SOURCES & TRANSPORT

LESSON: Watershed Walk

This activity was modified from the "Watershed Walk" lesson housed on the Northwest Aquatic and Marine Educators website (https://www.pacname.org/ocep-watershed-walk-high-school/), with permission from Oregon Sea Grant who is a co-author on the activity, along with the Oregon Coast Education Program (OCEP) Leadership team members.

Grade Levels: 5-12

Subject Areas: Marine Biology: Debris Sources, Ecology

NGSS Connections:

- MS-ESS3-1:
  - ESS3.A: Natural Resources - Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- MS-ESS3-3:
  - Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
  - ESS3.C: Human Impacts on Earth Systems - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
  - ESS3.C: Human Impacts on Earth Systems - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
- HS-ESS3-1:
  - ESS3.A: Natural Resources - Resource availability has guided the development of human society.
  - ESS3.B: Natural Hazards - Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.
- Appendix F: Science & Engineering Practices

Time:

- 90 min prep
- 3 class periods: 1 class period – introductory presentation; 1 class period – field experience; 1 class period –- reflection.

Description & Objectives: These lessons are designed to be used after completing any of the Composition & Abundance lessons. Students will investigate and learn about nearby watersheds and about the ridge-to-reef concept. Students will use this knowledge to investigate how marine debris gets into and moves around the ocean. They will look for evidence to determine the source (land or sea) of different types of marine debris.

Guiding Questions:

- Where does most marine debris come from in the U.S. Virgin Islands?
- How does marine debris get into the ocean?
- How are terrain, water systems, and marine debris connected?

Key Ideas & Concepts:

- Marine debris exists both where we can easily see it (beaches, wrack lines on the beach) and cannot easily see it (ghuts leading to the beaches or under sand and the surface of the water).
- Most marine debris comes from land-based sources (us!).
- Debris deposited by accident or on purpose, can travel downhill from waterways and through watersheds into the ocean.

Pre-Requisite Skills: Students will need to understand the basic concepts of marine debris, topography, watersheds, and the water cycle.

Teacher Preparation: Scout out an appropriate watershed to observe either on school property (ideal!) or nearby. As one of the goals of this activity is to provide experience with local watersheds that connect to local reefs, adequate time outdoors is helpful. The activity can be completed using Google Earth, if needed. Make a list of features of the chosen watershed (flat vs. steep, number of ghuts/human-made drainages, amount of natural vegetation, concrete/asphalt or dirt surfaces). This works best in an area where students can see the whole watershed to answer some of the questions in the Watershed Worksheet, though this is not always possible. If needed, review general topographic and watershed concepts with your students. This can be done as separate lessons/class periods, if needed.

The United States Geological Survey has two introductory classroom activities that explain how to read and create topographic maps which may be helpful to review or complete with your students prior to this lesson. Those activities can be found here: http://www.orange.wateratlas.usf.edu/upload/documents/HowToReadTopoPlusActivity.pdf and https://education.usgs.gov/lessons/toposaladtray.pdf.

NOAA also has a great lesson which is available here: https://oceanexplorer.noaa.gov/edu/lessonplans/ring_topographic_6_8.pdf

There is a mini-topography worksheet that can be used as part of this lesson plan, as well. This lesson can be

used with students to predict how topography might influence what, where, and how much trash might enter the ocean, becoming marine debris: http://www.education.com/worksheet/article/topographic-map-matching/

For more information about watersheds, visit: https://oceanservice.noaa.gov/facts/watershed.html then answer a worksheet about it.

Materials Needed:

- Computer/projector and internet access
- Video: NOAA Video "TRASH TALK: Where Does Marine Debris Come From" (https://www.youtube.com/watch?v=FN9FF7VH4ig)
- Watershed Walk Worksheet (at end of instructions)
- U.S. Virgin Islands Watershed Map (at end of instructions)
- Pencils, sturdy surface to write on (clipboards/notebooks), safety equipment (first aid kit, field trip paperwork, if leaving campus), camera (optional), art supplies (optional)
- Students: proper footwear/attire for outside exploration

Teacher Instructions:

Classroom introduction - explore the area around the school and define "watershed": An engaging way to introduce this topic is to show students a mapping website that has topographical features on it, such as Google Earth. You can ask them to describe the area around their school using the map.

- **Guiding questions:** Where is the school in relation to mountains or steep terrain? Where are flat or low areas in the landscape that might flood with heavy rain? Where is the closest ghut and/or drainage ditch? Follow the ghut and/or drainage ditch - where does it lead to? Does it cross any streets or appear to go underground? Where does it meet the ocean?

After the class has described the area, this is a good time to define/describe what a watershed is and to review the water cycle, if this has not already been taught.

- According to NOAA, a watershed is "a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays and oceans."
- In the U.S. Virgin Islands, we don't have snow, but we do have rain. Here and elsewhere, water flows from higher ground, like the hills and mountains, along low points in the landscape, like streams, ghuts, and human-made channels, to areas of lower ground where it fills retaining ponds or empties into the ocean.
- Have the students relate the description of a watershed, local topography, and other landscape features (e.g., ghuts, human-made channels, low areas) back to the previous discussion about the area around their school.
    - **Guiding questions:** Is our school part of a watershed? How can you tell? (Answer: Yes! Every place on land is part of a watershed which can vary in size and shape based on terrain. This is a great place to show and talk about the U.S. Virgin Islands Watershed Map (included), which depicts watershed boundaries, locations of some U.S. Virgin Islands schools, and ghuts in relation to topographic features like hills, mountains, and drainages).

Watershed presentation: After the class has described their area and recognize that it is part of a watershed, you should begin your watershed presentation in preparation for the Watershed Walk. *Make sure students know they will be using this information to answer questions during their Watershed Walk.*

- Emphasize the role local terrain and landscape features have in moving water across the land. It will help students if you emphasize the effect of plants and dirt (which absorb water) versus concrete and metal (which tend to repel water, moving it elsewhere), in how water moves through the watershed. Where would you expect water to move more quickly, over the natural landscape (plants, dirt) or the human-made landscape (concrete/metal)? Answer: concrete/metal. What might this mean for trash in the watershed? How might it be expected to move across the landscape? Where might it aggregate (low spots in the landscape, like ghuts, human-made drainages, and drainage ponds)? What other features in the landscape might affect the amount of trash in the watershed (e.g., presence and location of roadside dumpster bins, the landfill, areas with high human use)? Ultimately, where could all this trash end up? Answer: the ocean. Emphasize the ridge-to-reef concept. Debris higher in the landscape can travel downhill where it can be deposited into salt ponds, mangroves, beaches, and adjacent coral reefs and seagrass meadows, putting those habitats and the organisms that live there at risk.
- Next, show your students the NOAA video "TRASH TALK: Where Does Marine Debris Come From" (https://www.youtube.com/watch?v=FN9FF7VH4ig). The following discussion could be expanded to its own class period depending on time and interest.
    - **Guiding questions:** Think about the TRASH TALK video. In it, they talk about the many ways trash can find its way into the ocean, including land-based and ocean-based sources. Which do you think is most important in the U.S. Virgin Islands? Data from the territorial beach cleanups indicates that most marine debris found on U.S. Virgin Islands beaches comes from land-based sources - that means it comes from us! What's the good news? If it comes from land-based sources, it means that we can prevent it. What do you think happens to trash, like a plastic bag, on a windy day? What about a water bottle on a slightly rainy day? On a really rainy

day? Ask students to think about how roadside dumpsters could impact the watershed (where does the trash enter the watershed and where could it end up? How might dumpster location matter? Or the number of dumpsters?). What do you think happens to the trash that blows or washes in from roadside dumpsters or is thrown into the ghuts on purpose? What about storm drains? Do those get flooded and overflow during the rainy season? Many ghuts are dry for part of the year. What happens to the trash that collects in them during the dry season when it comes to the rainy season? What about recycling? If the U.S. Virgin Islands had a wide-spread recycling program how might that impact how much trash ends up in the ocean? Ask students to think about how waste management practices (e.g., placement of roadside dumpsters, frequency of hauling) and personal behaviors (e.g., reducing the amount of garbage that they individually produce, reducing their use of single-use products like plastic beverage bottles or plastic cups, making smart choices to reduce packaging when making purchases, not littering, making sure their garbage ends up in a waste bin and not overflowing onto the ground, picking up after themselves at an event like a beach party) could reduce the amount of marine debris that ends up in our local waters. Emphasize the reduce, repurpose, reuse concepts rather than recycling, since no formal, widespread recycling program currently exists in the U.S. Virgin Islands. Have students consider U.S. Virgin Islands-specific marine debris issues not covered by the video (e.g., landfills that are at or near capacity, no landfill on St. John, cruise ship passengers that generate waste locally, prevalence of single-use water bottles (in schools and as fundraising items), shipping (>95% of our food is imported, most other household items are also imported), fishing (traps, lines, nets), storm impacts (e.g., abandoned and capsized boats).

Field trip - Watershed Walk: Make sure all students have a sturdy surface to write on, pencil, appropriate clothing (sneakers, especially if you are leaving campus) and the Watershed Walk worksheet (included). The students will travel to the selected watershed (on- or off-campus) and will be answering questions about what they are observing and how it relates to the information you provided in the watershed introduction and the water cycle. It is a good idea to plan 2-4 stopping points to help students connect the worksheet questions with a local area.

- **Guiding questions for each stop:** We are stopping to look at this area, what do you notice about it? Is it covered in human-made materials or is it natural (linking to previous activities to engage prior knowledge)? Why does the surface material matter, in terms of the water cycle? Does the rain run-off this area or get absorbed? What plants (if any) are growing here? How are these different from plants found on different areas of the school grounds? How might they impact the way water flows? What types of plants are going to stop small pieces of debris? What types of plants are going to stop large pieces of debris? Are there any types of debris that plants won't stop? What about the trash that's out here (if any) - what is likely to happen to it when it rains? Where might it end up?

Watershed Worksheet (included) – modify based on number of stops during your walk:

1. Look around the area. Where is the highest point in the watershed? If water falls or runs off the edge of that point, where does it go? Is there more than one high point in the area? What would happen to rain, if there are multiple high points in this area?
    - ***Teacher Note:*** *This is a good time to review the water cycle – Ask them what happens to rain drops after they fall from the sky. Have them answer this question and questions 2-3 at each stop.*
2. Are there any ghuts nearby? Can you see them easily, or are they hidden by plants or human-made structures? Can you tell if they are straight or curved?
    - ***Teacher Note:*** *If there is a nearby ghut, take the students to it if possible. If a ghut or other natural water feature is too far away, take time to discuss what would happen if a ghut was running through the middle of the area you are in. Your students should make notes that ghuts tend to curve, while human-made ditches tend to be straight.*
3. Keep a running list of the different types of surfaces you came across during your walk.
    - ***Teacher Note:*** *Encourage students to notice the differences between dirt, grass, gravel, paved roads, parking lots, sidewalks, dirt roads, etc. The rest of the questions could be completed inside or as homework, depending on class time available, but are best answered while still outside.*
4. What are some things you noticed on your walk that may negatively impact the water flow? Think about how watersheds hold and release water. Think about the quality of water moving through the area, did you see any trash?
    - ***Teacher Note:*** *Encourage students to think about the water cycle again and how water moves through an area. This is a good time for talking about how different surfaces interact with water (added pollution, water getting absorbed or not, the effect of plants on water movement). Ask students to think about where the roads are built: Are they in a naturally flat area or hilly areas? Are they next to a drainage ditch? Are they built over a ghut or where a ghut used to be? All these things impact water flow and it is good to ask students to think about them while they are standing outside, looking at the environment around them.*
5. Did you notice any storm drains? Did you see any that could get backed up when it rains? What happens to all the trash when the drains get backed up?
    - ***Teacher Note:*** *Encourage students to think about human impacts on the environment with these questions. On St. Thomas – ask students to think about the storm drain in front of Banco Popular by Addelita Cancryn Junior High School. On St. Croix – ask students to think about either Gallows Bay or the bottom of King Cross St. in*

Christiansted. Also, ask students to note the differences around storm drains during dry times and right after a heavy rain. What do students remember seeing and smelling? Can they see and smell marine debris in those areas? Also, ask them to think about how water flows over concrete and metal (storm drains) versus dirt and plants (ghuts): is trash going to get caught in the storm drain or will it be easier for it to flow to the sea?

6. What are some things you noticed on your walk that may positively impact the water flow? Think about how watersheds hold and release water.
    - ***Teacher Note:*** *This is an especially good time to ask students to observe and record the type of plant life in the area. Native plants are especially adapted to hold soil in place, preventing lots of water and dirt from flowing into the sea and filtering the water so there is not so much silt being dumped into the ocean. Have students look to see if they can observe a nearby salt pond or mangrove ecosystem or think about where these occur nearby. Salt ponds and mangroves are great at catching all sorts of materials before they enter the ocean. Ask students to try to think of things they can see on the walk that would be good for a salt pond or mangrove forest to catch and keep out of the sea.*
7. What are some of the ways that water flowing from high in the watershed down to the ocean below, impacts marine life?
    - ***Teacher Note:*** *This is a good time to have the students re-think about what happens when it rains, but this time have them focus not only on how water moves, but what it carries with it (oil, trash, dirt, other contaminants, etc.) and how those things can impact nearshore environments (mangroves, reefs, and seagrass meadows). Ask students to think about how impacts might be different in these different habitats. This is also a good time to make the distinction between pollutants (e.g., oil, heavy metals, other contaminants) and marine debris (which is defined as "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes").*
8. Do these impacts change when there is a heavy rain or a light rain?
    - ***Teacher Note:*** *It would be good for students to make note of how the water flow changes during light and heavy rains and thus with rainy and dry seasons. Ask the students to think about areas they know are dry except for when it rains. If this is a site that you visit regularly and it experiences very different wet and dry conditions, consider taking pictures or video to share with your students so they can appreciate how different weather conditions affect the area and how that could impact how land-based sources of marine debris could enter the ocean.*
9. Do these impacts change during the different seasons of the year?
    - ***Teacher Note:*** *It would be good for students to make note of how the water flow changes during the rainy season compared to the dry season on the island. Ask them to think back to question 5 and to think about what those areas look like during the dry season and the rainy season. As in question 8, if this is a site that you can visit regularly, and it experiences very different conditions during rainy and dry seasons, consider taking photos or video to share with your students, to enrich this discussion.*

In the classroom: Reflect: Ask the students to share something they found interesting or something that surprised them, while on the Watershed Walk. Show students the map of the area around their school and show them the map of an area on a different island in the U.S. Virgin Islands.

- Have the students share some of the similarities and differences they can spot. Ask the students how the difference in elevations (topography) might change how the flow of trash, oil, and dirt move through the watershed. Have them think about how topography, natural landscape features (e.g., forests, salt ponds, mangroves, beaches) and human-made modifications to the landscape (e.g., roads, human-made drainages, locations of roadside dumpsters, locations of landfills) could influence what, where, and how much trash might enter the ocean, becoming marine debris.
    - ***Teacher Note:*** *Based on student answers, guide them toward the idea that more rain is needed to move larger, heavier objects. During light rain some trash will get stuck in the ghuts, while during heavier rain events, it is more likely that more trash will be flushed into the ocean. This could also be a time to explore inter-island differences in human populations across the U.S. Virgin Islands and how waste is managed differently on each of the islands.*
- Continued exploration: Ask the students to complete a neighborhood Watershed Walk around their home or on their walk home from school as additional homework. Ask them to share similarities and differences from what they observed during the in-class Watershed Walk.
- Links to other subject areas:
    - Link to language arts: Have the students write a short story from the perspective of a piece of litter that becomes marine debris. Have them consider its journey from ridge-to-reef and impacts to the local environment and local community.
    - Link to mathematics: Create simple math problems that have students predict transport of marine debris items under variable watershed, seasonal, and weather conditions (e.g., topography, slope, amount of rain, flow rates, etc.).

- Link to the arts: Have students draw a picture of their local watershed, the path a trash item might take through this landscape to the ocean to become marine debris, and the impacts to local environments and communities.

Assessment and evaluation: Ask students to draw and label a local watershed with the following traits: ghuts and where they meet the ocean, high/low areas, the types of surfaces (grasses, dirt, pavement), and have them incorporate the steps of the water cycle.

- Have students label/identify the features of the watershed that make marine debris more mobile.
- Have students predict which ghuts might have the most debris in them (students might predict that those ghuts running through or directly adjacent to roadside dumpsters, ghuts with easy road-side dumping access, and ghuts closer to large population centers, might have more debris than other ghuts).
  - Have students label different dumpster sites on a map and draw the possible debris transport pathways. As students complete additional marine debris lessons, and lessons about watersheds and the water cycle, they can add more ghuts and bays, and outline watersheds on the map. Additionally, students could identify where debris collects in their communities and map those areas as well. Students could then present this at the end of the year to different classes in their school or in different schools.
- Have students hypothesize how marine debris accumulation and movement would be different in this watershed under different weather events – rainy season versus dry season, before and after storm events.
  - What do you think happens to the trash on a windy day? On a lightly rainy day? A really rainy day? What do you think happens to the trash that blows off the road side dumpsters or is thrown into the ghuts on purpose? Where does the trash end up after a storm event? How might the volume of trash entering the ocean be different before and after a storm?

Teacher Note: *For more information about how debris from land can become trapped in mangrove shorelines of the U.S. Virgin Islands, read Spotlight: The Great Mangrove Cleanups.*

Roadside dumpster bins on St. Thomas. Trash that doesn't make it into the bins, has the potential to become marine debris (Photo credit: Kristin Wilson Grimes).

The generally steep terrain of the U.S. Virgin Islands means that land-based activities are connected to the ocean via the ridge-to-reef continuum. This view is looking east over Magen's Bay on St. Thomas (Photo credit: Kristin Wilson Grimes).

Watershed Walk Worksheet

Modified from (Northwest Aquatic and Marine Educators, 2016), with permission from Oregon Sea Grant

1. Look around the area. Where is the highest point in the watershed? _____

   a. If water falls or runs off the edge of that point, where does it go? _____

   b. Is there more than one high point in the area? _____

   c. What would happen to the rain if there are multiple high points in this area?

2. Are there any ghuts nearby? _____

   a. Can you see them easily, or are they hidden by plants or human-made structures?

   b. Can you tell if they are straight or curved? _____

3. Keep a running list of the different types of surfaces you came across during your walk.

4. Think about how watersheds hold and release water. What are some things you noticed on your walk that may negatively impact the water flow? _____

   a. Think about the quality of water moving through the area, did you see any trash?

5. Did you notice any storm drains? _____

   a. Did you see any that could get backed up when it rains? _____

   b. What happens to all the trash when the drains get backed up? _____

6. Think about how watersheds hold and release water. What are some things you noticed on your walk that may positively impact the water flow? _____

7. What are some of the ways the water flowing from high in the watershed down to the ocean below, impacts marine life? _____

8. How might these impacts change when there is a heavy rain or a light rain? _____

9. How might these impacts change during the different seasons of the year?

Figure 2. A map of schools (public and private; elementary through senior high school) and watershed boundaries on St. Thomas (Figure courtesy of Allie Durdall).

St. Thomas Schools

1. E. Benjamin Oliver Elementary School
2. Gladys A. Abraham Elementary School
3. Jane E. Tuitt Elementary School
4. Joseph Gomez Elementary School
5. Joseph Sibilly Elementary School
6. Leonard Dober Elementary School
7. Lockhart Elementary School
8. Ulla F. Muller Elementary School
9. Yvonne E.Milliner-Bowsky Elementary School
10. Addelita Cancryn Junior High School
11. Bertha C. Boschulte Middle School
12. Edith L. Williams Alternative Academy
13. Charlotte Amaile High School
14. Ivanna Eudora Kean High School
15. University of the Virgin Islands-St. Thomas Campus
16. Calvary Baptist School
17. Wesleyan Academy
18. Saints Peter & Paul Catholic School
19. All Saints Cathedral School
20. Memorial Moravian School
21. Antilles School
22. Montessori School
23. St. Thomas Seventh-day Adventist School

Figure 3. A map of schools (public and private; elementary through senior high school) and watershed boundaries on St. John (Figure courtesy of Allie Durdall).

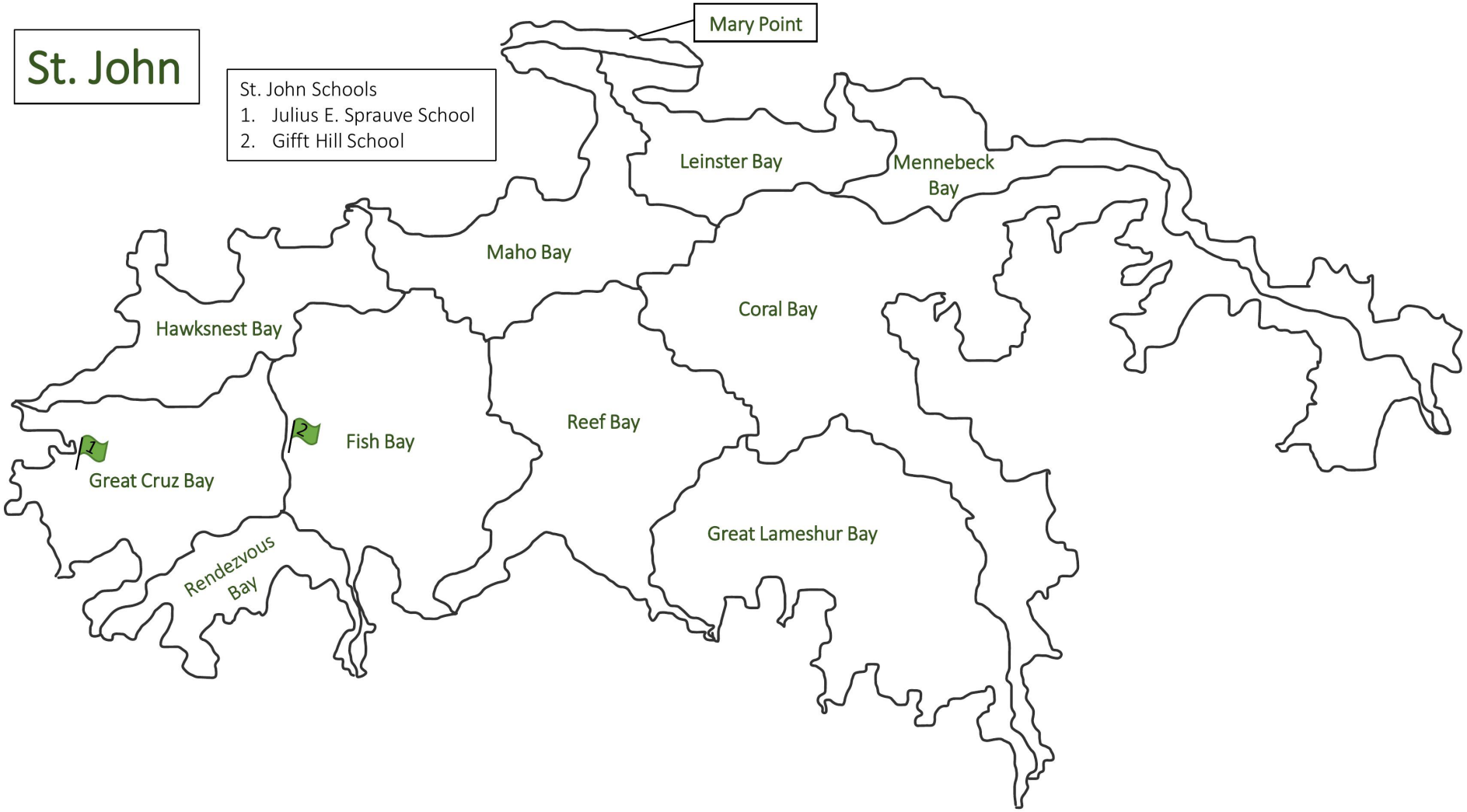
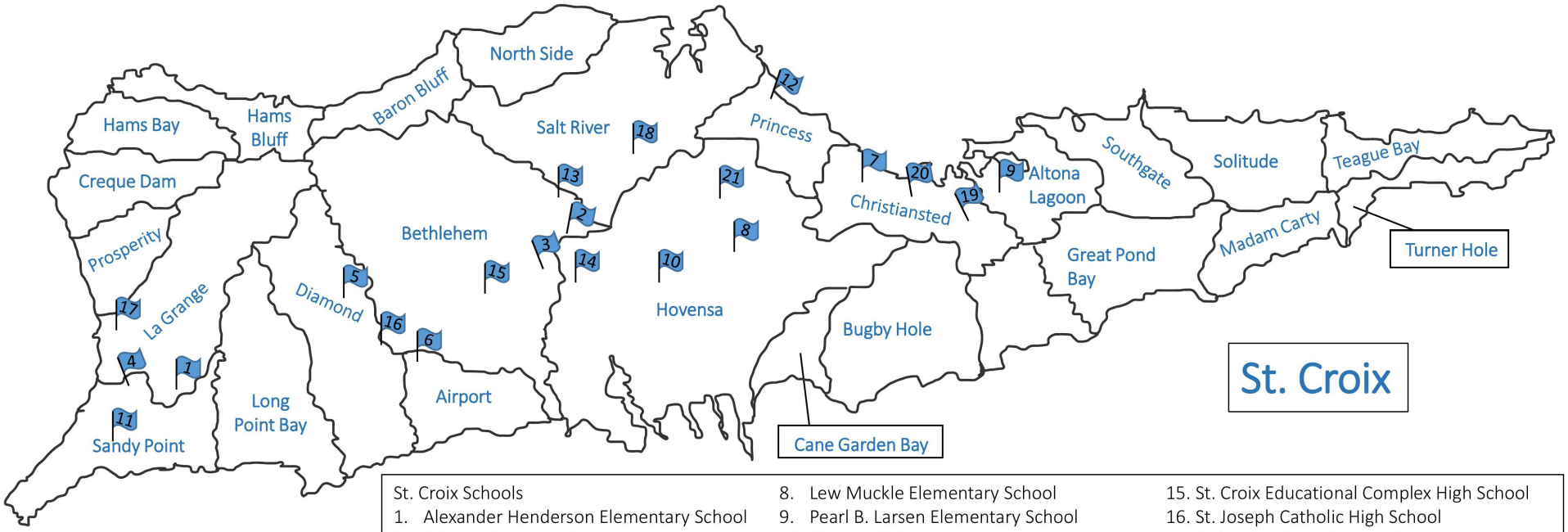


Figure 4. A map of schools (public and private; elementary through senior high school) and watershed boundaries on St. Croix (Figure courtesy of Allie Durdall).



St. Croix Schools

1. Alexander Henderson Elementary School
2. Alfredo Andrews Elementary School
3. Charles Emanuel Elementary School
4. Claude O. Markoe Elementary School
5. Eulalie Rivera Elementary School
6. Evelyn M. Williams Elementary School
7. Juanita Gardine Elementary School
8. Lew Muckle Elementary School
9. Pearl B. Larsen Elementary School
10. Ricardo Richards Elementary School
11. Arthur A. Richards Junior High School
12. Elena Christian Junior High School
13. John H. Woodson Junior High School
14. St. Croix Central High School
15. St. Croix Educational Complex High School
16. St. Joseph Catholic High School
17. St. Patrick Catholic School
18. Good Hope Country Day School
19. St. Croix Seventh-day Adventist School
20. St. Mary's Catholic School
21. Free Will Baptist Christian School