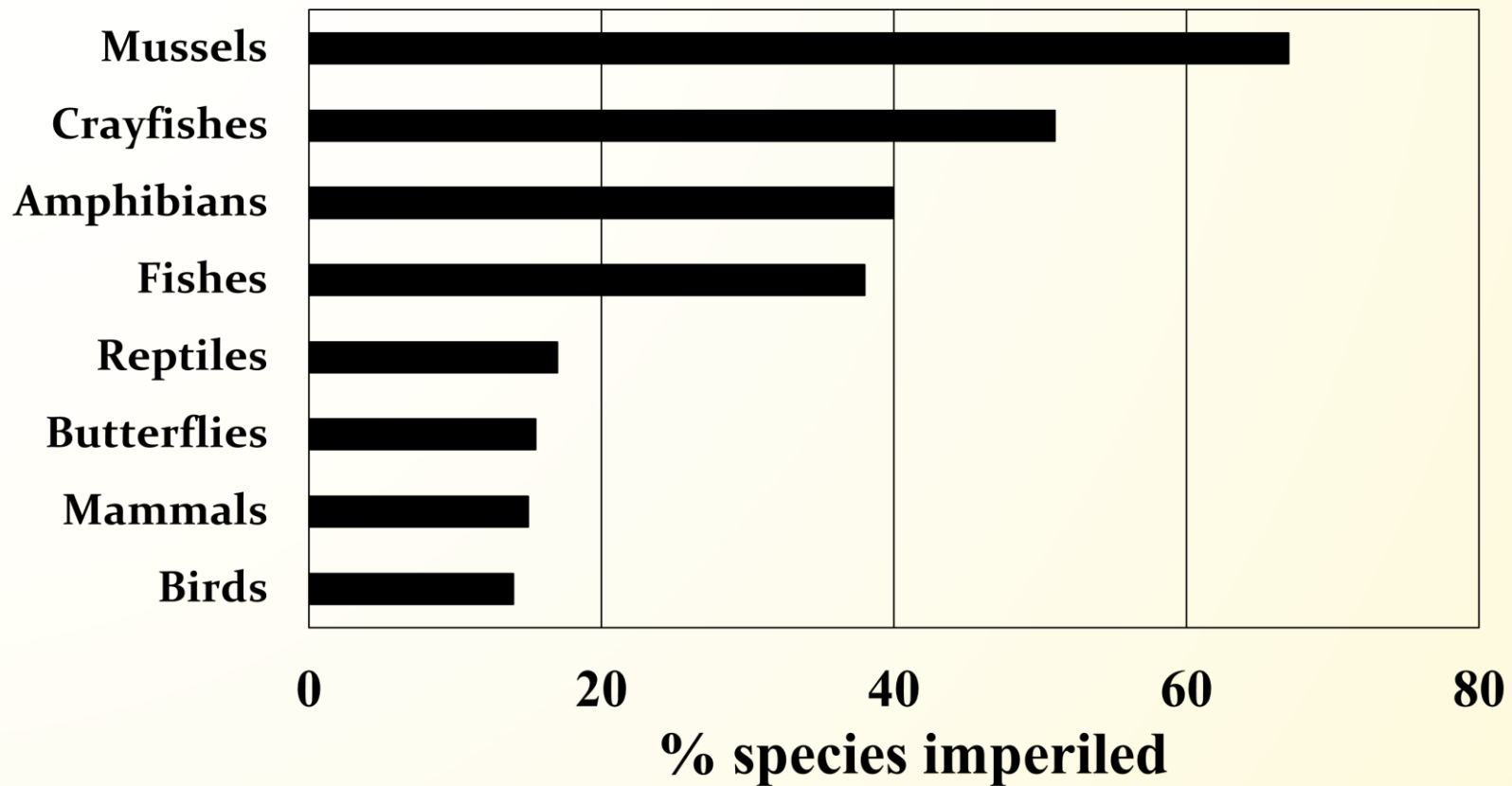
From one site in the Clinch River in one day, Scott County, VA

24 Species, of which 10 are listed federally endangered of extinction!



- Littlewing Pearlymussel • Cumberlandian Combshell
- Applachian Rockshell • Tennessee Bean • Elephantear
- Cracking Pearlymussel • Wavyrayed Lampmussel • Sheepnose
- Longsolid • Slippershell mussel • Pink Heelsplitter • Fanshell
- Slabside Pearlymussel • Golden Riffleshell • Deertoe
- Mountain Creekshell • Shiny Pigtoe • Rabbitsfoot
- Tennessee Clubshell • Fluted Kidneyshell
- Cumberland Moccasinshell • Mucket • Rough Pigtoe
- Black Sandshell • Birdwing Pearlymussel • Elktoe
- Green Blossom • Purple Wartyback • Acornshell
- Fragile Papershell • Snuffbox • Spectaclecase • Oyster Mussel
- Finerayed Pigtoe • Rayed Bean • Flutedshell • Pimpleback
- Brook Floater • Kidneyshell • Pink Mucket • Tennessee Pigtoe
- Creeper • Pocketbook • Cumberland Rockshell
- Tennessee Heelsplitter • Ohio Pigtoe • Rainbow
- Yellow Lampmussel • Purple Lilliput • Spike
- Dromedary Pearlymussel • Pheasantshell • Threeridge
- Pyramid Pigtoe • Cumberland Bean •

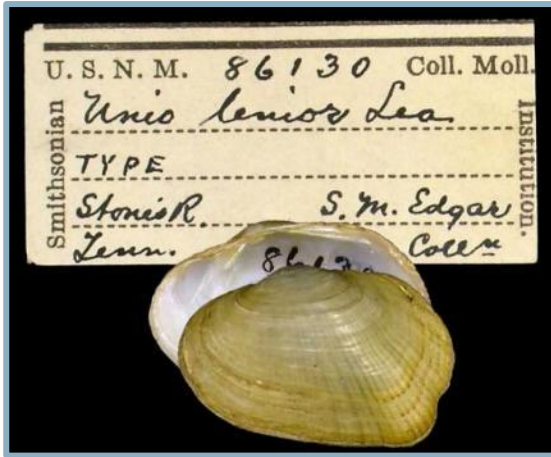




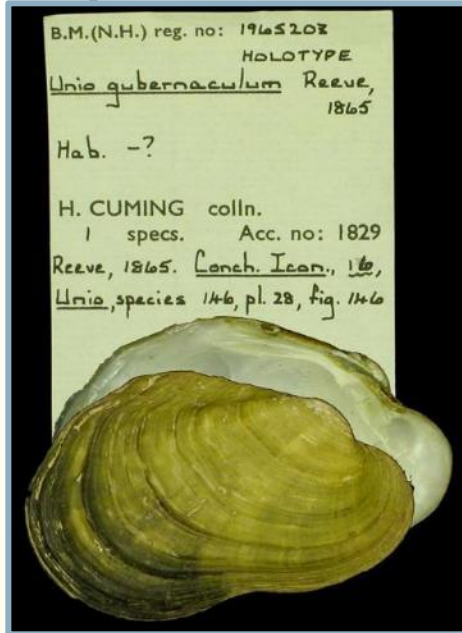
In North America, freshwater mussels are highly imperiled (nearly 70% endangered, threatened, or of concern)



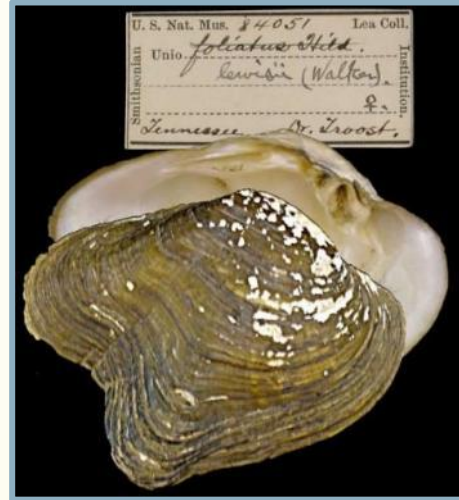
Extinct



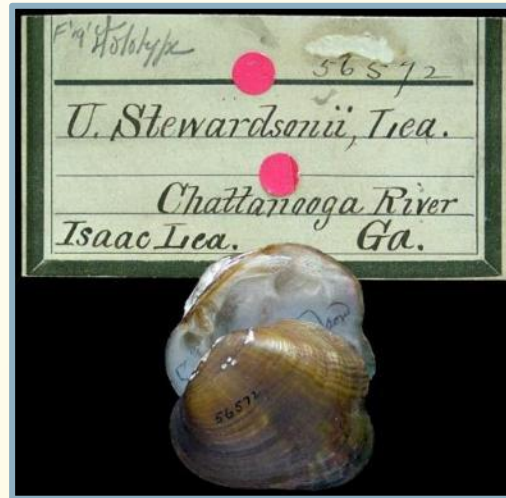
Narrow Catspaw
(*Epioblasma lenior*)



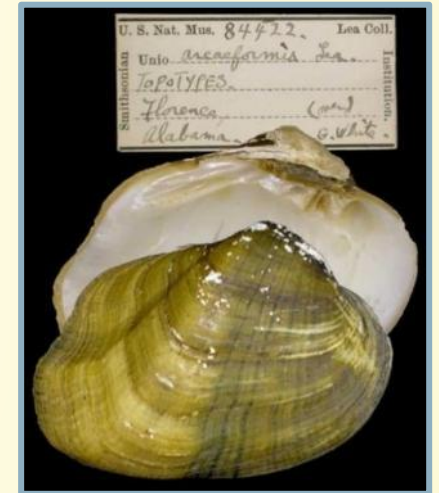
Green Blossom
(*Epioblasma torulosa gubernaculum*)



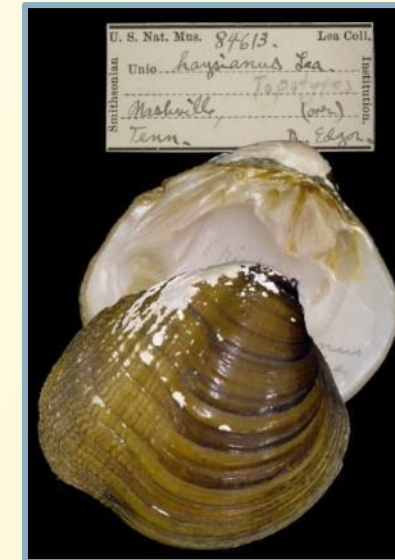
Leafshell
(*Epioblasma lewisii*)



Cumberland leafshell
(*Epioblasma stewardsonii*)



Sugarspoon
(*Epioblasma arcaeformis*)



Acornshell
(*Epioblasma haysiana*)



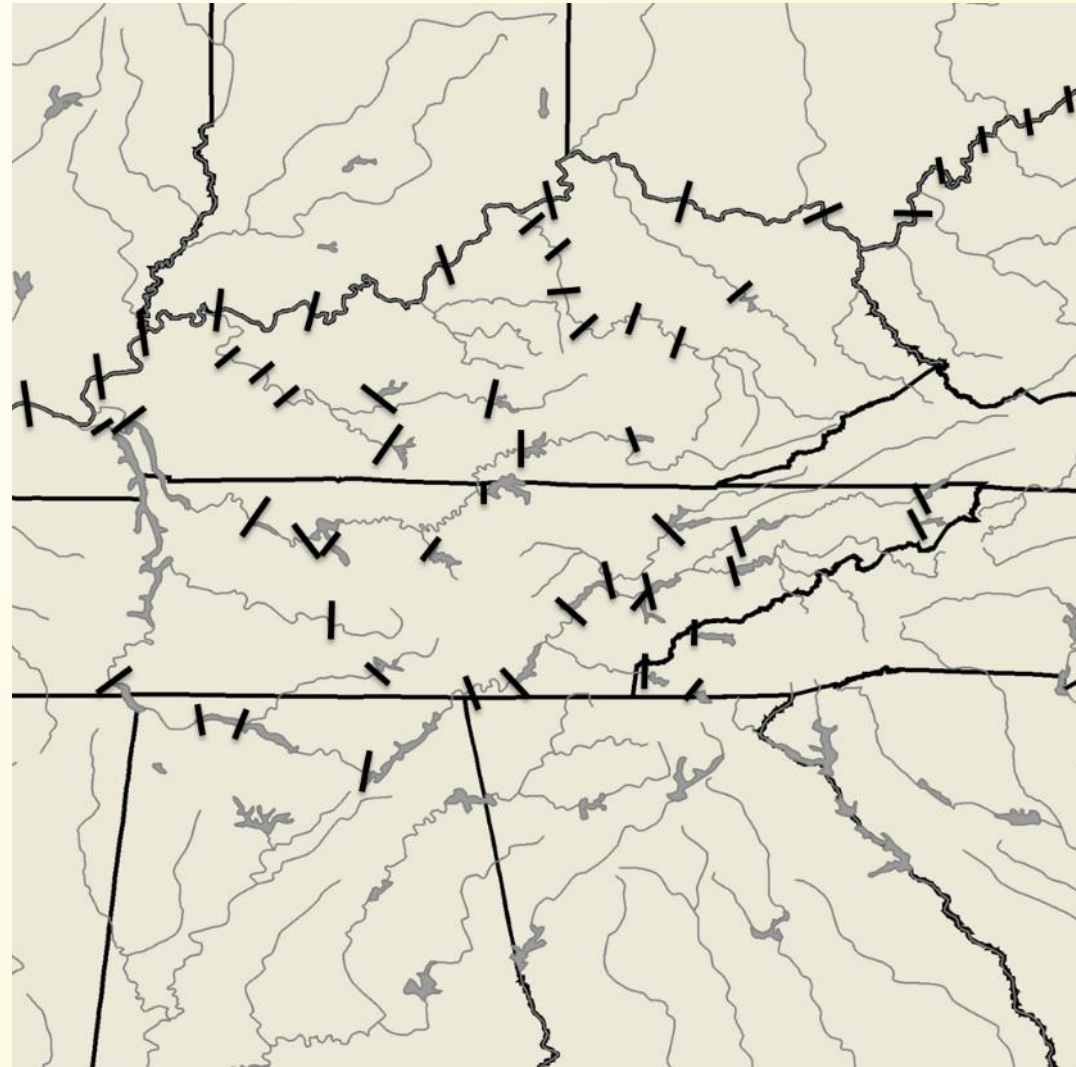
Cause for Decline: River Impoundment

- Degradation of stable mussel habitats
- Change how rivers function
- Hold back massive sediment loads
- Many release cold water, turning large sections of temperate streams to permanent cold water streams



Cause for Decline: River Impoundment

- Over 50 Major Dams on Ohio, Cumberland, Tennessee River Basins
- Does not show hundreds of other small impoundments
- Block native host fish passage



Elephantear – Functionally Extinct in Virginia



Causes for Decline: Exploitation for Button Industry



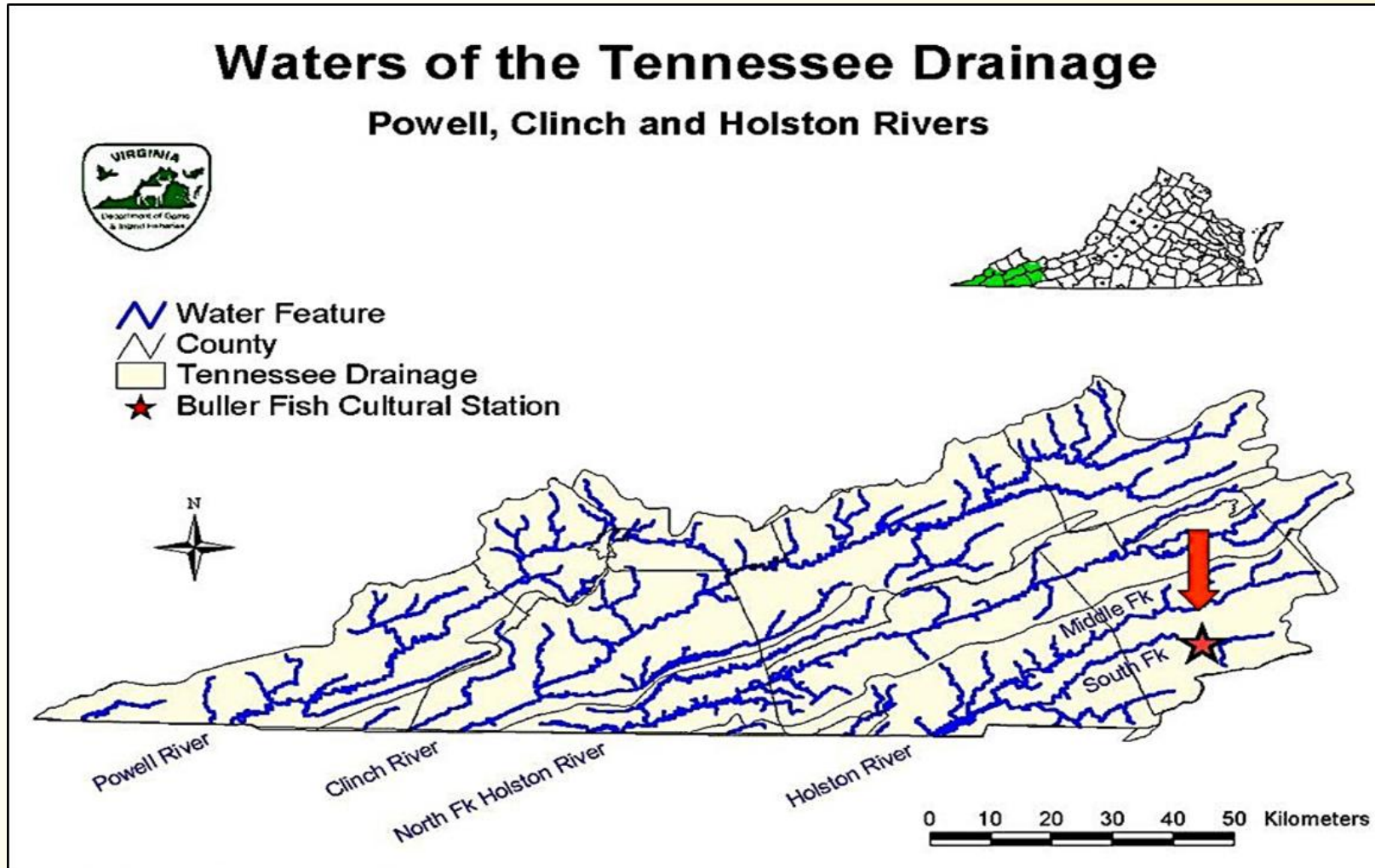
Cause for Decline: Sedimentation/Ag Runoff/Toxic Spills



DWR's Aquatic Wildlife Conservation Center Marion, VA



Located in Marion, VA



Pocketbook Mussel (*Lampsilis ovata*)



https://www.dropbox.com/sm/password?cont=https%3A%2F%2Fwww.dropbox.com%2Fs%2F9of4kumcctoykec%2FMussels%2520for%2520Tim%2520Lane.mp4%3Fdl%3Do&content_id=AJW9iOblbL5IEIB8T1MMJJXdVOA82r-pKLc

Black Sandshell (*Ligumia recta*)



Up to 6 inches in length



Wave lure
(similar to angler
jig) at dawn and
dusk in deeper
water



Walleye are known
to hunt
prey fish in early
morning
and late evening
hours in
deep pools and runs



Birdwing Pearlymussel (*Lemiox rimosus*)



**Birdwing
Pearlymussel**



Snail lure



**Greenside darter
Primarily food =
snails!**

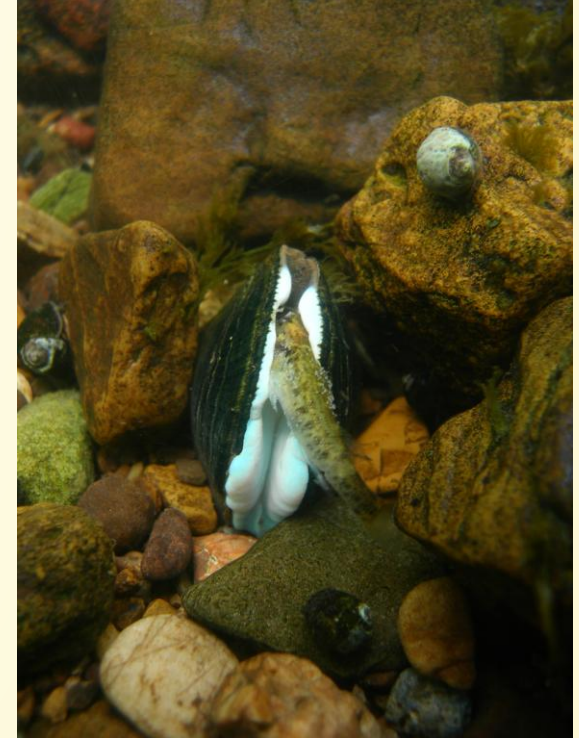
Oyster Mussel (*Epioblasma capsaeformis*)



**Oyster Mussel mantle
lure**



**Bluebreast darter (Top)
Redline darter (Bottom)**



Darter Captured

Capturing the Host Fish



Golden Riffleshell
Epioblasma aureola



Snuffbox
Epioblasma triquetra

Host capture by snuffbox mussel

Epioblasma triquetra

M. C. Barnhart 2005

<https://www.youtube.com/watch?v=-1YcaIN8cRs>



Larval Packets



Kidneyshell



Fluted
Kidneyshell



Fanshell
Mussel



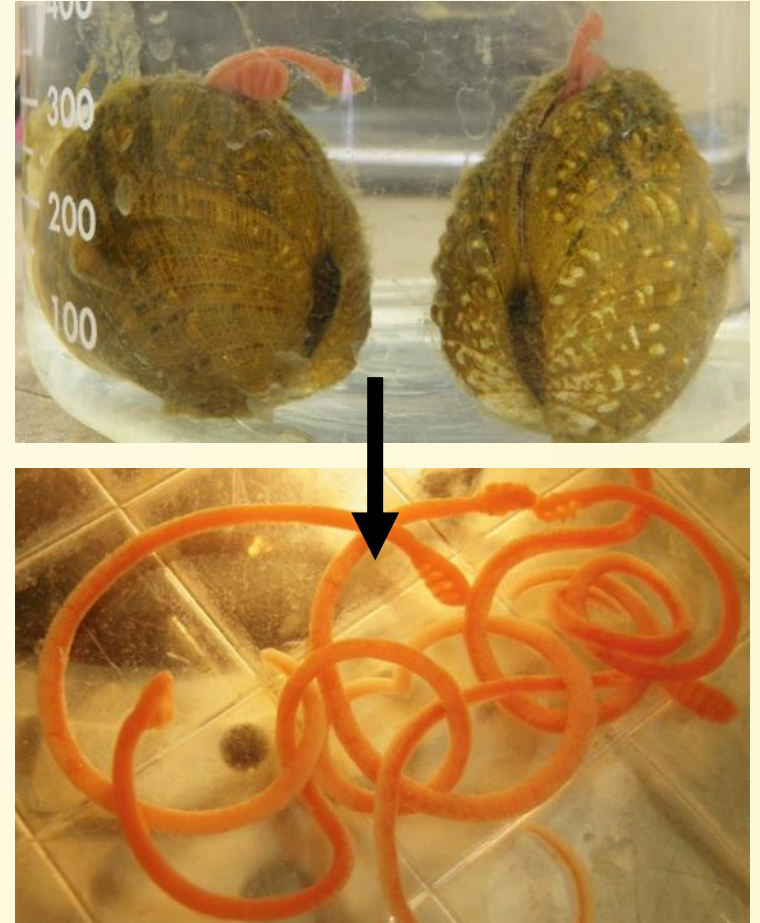
Dromedary



What We Do in the Lab



OR



Collecting Host Fish



Inoculation Of Fish Hosts

Glochidia Bath



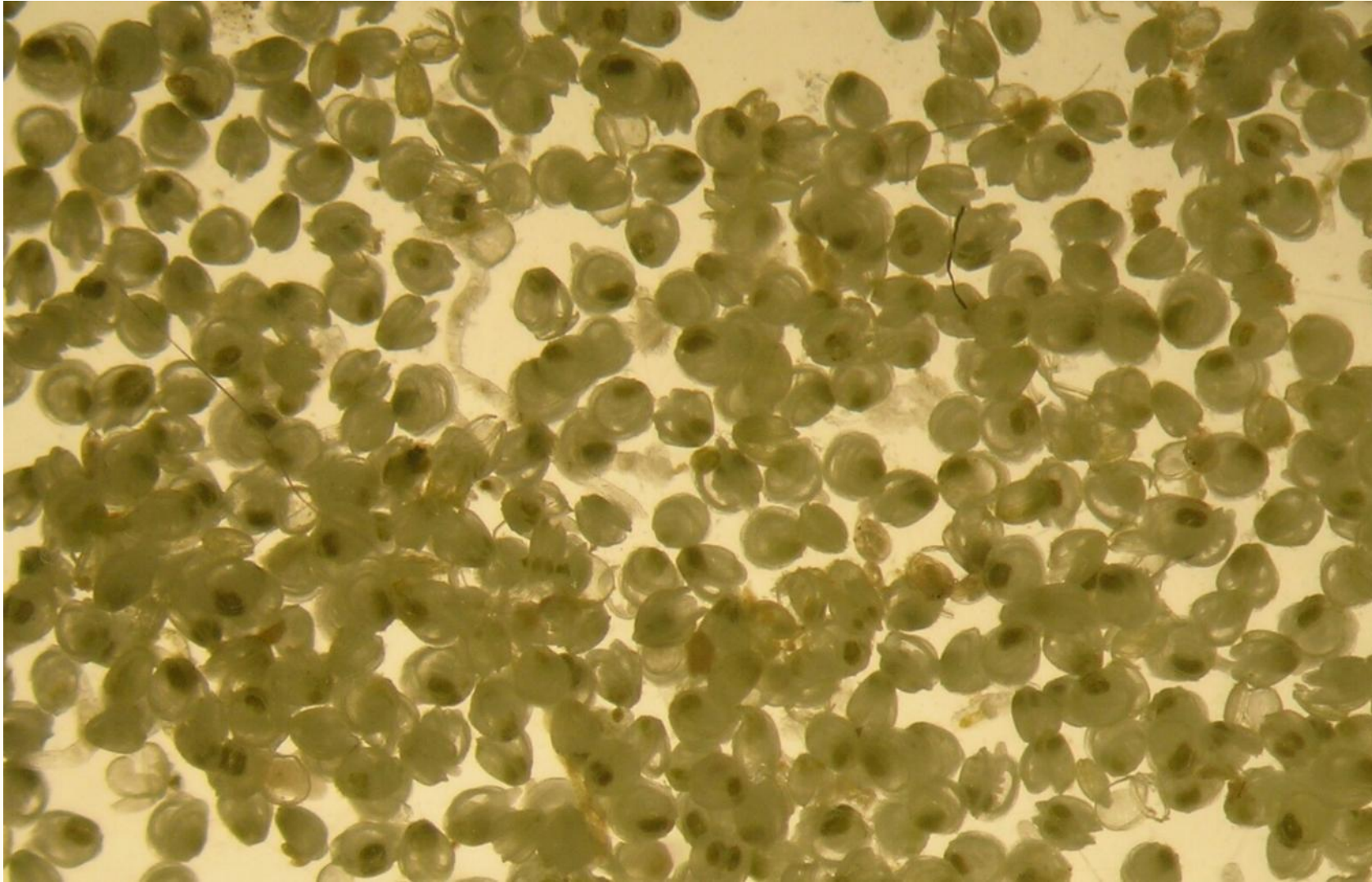


Encysted glochidia develop into juvenile mussels on captive fishes

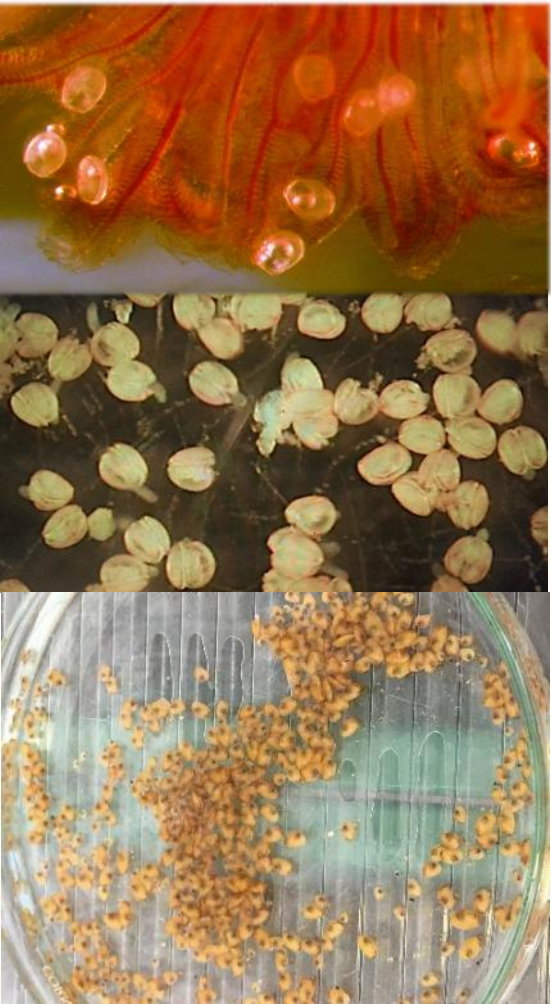
Propagation Systems



**Babies are
collected
and
counted by
the
thousands**



AWCC Production



Species	Status	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
<i>Actinonaias ligamentina</i>	Stable	24,867	0	52,889	0	41,684	0	0	0	0	0	0	0	0	0	0	12,880	26,576	0	0	0	0	158,896
<i>Actinonaias pectorosa</i>	Stable	3,092	65,921	48,789	187,519	218,472	131,850	88,958	0	0	0	0	0	0	0	0	52,132	84,243	36,005	0	5,448	10,437	932,866
<i>Alasmidonta marginata</i>	Stable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,220	0	0	0	4,220
<i>Alasmidonta viridis</i>	SE	0	0	0	0	0	0	0	0	0	0	0	0	0	850	4,773	0	261	0	0	0	0	5,884
<i>Cambarunio iris</i>	Stable	32,590	58,777	71,752	30,741	100,722	56,839	16,918	3,925	28,676	0	0	0	0	0	0	1,403	0	7,476	686	1,458	10,010	421,973
<i>Cyclonaias tuberculata</i>	Stable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,191	23,307	3,915	0	0	0	33,413
<i>Cyprogenia stegaria</i>	FE	0	0	0	0	607	6,017	475	0	5,755	0	0	0	201	28	8	0	0	430	1,143	11,871	0	26,535
<i>Dromus dromas</i>	FE	0	0	3,567	1,429	5,565	25,765	23,420	0	28,753	448	0	1,777	431	240	0	0	339	11,944	6,804	5,995	0	116,477
<i>Epioblasma aureola</i>	FE	17	0	~3000	~8000	~300	~4,500	~2,000	0	0	1,159	3,119	296	0	0	0	53	6,498	0	0	0	0	11,142
<i>Epioblasma brevidens</i>	FE	1,018	4,092	35,242	24,120	21,935	33,666	25,884	63,872	99,480	59,979	75,268	22,458	58,878	76,653	0	22,005	26,301	16,400	24,858	21,233	0	713,342
<i>Epioblasma capsaeformis</i>	FE	8,154	2,420	58,746	28,951	54,399	58,823	36,885	45,282	30,990	33,204	9,023	11,338	41,085	22,659	3,301	10,690	26,077	45,338	34,504	29,861	7,167	598,897
<i>Epioblasma triquetra</i>	FE	0	9,965	256	310	3,519	8,542	14,782	0	0	0	0	0	1,040	1,038	2,904	5,703	6,953	1,319	1,359	326	2,406	60,422
<i>Eurynia dilatata</i>	Stable	0	0	147	0	0	35,657	0	0	7,069	0	0	0	0	0	0	1,724	1,318	2,493	0	0	0	48,408
<i>Fusconia cor</i>	FE	0	0	128	39	103	0	0	80	0	67	0	0	0	363	0	0	0	0	0	0	21	801
<i>Fusconia cuneolus</i>	FE	0	0	0	0	0	0	0	0	2,285	0	0	0	0	0	185	0	0	0	0	0	0	2,470
<i>Hemistena lata</i>	FE	0	0	0	0	20	0	0	0	145	0	0	0	0	1	2	378	264	120	41	24	0	995
<i>Lampsilis abrupta</i>	FE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,230	0	0	0	0	0	452,402
<i>Lampsilis cardium</i>	Stable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21,234
<i>Lampsilis fasciola</i>	Stable	7,616	62,286	103,614	272,174	0	0	0	0	0	0	0	0	0	0	23,588	0	0	51,897	8,426	0	2	1,633,537
<i>Lampsilis ovata</i>	Stable	15,542	55,964	90,558	171,891	0	0	0	0	0	0	0	0	0	9,496	30,670	34,934	0	46,267	0	0	0	820,144
<i>Lasmigona costata</i>	Stable	0	0	0	4,648	4,980	4,846	1,908	827	0	63,655	0	0	0	0	0	0	0	0	0	0	4,519	85,183
<i>Lasmigona holstonia</i>	SE	0	0	0	0	0	53,025	16,268	51,655	0	6,097	52,266	0	0	0	11,654	0	0	0	0	0	0	190,965
<i>Lasmigona subviridis</i>	SE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	117,315	28,482	0	0	0	0	145,797
<i>Leaunia vanuxemensis</i>	Stable	0	3,488	14,337	42,936	45,802	8,122	23,400	29,279	0	0	0	6,743	5,979	19,576	3,362	529	0	0	0	0	0	203,553
<i>Lemiox rimosus</i>	FE	0	0	0	0	139	2,853	5,817	0	12,134	1,008	0	1,682	1,390	37,684	14,039	4,575	0	1,338	1,114	5,921	1,730	91,424
<i>Ligumia recta</i>	SE	0	17,791	32,184	0	43,400	0	0	0	21,138	43,464	897	0	0	0	9,469	1,896	21,814	0	362	0	6,889	199,304
<i>Medionidus conradicus</i>	Stable	0	456	0	0	0	0	5,867	482	6,370	0	4,759	0	7,429	145	0	903	0	0	0	0	147	26,558
<i>Plethobasus cyphus</i>	FE	0	0	0	0	0	0	0	516	0	0	0	0	0	0	7	199	0	74	0	0	0	796
<i>Pleurobema oviforme</i>	Stable	0	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46
<i>Pleurobema plenum</i>	FE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	72	52	53	299	109	605
<i>Pleuronaia barnesiana</i>	Stable	0	0	0	0	0	0	0	0	150	0	0	0	1,171	0	0	0	0	0	0	0	0	1,321
<i>Pleuronaia dollabelloides</i>	FE	0	0	0	0	0	0	0	0	457	0	0	0	0	0	0	0	0	0	0	0	2,558	3,015
<i>Ptychobranchus fasciolaris</i>	Stable	0	0	392	5,040	0	0	173	3,326	0	49	8	0	0	0	0	1,370	0	0	0	0	0	10,358
<i>Ptychobranchus subtentus</i>	FE	0	1,784	0	0	756	41,849	3,002	0	0	0	0	0	3,113	10,773	0	0	327	0	0	0	19,681	81,285
<i>Strophitus undulatus</i>	Stable	0	0	0	0	0	0	916	0	0	0	0	0	0	0	4,701	143	0	0	0	0	0	5,760
<i>Theliderma cylindrica</i>	FE	0	0	0	0	0	0	0	310	60	0	0	0	0	211	7	179	22	761	607	0	1,017	3,174
<i>Theliderma intermedia</i>	FE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	152	31	0	0	0	211
<i>Theliderma sparsa</i>	FE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	375	858	470	51	5,102	6,856
<i>Tritigonia verrucosa</i>	SE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28,679	0	0	0	0	28,679
<i>Venustaconcha trabalis</i>	FE	1,272	2,961	7,965	3,764	13,858	4,148	2,285	6,474	2,809	8,914	8,009	8,765	5,795	8,910	45,896	6,867	5,948	11,470	7,663	5,202	2,004	170,979
Total		94,168	285,905	520,566	773,608	924,496	855,932	662,930	571,015	466,432	220,642	220,139	114,305	158,021	188,627	154,566	190,032	348,162	320,803	88,090	87,689	73,799	7,319,927

7.3 Million Mussels

20 FE Species + 5 SE Species + 15 Stable Species/Under Review = **Total 40 Species!**

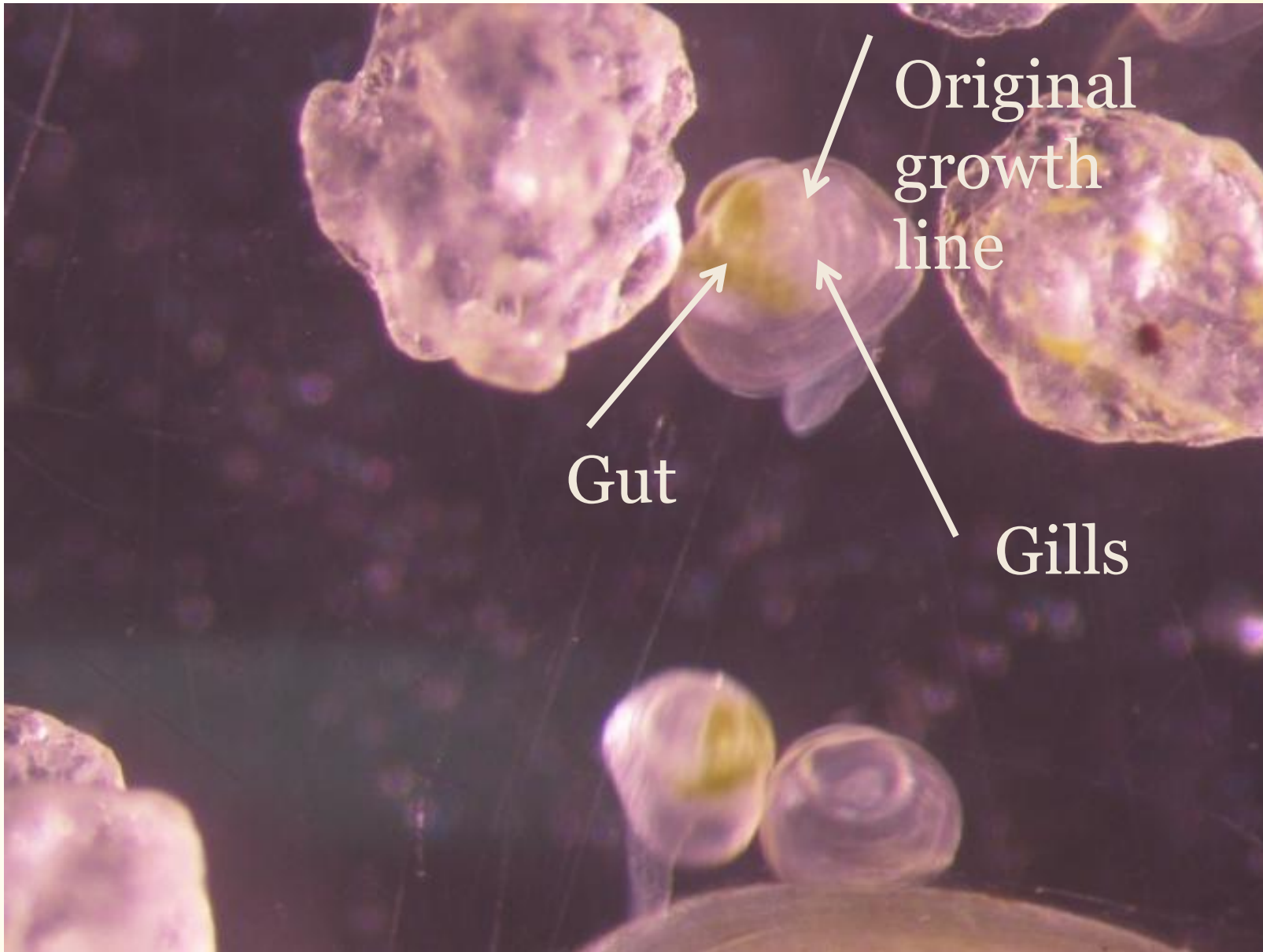


Pulse Flow Boxes



Fed marine algae
grown in California





Recirculating Rearing Unit



Outdoor Pond Culture System



Fed naturally growing algae from the pond



AWCC Releases



~200,000 Sub-Adult Mussels of 38 Species
Stocked to Virginia Streams and Donated to
Regional Partners from 2003-2025!

18 FE Species + 5 SE Species + 15 Stable Species/Under Review = **Total 38 Species!**



Endangered Species Released

Fanshell



Tennessee Bean



Dromedary Pearlmussel



Birdwing Pearlmussel



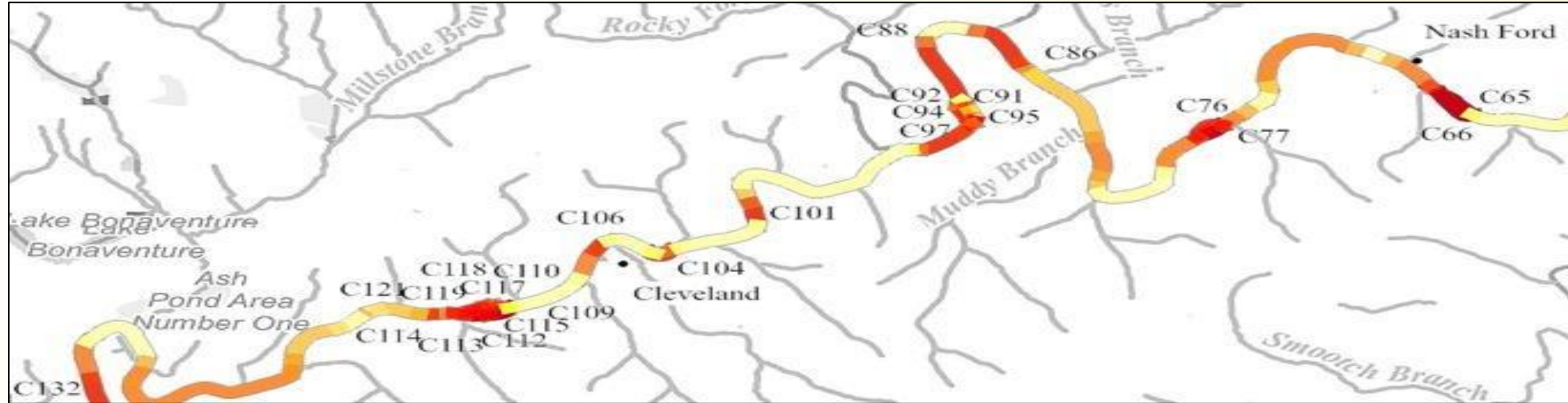
Shiny Pigtoe



Cumberlandian Combshell



Focal Reach (Restoration Reach 4), Clinch River, Russell Co.



Monitoring Survival Post-Release





Golden Riffleshell Release, Cedar Bluff (Restoration Reach 5)

- After 1998 spill ~350 Golden Riffleshell were counted dead – largest single kill in history of ESA
- Worked with VT and KY partners to produce juveniles using *in vitro* incubation techniques
- In 2017 we released 710 animals across 3 sites at and nearby kill zone – 20 year process



Photo credit: Gary Peeples, USFWS





Photo credit: MUSSELP Database

Theliderma sparsa (I. Lea, 1841)

- Appalachian Rockshell (formally Appalachian Monkeyface)
- Status: CR Endangered (IUCN); G1 Critically Imperiled (NatureServe); Endangered (USFWS)
- 1 of first 5 mussels listed under ESA in April 1976
- Type Locality: I. Lea (via Troost and Edgar)
Holston River

Could not figure out fish hosts for 50 years!!!



	Years Tested and Produced											
	2019			2020			2021			2022		
	Total Fish Tested	Days to excyst	N	Total Fish Tested	Days to excyst	N	Total Fish Tested	Days to excyst	N	Total Fish Tested	Days to excyst	N
Fish Species	(Survived)			(Survived)			(Survived)			(Survived)		
Catostomidae												
Hypentelium nigricans (Northern Hog Sucker)	1 (0)	-	-									
Moxostoma anisurum (Silver Redhorse)	1 (0)	-	-									
Moxostoma erythrurum (Golden Redhorse)	1 (1)	-	-									
Centrarchidae												
Ambloplites rupestris (Rock Bass)	1 (1)	-	-									
Lepomis auritus (Redbreast Sunfish)	1 (1)	-	-									
Lepomis macrochirus (Bluegill)	1 (0)	-	-									
Cottidae												
Cottus carolinea (Banded Sculpin)				8 (8)	-	-						
Camptostoma anomalum (Central Stoneroller)	4 (3)	-	-									
Cyprinella galactura (Whitetail Shiner)	8 (1)	-	-									
Cyprinella spiloptera (Spotfin Shiner)	5 (4)	-	-									
Erimystax maculatus (Spotfin Chub)	1 (1)											
Erimystax dissimilis (Streamline Chub)	4 (0)	>55**	-	2 (0)	-	-	24 (19)	32-56	858	14 (5)	19-37	110
Erimystax insignis (Blotched Chub)				13 (6)	16-42	975				40 (30)	18-28	360
Hybopsis amblops (Bigeye Chub)				2 (1)	-	-						
Luxilus chrysocephalus (Striped Shiner)				2 (2)	-	-						
Nocomis micropogon (River Chub)	2 (0)	-	-	1 (1)	-	-						
Notropis hudsonius (Spottail Shiner)	5 (4)	-	-									
Notropis telescopus (Telescope Shiner)				1 (1)	-	-						
Phenacobius uranops (Stargazing Minnow)	2 (0)	-	-									
Pimephales vigilax (Fathead Minnow)	4 (0)	-	-									
Rhinichthys cataractae (Longnose Dace)				1 (1)	33-38	6						
Rhinichthys obtusus (Western Blacknose Dace)				8 (5)	22-24	2						
Ictaluridae												
Ameiurus natalis (Yellow Bullhead)	1 (1)	-	-									
Noturus eleutherus (Mountain Madtom)	1 (0)	-	-									
Percidae												
Etheostoma blennioides (Greenside Darter)	3 (2)	-	-									
Etheostoma flabellare (Fantail Darter)				4 (2)	-	-						
Etheostoma rufileatum (Redline Darter)	2 (2)	-	-									
Percina aurantiaca (Tangerine Darter)	1 (0)	-	-									
Percina caprodes (Logperch)	2 (2)	-	-									

Highly Suitable



E. Insignis
Blotched Chub

Suitable



E. dissimilis
Streamline Chub





T. sparsa Successful Release in 2022!



Aquatic Wildlife Conservation Center Staff

- Joe Ferraro, Natural Resource Specialist (retired)
- Sarah Colletti, Mussel Recovery Biologist
- Tiffany Leach, Mussel Recovery Biologist
- Tim Lane, former SWVA Coordinator
- Hayley Bordwine, Mussel Restoration Specialist



Everything is connected!

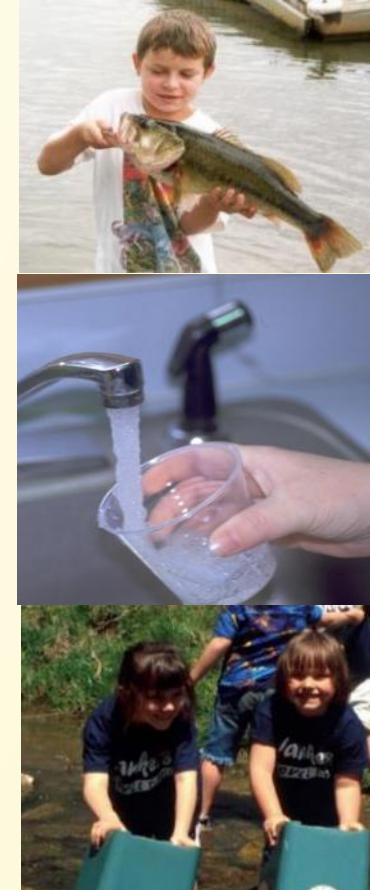
Healthy
Mussels



Healthy Rivers



Healthy
Humans



Thank you! Questions?

