OBJECTIVE

Students will investigate invasive species and their impacts on biodiversity.

TIME REQUIRED

55 minutes

BACKGROUND

INVASIVE SPECIES

An introduced species, also called an alien or exotic species, is any species that is not native, or original, to an ecosystem. An introduced species that significantly modifies or disrupts an ecosystem and poses a threat to the environment, human health, or the economy is called an invasive species or invasive alien species in that ecosystem.

A species may be considered native in one place, but introduced and/or invasive in another, nearby location. For instance, northern pike (*Esox lucius*)are native to most of Alaska, but where they have been introduced in the waterways of south-central Alaska, they are an invasive species because they are preying on populations of trout and salmon, causing a threat both to the environment and to the economy.

Several key characteristics make an introduced species more likely to become invasive:

- they have few natural predators, disease, or parasites to keep their numbers in balance in the new ecosystem;
- they reproduce quickly and often;
- they can adapt to many habitat conditions;
- they are able to migrate (and therefore spread) easily;
- they are generalists, i.e., they can eat a variety of foods and live in a variety of habitats; and
- they often defend themselves well or are particularly aggressive predators.

Introduction of invasives

Species are restricted to a natural range by their characteristics and those of the environment around them. Physical barriers such as high elevations, desert regions, or expanses of water prevent movement of the species into new areas. Invasive species have overcome those barriers to invade new habitats; human activities are the most common way that invasive species are transported to new habitats. Some examples include escaped (or released) pets (e.g., red-legged frog [*Rana aurora*]); boats that either sail from one port to another (e.g., Norway and black rats [*Rattus norvegicus*, *Rattus rattus*]) or are used in one lake and then moved to another lake (e.g., zebra mussels [*Dreissena polymorph*a], Eurasian water-milfoil [*Myriophyllum spicatum*]); movement of animals for sport hunting/fishing or for farming ventures (e.g., northern pike, arctic fox [*Vulpes lagopus*]); or intentional introduction because a person likes the species (e.g., European Starling [*Sturnus vulgaris*]). Many intentional introductions are the result of economic motivations, such as the introduction of Arctic foxes to the Aleutian Islands to bolster the fur farming industry in the 18th century. In this and many other cases, the ecological consequences of introducing an invasive species were not considered first, resulting in often devastating effects on the native ecosystem.

Introduced, non-invasive species

Not all species that are introduced are considered invasive. Plant and animal species that have been domesticated by humans, or are under the control of humans, and introduced species that are more beneficial than they are harmful are not considered invasive. As an example, many of the plants and animals that we consume for food are not native. Domestic chickens originated in India but are now raised for eggs and meat around the world; European honeybees (*Apis melifera*) have been introduced around the world to pollinate fruit trees and other agricultural crops; and potatoes, tomatoes, and peppers (sweet and hot) all originated in South America. Despite having been introduced around the world; these species are not considered invasive because their economic benefits (food production, food security) outweigh any negative effects (e.g., honey bees may out-compete native bees for pollen). However, domesticated plants that spread and animals that become feral may be considered invasive if they begin to negatively impact the environment and economy where

they are located. Feral goats are a problem on a number of islands around the world, where they overgraze areas leading to loss of biodiversity and increased soil erosion.

Some species have an overall negative effect on the environment or the economy in a location, but are not considered invasive because they are native species. Canada geese (*Branta canadensis*) are native to most of North America and most populations migrate annually, though there are also non-migratory populations throughout much of the United States, where they are often found grazing in parks and on lawns and golf courses. They are often considered to be a pest and may have a negative impact where they are found, but they are a native species, and thus not considered an invasive.

Islands and invasives

Invasive species may drive native species to extinction or localized extirpation via predation or competition for resources (e.g., food, habitat). This in turn can have a cascading effect on entire ecosystems. Island species and ecosystems are especially vulnerable and the introduction of a new species usually has a dramatic negative impact. Often, island species (and particularly endemic species) have evolved in an environment without any threat from non-native predators and thus have not developed defense mechanisms to respond to the threat of predation. Similarly, invasive species may out-compete native species for local resources. Currently, 75% of all threatened bird species found on oceanic islands are experiencing population declines that are attributed to predation or competition for resources by invasive species. Invasive predators, especially rats, represent the greatest threat to native island species. However, the impacts of habitat modification by herbivores such as goats and feral pigs and reduced fitness resulting from invasive micro-organisms (e.g., disease caused by microparasites) are also significant. There are many examples in which these threats, alone or combined, have caused extremely rapid declines and even extinctions.

Impacts

There are also indirect impacts caused by invasive species; the removal or reduction of one species can change how the food web functions, upsetting the balance of the ecosystem. For example, the Aleutian Islands are considered to be one of the most productive seabird breeding areas in North America with more than 10 million seabirds of 26 species breeding on the archipelago. Until three centuries ago the islands were free of predatory land mammals. In the years that followed, Arctic foxes were introduced intentionally for fur farming, and rats were introduced unintentionally. Both foxes and rats preyed on burrow and ground nesting seabirds, eating eggs, nestlings, and adult birds, decimating local populations. Only species that nested on unreachable cliff faces escaped predation.

On islands with mammalian predators, the populations of seabirds are much lower than they are on islands that have remained predator-free. With the reduction in seabirds comes a reduction in the productivity of the entire ecosystem because nesting seabirds transfer a great quantity of nutrients from the ocean to the islands in the form of guano. The guano fertilizes the islands, providing nutrients to support a diverse grassland habitat, which in turn provides food and shelter for herbivores such as slugs and the native species that prey upon them (e.g., spiders and land birds).

The elimination of seabird colonies by non-native arctic foxes and rats interrupted the transfer of nutrients from ocean to island, resulting in reduced soil nutrients, which in turn led to a shift in plant communities from a grass, sedge, and large forbe dominated community to a less diverse dwarf-shrub tundra vegetation community. Changes to the vegetation community consequently lead to a reduction in native herbivore and predator abundance and diversity. The introduction of a non-native mammalian predator can thus cause indirect impacts to an entire island ecosystem.

BIODIVERSITY

Biodiversity is the variety of life that is found on Earth. We can talk about the biodiversity of Earth as a whole, the biodiversity of a specific region of Earth, such as a continent, country, or town, or even the biodiversity of a space as small as your backyard. Often, we want to compare the

biodiversity of one location to another. One way to do this is to determine the species richness of a place by counting the number of species that are present. All kinds of life are included in this count: plants, animals, fungi, bacteria. Tropical rainforests tend to have many more species than arctic regions; we say that rainforests have greater species richness than arctic regions (tropical rainforests are thought to be the oldest biome on Earth and thus it is not surprising that they contain the most species, because they have had the most time for their inhabitants to diversify). It can be difficult to accurately determine the species richness of a place, especially if we include bacterial species, which are hard to count, so we often look only at the more obvious species, measuring biodiversity by counting, for instance, the number of bird species or the number of plant species.

The number of species isn't the only thing that contributes to biodiversity. Genetic variation, that is differences in the physical features of individuals within a species due to small differences in their DNA, increases the diversity of a population, both within a single species and within a group of species.

Groups of species form a wide variety of ecological communities, this depends partly on their habitat– natural environment in which a species or group of species lives. Habitat features include the physical features—soil, temperature range (climate), light availability, and weather (moisture)—as well as the availability of food and the presence of predators. A habitat can be said to be more diverse when it contains more ecological communities. For instance, a place with a forested area and open grassland has more diversity than just the grassland alone. Similarly, a backyard with a lawn, a few trees, and some garden beds has more diversity than one that is just a grassy lawn.

In an ecological community, species evolve (evolution) to coexist with one another. Every species has a role to play; these roles are interconnected and can be described using a food web. In a typical food web, plants fill the role of primary producer or autotroph, producing organic matter from inorganic substances (sunlight, water, carbon dioxide, minerals). These plant species are consumed by herbivores, animals that eat only plant matter. Herbivores are in turn consumed by primary predators (animals that eat herbivores), which are in turn consumed by secondary predators (animals that eat other predators). Throughout this cycle, plants and animals die, and their bodies are consumed by detritivores, animals (especially invertebrates), fungi, and bacteria that breakdown plant and animal matter and release the nutrients back into the soil where it can be used again by primary producers. Together, herbivores, predators, and detritivores are referred to as heterotrophs because they must obtain their energy from organic sources.

BIODIVERSITY ON ISLANDS – A SPECIAL CASE

Throughout the world, islands are unique examples of biodiversity. Geographical size, habitat features and distance from the mainland result in ecosystems that may be vastly different from the nearest mainland ecosystems. The isolation of islands results in the evolution of a large number of endemic species (a species that is only found in a defined geographic location, such as an island, nation, country or other defined zone, or habitat type). For example, over 90% of the native species found on the Hawaiian Islands are endemic, and the island of Madagascar, off the east coast of Africa, is home to more than 8,000 endemic species. Endemic species have become specially adapted to the habitat features that make their island home unique.

Most islands lack predators and in the absence of substantial predation pressure, many species have gradually lost anti-predator defenses (over the course of thousands of years) since they can cost energy and time that might otherwise be used for growth, foraging, mating, and reproduction. This can lead to the development of unique characteristics such as flightlessness in birds, loss of defense behaviors (e.g., the instinct to hide in the presence of a potential predator) and/or defensive mechanisms (e.g., thorns on plants), ground nesting behavior in some bird species, and gigantism or dwarfism (unusually large or small body size).

LESSON TWO INVASIVE SPECIES AND BIODIVERSITY

Endemic island species are particularly susceptible to changes to the habitat and ecosystem where they live. While island life presents unique opportunities for adaptation, it also imposes constraints: population sizes are often small, and genetic diversity is low due to isolation and the small population size. Because many species are less able to disperse, they tend to be concentrated in smaller areas. These characteristics and strategies work fine when there are no changes to the island, but island species are increasingly at risk as the human population increases and there are fewer places that are left pristine. Island species are less able to react to changes to their ecosystem, and many have become rare, threatened, or even extinct as habitats are destroyed by development and/or new species are introduced that either compete for food or prey on susceptible island species. One of the biggest threats to island biodiversity is invasive species.

MATERIALS

Worksheets 2.1, 2.2, 2.3, 2.4

Internet access

Appendix IV and V

PROCEDURES

LAB 2.1. INVASIVE SPECIES

Ask students or groups of students to research an invasive species and complete the worksheet. Please note, students are asked to research an animal not a plant. This curriculum only addresses invasive animals.

LAB 2.2. INVASIVE SPECIES SUMMARY

As a class summarize the information on the invasives species each group researched.

LAB 2.3 INVASIVE SPECIES FOOD WEB

Based on the information gathered in Lessons 1 and 2, complete the food web worksheet.

LAB 2.4 CROSSWORD PUZZLE

Test the students knowledge with the crossword puzzle.

DISCUSSION

How has an invasive species changed the biodiversity of your local ecosystem?

How do invasive species alter food webs? What are the consequences?

EXPLORE AND EXTEND

Discuss humans as invasive species.

RESOURCES

Alaska Department of Fish and Game
http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=145

Alaska Sea Grant Marine Advisory Program
http://seagrant.uaf.edu/map/conservation/rats/index.html

National Geographic: Rat Reproduction
http://video.nationalgeographic.com/video/rat_indian_reproduction

Science

Science Warriors: The Battle Against Invasive Species. 2008. Sneed B. Collard III. ISBN-10: 0618756361

What Can We Do About Invasive Species. 2010. Amelia von Zumbsch (ed.). IISBN-13: 978-1435824874

LESSON TWO LAB 2.1 INVASIVE SPECIES WORKSHEET

Student Name: _____

Date: _____

Research an invasive animal species.

Species Name: _____

Country of origin: _____

Method of introduction: _____

Consequences of introduction: _____

Life history of introduced species (How long does it live?, How many offspring does it have? How often does it have offspring?, What does it eat?, Where does it live?)_____

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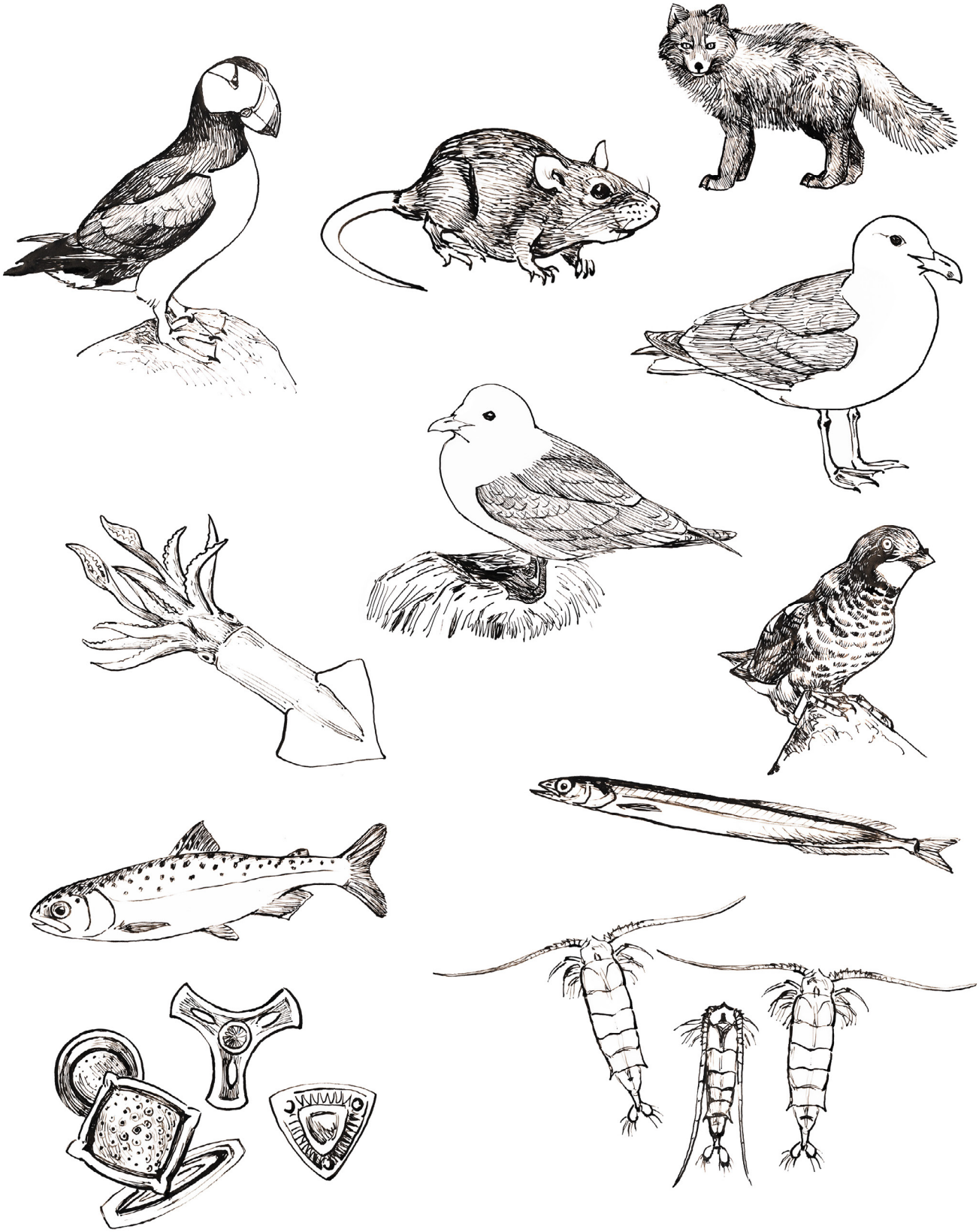
LESSON TWO LAB 2.2 INVASIVE SPECIES SUMMARY

As a class, summarize the invasive species information gathered.

Species Name	Country of Origin	Method of Introduction	Consequences

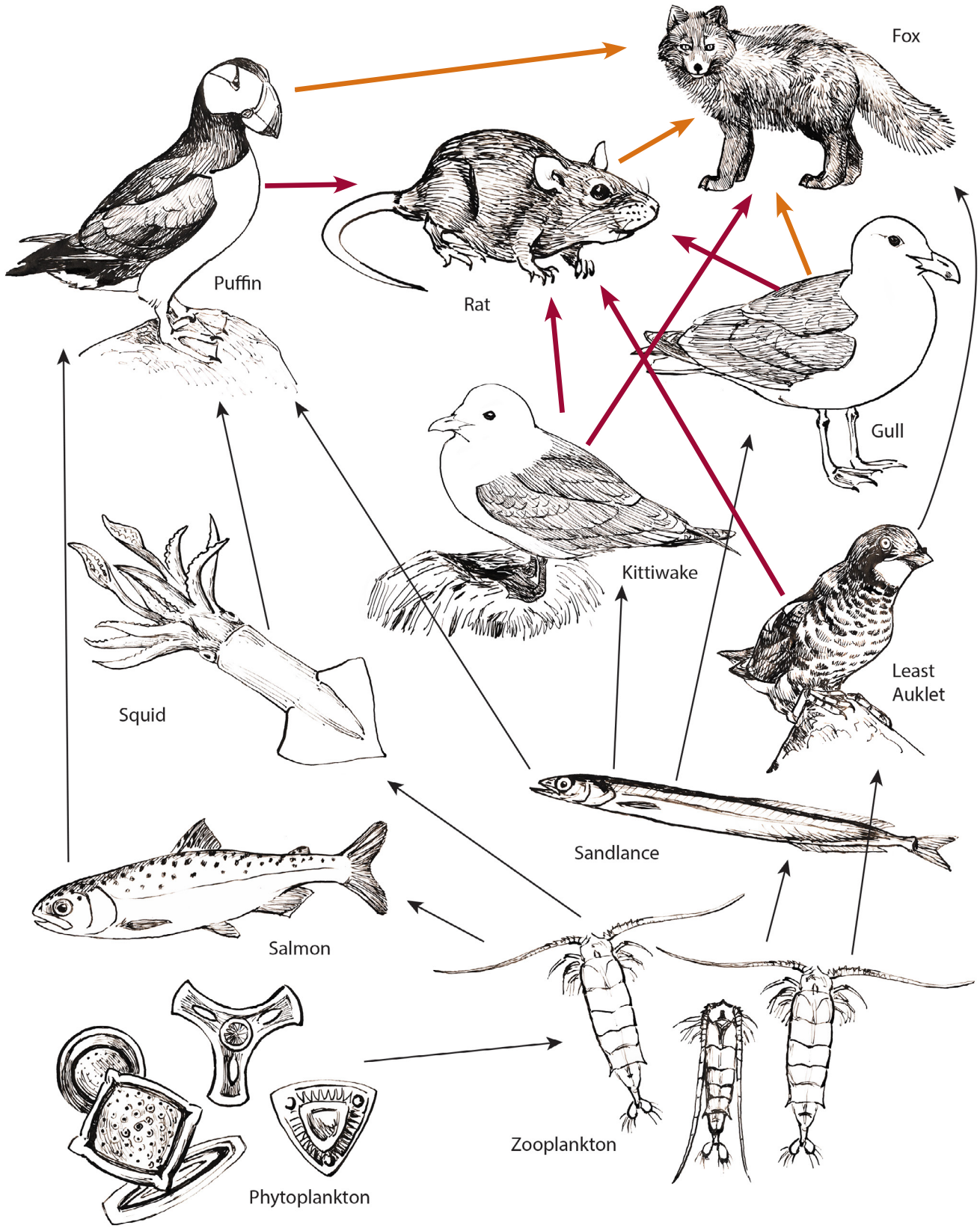
LAB 2.3 ALASKA INVASIVE SPECIES FOOD WEB

Label each species and draw arrows showing the transfer of energy or consumption from the primary producers to the top predator. Use a different colored to identify the invasive species.



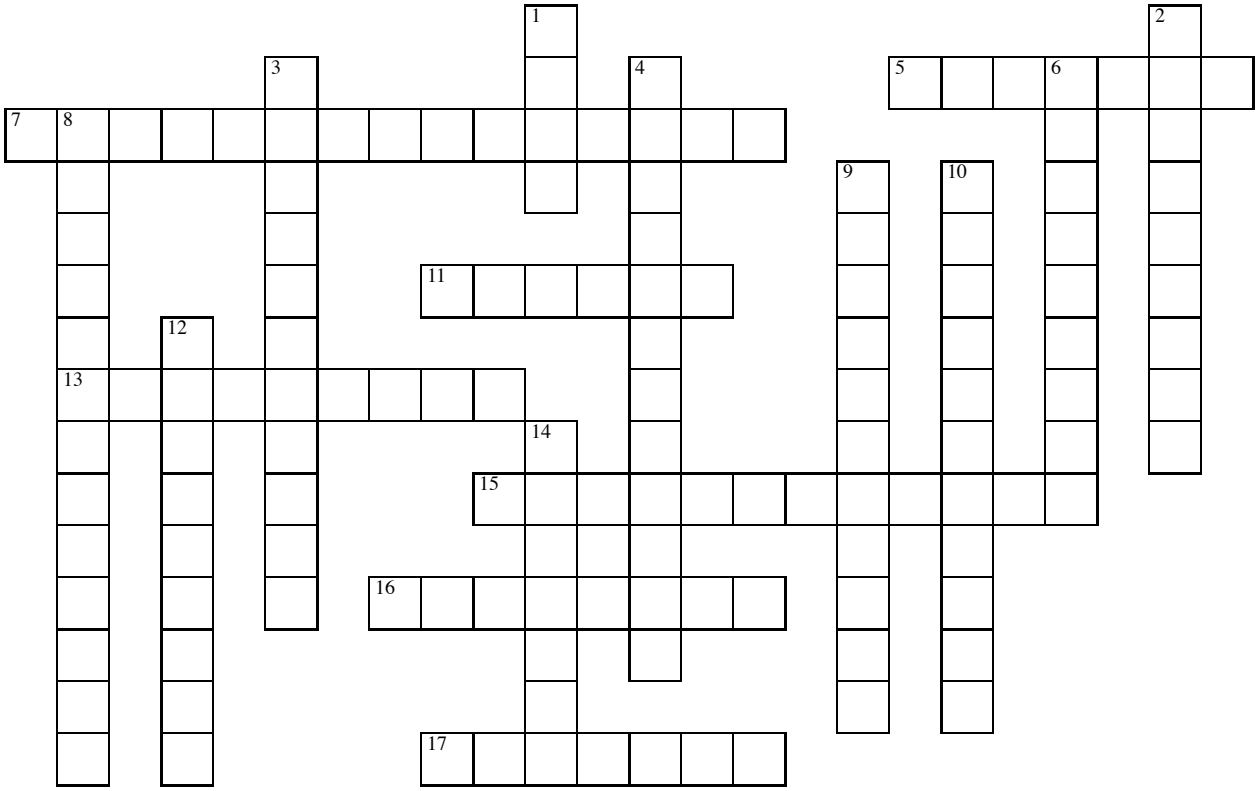
LESSON TWO LAB 2.3 ALASKA FOOD WEB - TEACHER KEY

Label each species and draw arrows showing the transfer of energy or consumption from the primary producers to the top predator. Use a different colored to identify the invasive species.



Student Name: _____ Date: _____

Invasive Species



ACROSS

- End of a species
- **5** End of an organism
- **7** A plant or animal not native to a specific location
- **11** Offspring of two different breeds or species
- **13** Change in inheritable traits over successive generations
- **15** Act of protecting or preserving natural resources
- **16** An organism that eats another organism
- **17** Natural environment in which an organism lives

DOWN

- **1** The organism which the predator eats
- **2** Community of living organisms and their environment
- **3** Actions to reduce the introduction of an invasive species
- **4** Degree of variation of life
- **6** Arrival of invasive species in a non-native ecosystem
- **8** Species whose presence in the region is result of natural processes not human intervention
- **9** A species that ceases to exist in a one area but still exists elsewhere
- **10** Poisoned bait used to eradicate invasive species
- **12** Rattus norvegicus
- **14** Feeding relationships within an ecological community

LESSON TWO | **LAB 2.4 CROSSWORD - TEACHER KEY**

Student Name: _____ Date: _____

Invasive Species