Invasive Species: Map the Invasion

High School Upperclassmen (Juniors)

AP Biology; AP Environmental Science

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BIG IDEAS

Key Concepts in this lesson:

1) Invasive Species are non-native organisms that cause harm to the environment, economy, and human health.
2) Invasive species can be introduced to new environments through both human activities (e.g., trade and travel) and natural processes (e.g., wind or water currents).
3) Various factors influence the distribution of invasive species, including climate, availability of resources, human activities, and natural barriers.
4) Geospatial tools (e.g., GIS mapping) are useful for studying and managing invasive species and can be used to draw conclusions about how the spread and impact of invasives vary by species as well as by ecosystem.

EDUCATION STANDARDS

NGSS Performance Expectation(s)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Developing and Using Models: HS-LS2-2 **Analyzing and Interpreting Data:** HS-LS2-2 HS-LS2-6 **Using Mathematics and Computational Thinking:** HS-LS2-2 **Constructing Explanations and Designing Solutions:** HS-LS2-7 HS-ESS3-4 **Engaging in Argument**	**LS2.A: Interdependent Relationships in Ecosystems** • HS-LS2-2: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it	**Cause and Effect:** HS-LS2-2 HS-LS2-7 **Stability and Change:** HS-LS2-6 HS-LS2-8 **Systems and System Models:** HS-LS2-2 HS-LS2-6 **Energy and Matter:** HS-LS2-6

from Evidence: HS-LS2-6 HS-LS2-8 **Obtaining, Evaluating, and Communicating Information:** HS-LS2-7 HS-ESS3-1	not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • HS-LS2-6: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods under stable conditions. However, changing conditions may result in a new ecosystem. • HS-LS2-7: Anthropogenic changes (induced by human activity) in the environment can disrupt an	**Patterns:** HS-LS2-2. HS-LS2-8 **Scale, Proportion, and Quantity:** HS-LS2-2 **Structure and Function:** HS-LS2-7

	ecosystem and threaten the survival of some species. **LS2.D: Social Interactions and Group Behavior** - HS-LS2-8: Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. **ESS3.C: Human Impacts on Earth Systems** - HS-ESS3-1: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. - HS-ESS3-4: Scientists and engineers can	

	make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ETS1.B: Developing Possible Solutions** • HS-LS2-7, HS-ESS3-4: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	

MEASURABLE STUDENT LEARNING OBJECTIVES

Students will be able to:

- *Visualize data using maps*
- *Use technology effectively and efficiently*
- *Compare and contrast data*
- *Utilize online applications*

STEM INTEGRATION

This assignment integrates two STEM subjects – Science and Technology – as well as literacy/public communication. Science is integrated through the concept of an invasive species, which touches on biology concepts including trophic interactions, ecosystem dynamics, and flow of matter through an ecosystem. Technology is integrated through the querying of an online database with authentic occurrence data for invasive species

submitted by citizen scientists. Students are asked to download the data into an Excel spreadsheet and make inferences about the abundances of invasives in different areas. Potential extensions could include creating graphs to compare abundance data over time in different areas. Finally, literacy and communication are integrated because students are presenting the results of their own independent research in the form of a PowerPoint presentation, which they will practice multiple times with their classmates before giving the presentation to the class.

By incorporating each of these subjects in an authentic way, students are tackling a real-world issue (mapping invasive species) in a way that professionals do, as well. Since nothing in the real world occurs in isolation, this is a preferred way to develop practices of critical thinking and communication.

NATURE OF STEM

*This lesson addresses several tenants pertinent to the Nature of Science. Students are collecting **empirical** data based on **observations**, and they are using these observations to make **predications and theories**. Additionally, students will make inferences based on an invasive species of their choice that they are investigating – providing an opportunity for **creativity** as well as them understanding that, while science is based on empirical data, there is a level of inherent **subjectivity** in all scientific conclusions.*

MATERIALS NEEDED

- Paper
- Writing utensils
- Colored pencils
- 4-cups
- 2-plastic knives
- 1-plastic spoon
- 1-fork
- 1-large binder clip
- 8 red pom-poms
- 10 black pom-poms
- 8 white pom-poms

- 3x4 piece of felt
- 20 bingo chips
- 1 timer
- TED-Ed video, "The Threat of Invasive Species": https://youtu.be/spTWwqVP_2s (4:45)
- Computer with access to EDDMapS (required) and ArcGIS Online (optional)

ENGAGING CONTEXT/PHENOMENON

The "hook" is a video discussing invasive species and several case studies (e.g., zebra mussels, rabbits in Australia, kudzu vines in the southeast). One of the things that makes this an effective hook is that one cannot easily answer the question of why certain invasive species tend to excel in specific ecosystems but not in others. For example, why does a plant like the Tree of Heaven do well along highways in Tennessee but not in grasslands in Oklahoma? Students will then have a chance to discuss questions with their neighbors and shine a light on what they still find confusing.

DATA INTEGRATION

Data for this lesson comes from EDDmaps, an initiative by the Center for Invasive Species and Ecosystem Health run by the University of Georgia. EDDmaps allows users to submit observations of invasive species, which are then used to classify the level of infestation that a particular area is experiencing. Observers can upload images of the invasive species as well, allowing experts to check the accuracy of the report. Students are not collecting the data, but analyzing it. They are using the observations to create a map and then comparing maps of different invasive species in different states (or, potentially, ecosystems).

I am not using NASA data at this time; however I have considered including vegetation indices such as the NVDI in a future iteration of this assignment or as something to build on after I was inspired when reading this article: https://www.earthdata.nasa.gov/learn/articles/sensing-invasive-species. However, I don't really understand remote sensing data and would need to better understand how vegetation coverage can be a proxy for invasive coverage, which I would imagine would be difficult to interpret when the canopy from something like Amur bush honeysuckle couldn't look all that different from a native canopy. However, the article I linked above

suggests that NASA data may indeed be appropriate for analyzing invasive species occurrences.

TEACHER BACKGROUND KNOWLEDGE

The teacher should have working knowledge of biodiversity, invasive species, and their impacts on ecosystems. They should be able to discuss mitigation strategies with students as well as ways that invasive species might migrate to new areas. As a cooperative learning assignment, students and teacher are learning alongside one another, which means a teacher need not be the expert and rather, students are directing their own learning based on the invasive species they choose.

DIFFERENTIATION OF INSTRUCTION

Students will be able to use their personal computers at certain points in the lesson to take notes or to view (or rewatch) any of the posted videos for this lesson. Additionally, they will have access to previous PowerPoint lectures and a handout on invasive species that they can review to help with understanding.

REAL-WORLD CONNECTIONS FOR STUDENTS

Students will all at some point have gone outside to experience nature (granted, in varying degrees of comfort). They should recognize the beauty in nature and understand that biodiversity plays a role in a healthy ecosystem. Additionally, once they are introduced to various examples of invasive species, they are likely to recognize them when they go back outside after the lesson is complete. Thus, the real-world connection will empower students to see invasive species anytime they go outside and will prime them to care about preserving native biodiversity

INTEGRATION POSSIBLE MISCONCEPTIONS

Students may think that all non-native species are invasive and harmful. I'll need to clarify that not all non-native species are invasive; only those that cause harm to the environment, economy, or human health are considered invasive. Students may also believe that invasive species are always introduced intentionally by humans, which is not always the case as often times they are accidentally released or carried through

hitchhiking on goods in cargo ships or luggage.

As far as damage, students may think that invasive species only affect plants and animals, and thus might not realize how invasive species can impact human health through damaging infrastructure or agriculture.

The biggest misconception I anticipate students may have is that they may believe invasive species can only survive in climates similar to their native range. I think there is a great opportunity here to show students that, while some invasive species indeed have a small window of environmental conditions they can tolerate, others can adapt to a wide range of conditions are thus spread across state lines to a variety of diverse habitats.

LESSON PROCEDURE

5E	Details of 5E Lesson Implementation
Engage *Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.*	**Procedure:** ***Teacher:*** *Ask students to pull out a blank sheet of paper. They should note 1 think they found interesting from the video they are about to watch, 1 invasive species they learned about and how it spread, and 1 question they still have. Then, show a short video clip about invasive species (["The threat of invasive species"](#)).* *Facilitate a class discussion to gauge students' prior knowledge and experiences with invasive species. Students share what they watched in the video, then teacher guides a Think-Pair-Share activity where students discuss "What do you think makes a species invasive?"* ***Student:*** *Watch the video, participate in the discussion, and engage in the Think-Pair-Share activity.* **Modifications:** *Provide video transcripts or subtitles for students with hearing impairments.* *Offer discussion prompts in written form for students with language processing difficulties.* **Standards Addressed:** ***NGSS HS-LS2-6:*** *Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.* **Formative/Summative Assessments:** *Participation in the class discussion and Think-Pair-Share activity.*

	Resources: *Video clip:* [*"The threat of invasive species"*](#) *Blank sheets of paper* *Discussion questions*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** **Part 1:** *Invasive Species Fish Game* **Teacher:** *Divide students into small groups of 4 and hand out "Invasive Species Game" handouts (see below attached handout).* **Student:** *Students will model the impacts of an invasive species of guppies in small groups to visualize how 1 invasive species can alter the composition of an entire ecosystem.* **Part 2:** *Independent Research* **Teacher:** *Divide students into groups of 2 and have them research a different invasive species in the state of Tennessee (our home state). Groups should be assigned either a plant, an animal, or an insect. Students can access a list of species at:* https://www.eddmaps.org/tools/state.cfm **Student:** *Student groups will create a PowerPoint to teach the rest of the class about the Invasive Species they have selected. Include:* • *A picture of the invasive species with its name (common and scientific)* • *A description of which habitats the organism can be found in (be specific!)* • *Where the organism comes from, and how (we think) it was introduced* • *A list of which native species are negatively impacted, and how* • *Any mitigation strategies currently underway to control*

	populations • *What is the ecological function and biological relevance of the invasive species?* *** Cite any sources you use in APA format *** **Modifications:** *Allow students to use various research tools (books, internet, videos) to accommodate different learning preferences.* *Provide research handouts with clear instructions and guiding questions for students who need additional support.* **Standards Addressed:** ***NGSS HS-LS2-7:*** *Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* **Formative/Summative Assessments:** ***Formative:*** *Participation in the Invasive Species game/* ***Summative****: PowerPoint presentation rubric for Invasive Species research (students should practice their presentation to other student groups, with those groups filling out rubrics for the students, and should hand in 5 completed rubrics showing that they have practiced their presentation before presenting it to the class)* **Resources:** *Access to internet/library resources* *Research handouts*

| **Explain**

Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts. | **Procedure:**

Teacher: *Facilitate group presentations and lead a class discussion on the similarities and differences between the invasive species studied.*

Student: *Present their research findings to the class and participate in the class discussion.*

Modifications:

Allow students to choose their presentation format (slides, posters, models) based on their strengths.

Provide presentation templates or outlines for students needing additional structure.

Standards Addressed:

NGSS HS-LS2-2: *Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.*

Formative/Summative Assessments:

Group presentations

Participation in class discussion

Feedback on practice rubrics

Resources:

Presentation tools (slides, posters, etc.)

Discussion prompts |

Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** ***Teacher:*** *Have students navigate back to* https://www.eddmaps.org/tools/state.cfm *and download occurrence data for the invasive species they selected. Have students create a map of the invasive species' abundance in Tennessee, and compare the abundance of this species in at least two other states. Using their maps, host a class discussion of have students type their answers to the following questions:* 1) *Which other invasive species (other than your own) did you find in Tennessee?* 2) *Was one invasive species more common than the others?* 3) *Did you notice any patterns with your invasive species? For example, do certain invasive species appear near particular habitats?* 4) *With your data points on a map, can you identify any ways the invasive species may have entered Tennessee? What about where its largest abundance is? What factors enable the survival and dominance of the invasive species here?* 5) *Can you identify any potential pathways of spread (how the invasive species may continue to spread)? How do you know? If you can identify this pathway, how could you block the invasive species from spreading further?* ***Student:*** *Create the map and engage in the class discussion. Afterwards, compare your invasive species' distribution in Tennessee with at least two other states, and compare and contrast them:* 1) *Do your two survey areas have any invasive species in common?* 2) *If there are species in common, why do you think that is? How do you think the same species got to these two different locations?* 3) *If your survey sites do not have invasive species in common, why do you think that is? Could it be something about the habitat? The type of invasive species?*

	Modifications:
	Provide students with already-created maps if they are having trouble accessing the online platform themselves.
	Allow students to work in pairs or small groups to prepare their arguments.
	Standards Addressed:
	NGSS HS-LS2-8: *Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.*
	NGSS HS-ESS3-4: Earth and Human Activity: *Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*
	Formative/Summative Assessments:
	Participation in the group discussion.
	Print-out or screenshot of the maps in a word document along with answers to the provided questions.
	Resources:
	Computer with internet access
	Maps of invasive species (if needed modifications)
	Papers with questions above written
Evaluate *Assess students knowledge, skills and abilities.*	**Procedure:** *Teacher: Assign a reflection essay and administer a quiz covering key concepts discussed in the lesson.* *Student: Write the reflection essay and complete the quiz.* **Modifications:** *Provide essay prompts and a quiz in multiple formats (written,*

	oral) to accommodate different learning needs.
	Offer additional time for students who require it.
	Standards Addressed:
	NGSS HS-LS2-6: *Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.*
	NGSS HS-ESS3-4: Earth and Human Activity: *Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*
	Formative/Summative Assessments:
	Reflection essay
	Quiz results
	Resources:
	Reflection essay prompt

REFERENCES

Widner, Brianna. Washington Pest Watch – Invasive Species Lesson Plans.
https://invasivespecies.wa.gov/wp-content/uploads/2019/10/LessonPlansAll.pdf

Invasive Species Game – Lesson Plan

Purpose:
Students will be introduced to the effects an invasive species has on an ecosystem. The limit of food and other nutrients will cause stagnation of native species growth or even decline, depending on the behavior of the organism.

Objectives:
1) Students will understand that resources are limiting factors in an ecosystem
2) Students will understand that each organism has adaptations that allow it to obtain resources
3) Students will understand that invasive organisms can upset the balance of an ecosystem and out compete native species for available resources

Context (Background Information):
This particular game involves the Goby an invasive species in Lake Erie. This game can be modified to be any invasive species depending on your region and natural inhabitants.
This game can be utilized when teaching about life cycles, pollution (pollution would reduce vital nutrients), invasive species, and aquatic life.

Ohio Academic Content Standard:
> *Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).*

By the end of the 12th grade, students should know that:
- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population grows, its size is limited by one or more environmental factors: availability of food, availability of nesting sites, or number of predators. 5D/H1*
- If a disturbance such as flood, fire, or the addition or loss of species occurs, the affected ecosystem may return to a system similar to the original one, or it may take a new direction, leading to a very different type of ecosystem. Changes in climate can produce very large changes in ecosystems. 5D/H2*
- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. 5D/H3

Equipment:

Per five person group:	Per four person group:
5-cups	4-cups
2-plastic knives	2-plastic knives
1-plastic spoon	1-plastic spoon
3-plastic forks	1-fork
1-large binder clip	1-large binder clip
10 red pom-poms	8 red pom-poms
12 black pom-poms	10 black pom-poms
10 white pom-poms	8 white pom-poms
3x4 piece of felt	3x4 piece of felt
25 bingo chips	20 bingo chips
1 timer	1 timer

Set-up:
There are four native species; one with a plastic spoon (perch), one with two knives (bass) in one hand, one with one fork (blue gill), one with two forks (walleye) in one hand. It is important to note that tools can only be held in ONE hand. So holding the two knives will take the dexterity of operating chopsticks. If this is too difficult for students, make changes as necessary.

Eating habits:
     Perch eats only white
     Walleye eats only white and red pom-poms
     Blue gill eats only black
     Bass eats black and red
     Gobies eat anything (using a binder clip) and are introduced after a few rounds so students can see how stable their ecosystems are before and after the Goby.

Instructions:
- o Randomly distribute the pom-poms onto the felt.
- o Each of the four native fish will have 30 seconds per round to collect food using one hand and their assigned tools.
- o The native fish will play 3 rounds before the invasive (Goby) arrives.
- o Play will continue with the goby now competing for resources for 3-5 more rounds.
- o It should be made clear to the gobies that it is in their benefit to eliminate native species. Their tactics should include selective feeding to knock out other species, e.g., eating only white, so the species that can only eat white cannot get enough to reproduce.

Scoring:
Each fish starts off with three lives represented by bingo chips.
At the end of the round each fish needs 5 pom-poms to survive the round
For every 3 pom-poms beyond the first 5 the fish produces 1 offspring which counts as an extra life. e.g. after round one the perch has collected 9 pom-poms, the perch does not lose a life (bingo chip) this round since he found five. The perch also gets one additional life (bingo chip) because of his three additional pom-poms. The ninth pom-pom only serves to keep other fish from reproducing.
Once the fish is out of lives he becomes extinct and that player joins the Goby player, collecting pom-poms with another binder clip.

Post-activity discussion questions:
1) Were you able to compete with the other native species for resources necessary to your survival and reproduction?
2) Were you able to compete with the invasive species for resources necessary to your survival and reproduction? Why? What made the Goby so successful?
3) What could be the consequences of organisms entering an ecosystem that have a competitive advantage over the native species?

Extensions
This can be applied to any ecosystem and can be used for pollution as it removes nutrients (eliminate some pom-poms after a few rounds) or as pollution as a poison (have one random color be a poison each round, this would require more pom-poms and a few more colors to make feeding more random.

Round Goby
Neogobius melanostomus

- Invasive, bottom dwelling fish
- Mottled coloring with frog-like raised eyes
- Habitat: Nearshore areas of the Great Lakes and tributaries
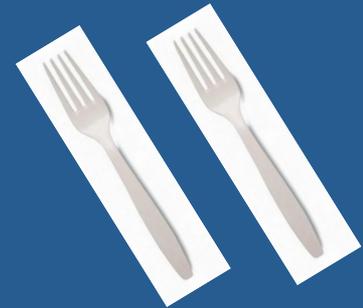
Walleye
Sander vitreus

- Popular Great Lakes sport fish
- Slender body with pointed snout. Two dorsal fins.
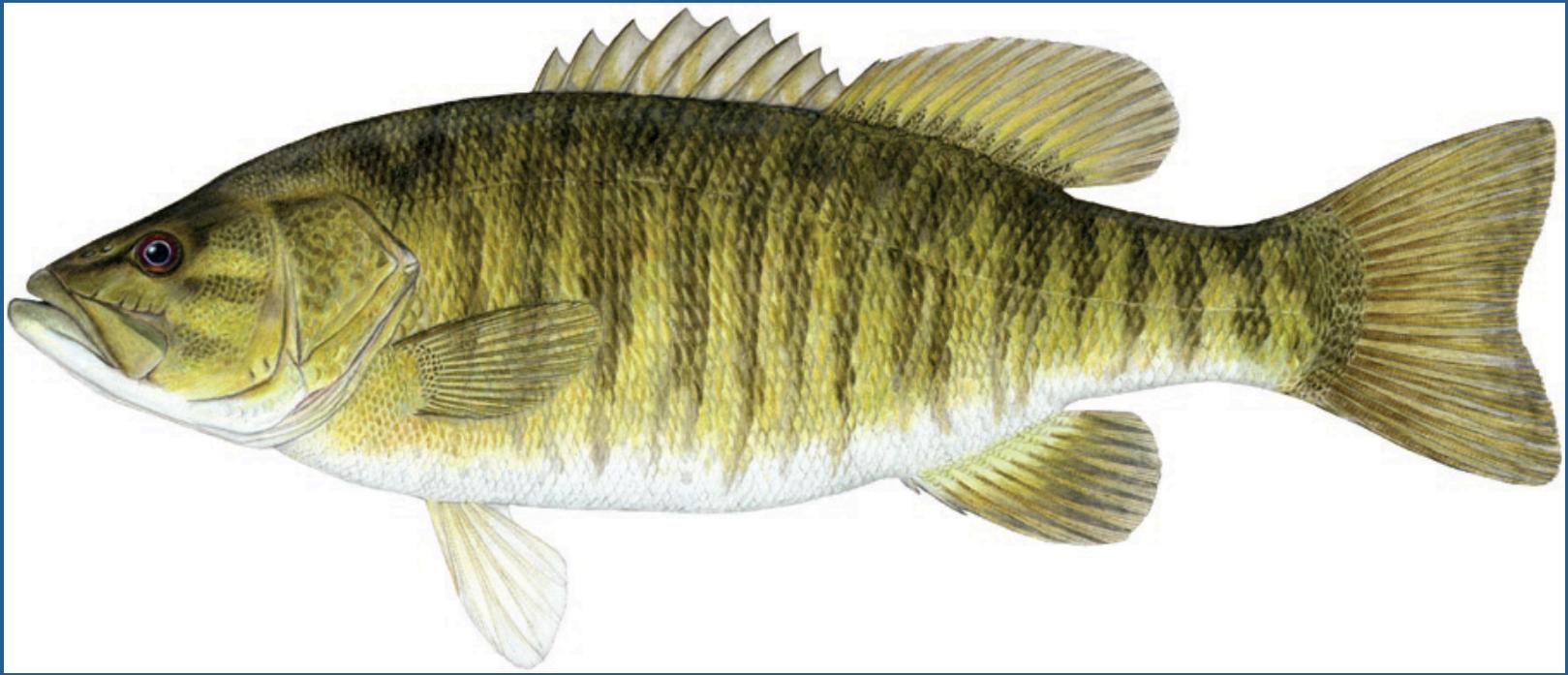- Habitat: Moderately fertile lakes with primarily sandy basins.
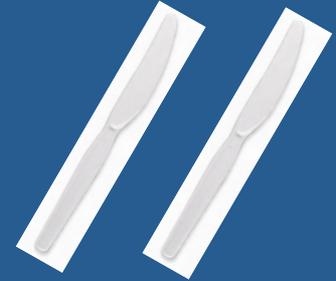
Yellow Perch

Perca flavescens

- Important food and sport fish throughout the southern part of the Great Lakes region.
- Two dorsal fins. Body has distinct vertical bands.
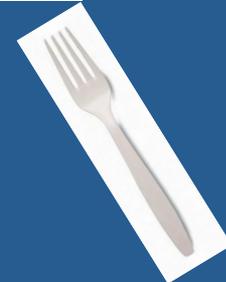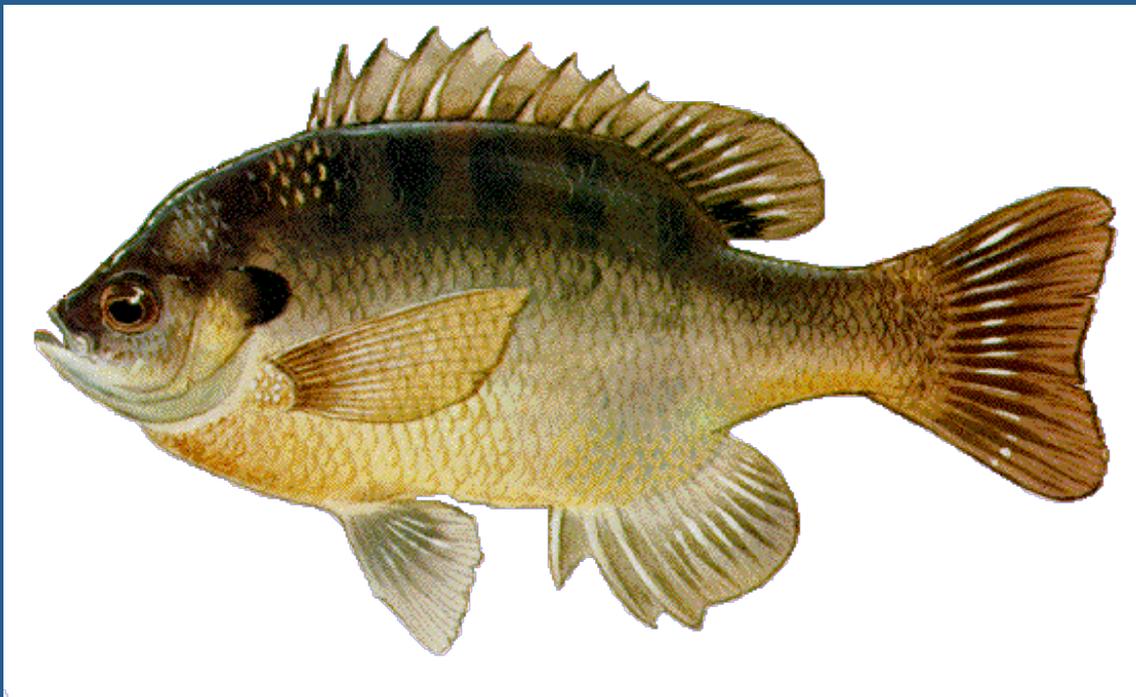- Habitat: Quiet ponds, streams with little current; large and small lakes.

Smallmouth Bass
Micropterus dolomieu

- Popular sport fish in Canadian and U.S. waters
- Narrow, oval-shaped body. Long dorsal fin with spines in first half and soft rays near end.
- Habitat: Clear, gravel-bottom runs in flowing rivers; shallow rocky areas of lakes.

Bluegill

Lepomis macrochirus

- Common and abundant sport fish
- Deep bodied with a solid black operculum (ear flap).
- Habitat: Clear lakes and ponds that have some aquatic vegetation