Activity #2

Dispersing on the Currents

● ● ● Class Period One *Dispersal of Marine Life*

Materials & Setup

- *Coral Reefs: Their Health, Our Wealth* video, cued up to the segment on coral reproduction (This is a relatively short video, so fast-forward with the picture showing until you start to see close-ups of corals. This is the beginning of the section on coral biology and habitat. You may choose to show this short segment of a couple minutes or begin where the narrator says, "Like all other animals, corals must produce new individuals to make sure their populations survive." The six-minute reproductive segment ends when the narrator begins to talk about causes of death.)
- VCR
- "Map of Pacific Ocean Currents" acetate (master, p. 38)
- "Known and Estimated Numbers of Inshore Fish Species by Area and Likely Routes of Colonization" acetate (master, p. 39)
- Overhead projector and screen

For each of five student groups

- "Map of Pacific Ocean Currents" (master, p. 38)
- "Known and Estimated Numbers of Inshore Fish Species by Area and Likely Routes of Colonization" acetate (master, p. 39)
- One "Current Conundrums" card (master, p. 40)

For each student

- Student Page "Marine Life on the Move" (pp. 41-43)

Instructions

1) Display the "Map of Pacific Ocean Currents" acetate. Ask students to look at the currents depicted on this map and speculate about where most Hawaiian marine life originally came from. Note that ocean currents in the Pacific do not generally favor the dispersal of marine life from west to east, yet most of the marine life in the Hawaiian Islands seems to have originated in the western Pacific.

2) Lead a class discussion using the series of questions in the Teacher Background "Marine Life Reproduction and Dispersal" (pp. 31-33). During this class discussion, you will show the segment of *Coral Reefs: Their Health, Our Wealth* on coral reproduction. The discussion will cover the following points:
   - Common reproductive strategies among marine animals, and
   - How those reproductive strategies have allowed dispersal among islands in the Pacific.

3) After this discussion, divide the class into five groups. Give each group the "Map of Pacific Ocean Currents" and "Known and Estimated Numbers of Inshore Fish Species by Area and Likely Routes of Colonization" map, along with one of the five "Current Conundrums" cards.

4) Have groups work together to form a hypothesis in response to the question on the card.

5) Bring the class back together and have each group share its "Current Conundrum," hypothesis, and reasoning. Use the Teacher Version of "Current Conundrums" (p. 34) to help groups fine-tune their responses if necessary.

6) As homework, assign the Student Page "Marine Life on the Move."

Journal Ideas

- Would you say that planktonic larvae navigate the currents? Why or why not?
- Write a first-person narrative about the life of a coral polyp, incorporating the stages of development and the process of dispersal.
- Compare the process of planktonic dispersal through which much Hawaiian marine life arrived here with the settlement of the Hawaiian Islands by Polynesian voyagers.

Assessment Tools

- Participation in group work and class discussion
- Group responses to "Current Conundrums" (teacher version, p. 34)
- Student Page "Marine Life on the Move" (teacher version, pp. 35-37)
- Journal entries

Teacher Background

Marine Life Reproduction and Dispersal

Use these notes as you conduct a class discussion that covers:

- Common reproductive strategies among marine animals, and
- How those reproductive strategies have allowed dispersal among islands in the Pacific

Part 1 — Setting the Stage

Initiate a student discussion about sexual reproduction and dispersal. Begin with a quick review of dispersal in flowering plants and land animals, using the following questions:

1. Do flowering plants have eggs and sperm? (Yes)
2. Where are the sperm? (In the pollen)
3. Where is the egg? (In the bottom part of the flower)
4. How does the sperm get to the egg? (Flowers attract animals such as bees and birds with scents, colors and nectar. The pollen sticks to these animals and is carried to another flower.)
5. Once the egg is pollinated, what happens? (It forms into a seed.)
6. Many seeds are dispersed away from the parent; how does this happen? (Seeds can be eaten by an animal and the animal walks or flies away, blown in the wind, have hooks on them so they stick to animals, and float in the ocean.)
7. Can seeds be dispersed very far? How do you think plants got to Hawai‘i before people? (Carried in the wind, stuck to migratory birds, carried in bird stomachs, and floated in ocean currents)
8. How is the egg fertilized by animals (mammals and birds) living on land? (Internal fertilization, copulation)
9. What are some of the strategies that ensure male and female animals get together and are ready to copulate at the same time? (Many species mate only in certain seasons, like spring; most animals have some sort of courtship ritual.)
10. How are the young dispersed from the parent? (They walk or fly away.)

Part 2 — Coral Reproduction

Once you have quickly reviewed the land plants and animals, turn the discussion to how marine animals reproduce and disperse their young. Focus first on corals.

Show the section of the video, *Coral Reefs: Their Health, Our Wealth*, on coral reproduction. Once the video segment is finished, lead a discussion on the following questions (or have students write down answers to these questions as a way of gauging how closely they watched the video).

1. How often do corals spawn? (Some spawn once a month; most spawn once a year. Each species spawns at the same time.)
2. What is a “larva”? (It is the early, free-living form of any animal that changes structurally when it becomes an adult or undergoes metamorphosis.)
3. Do you know any type of animal on land that goes through metamorphosis? (A caterpillar is the larva of a butterfly or moth, a tadpole is the larva of a frog or toad.)
4. What shape is a coral larva? (Pear-shaped)

5. Once it undergoes metamorphosis, what shape is it? (Polyp-shaped, like a flower)
6. How are the larvae dispersed? (They are free-swimming and are moved around in ocean currents.)

Part 3 — The Life Stages of a Marine Fish

Now, turn your attention to how most marine fish reproduce.

1. Do you know how marine fish reproduce? (Fish "spawn." Males and females release the eggs and sperm into the water, and fertilization is external, rather than internal. Sharks, rays, whales, and dolphins have internal fertilization.)
2. How do fish sychronize their spawning so that males and females are in the same place at the same time? (Environmental clues like water temperature, day length, moon phase, height of the tide, direction and intensity of the current, and courtship behaviors)

Part 4 — Dispersal of Marine Animals to Hawai'i

Show the "Map of Pacific Ocean Currents" acetate on an overhead projector, and use these questions:

1. Most marine animals and plants, including marine invertebrates, have planktonic larval stages. What does this mean? (The larval stages float in the open ocean currents for a while.)
2. What marine animals don't have this? (Examples include sharks, rays, whales, dolphins)
3. If some parrotfish (*uhu*) spawned off the coast of Japan, could their larval stages reach the Hawaiian Islands? If yes, how? (By floating in the North Pacific current)
4. What factors could affect whether the parrotfish could colonize Hawaiian waters?
   (• Whether their larval stage lasts long enough for viable larvae to reach Hawai'i adrift on the current,
   • Predation,
   • Water temperatures within the current or different water temperatures within Hawaiian waters,
   • Whether the current takes the larvae close to the islands or not,
   • Whether there is appropriate habitat for the larvae to settle and metamorphose, and
   • Whether the parent parrotfish produced enough offspring so that some would make it to the islands)

Now show the map of the Pacific showing most recent known and estimated numbers of inshore fish species by area and likely routes of colonization. An asterisk indicates an estimate. As needed, show the map of the Pacific currents that includes the names of the island groups and the Tropics of Cancer and Capricorn.

Work with the class to answer the following questions using these two maps:
1. What country has the most species of fish? (Indonesia)
2. The least? (Easter Island)
3. Do you see any trends in the number of marine fishes as you move from west to east? (In general, the number of species decreases.)

Use the following paragraph as background to help students understand the importance of the Indonesia-Malay Archipelago as a center of dispersal for marine life.

> The greatest concentration of species of marine life is found in the waters of the Indonesia-Malay Archipelago of the western Pacific Ocean. This area of shallow, warm water and intense tropical sunlight has offered a large, stable, and diverse habitat area that has nurtured marine life for millions of years. Consequently, it has acted as the center of dispersal for marine life inhabiting the tropical Indian and Pacific Oceans as far west as the coast of Africa and as far east as Hawai‘i, the Line Islands, and Easter Island. Marine life in the Atlantic shares a common ancient origin in the Tethys Sea with that of the Indo-West Pacific, but because of land barriers formed when Africa joined with Eurasia approximately 65 million years ago, the two are separate biological entities. During that time the Indonesia-Malay Archipelago appears to have been quite hospitable for the evolution of new species, as it hosts many more kinds of marine life than the Caribbean and tropical Atlantic.
>
> — *Ann Fielding and Ed Robinson,* An Underwater Guide to Hawai‘i, *University of Hawai‘i Press, Honolulu, 1987, pp. 15-18.*

Teacher Version

Current Conundrums

#1 — Tahitian Ancestry?

Would fish species from Tahiti be likely to colonize Hawai‘i? Why or why not?

No, currents from Tahiti don’t go north. However, that doesn’t mean that the same species of fish may not live in Tahitian and Hawaiian waters, but these species would have reached both Tahiti and Hawai‘i from somewhere else.

For an interesting side note, you could have students suggest complicated routes a larva would have to take to be transported by currents from Tahiti to Hawai‘i.

#2 — Johnston Atoll

Why do you think Johnston Atoll has fewer species than Hawai‘i?

The land and reef area is quite a bit smaller than Hawai‘i, offering fewer kinds of habitat. Also, there is only one small current coming from Hawai‘i.

Draw in the Tropics of Cancer and Capricorn on the overhead map with the fish species numbers. Between these two lines lie the tropics. As you go north or south you enter the temperate regions where the water is cooler.

#3 — Midway Atoll

Why do you think Midway Atoll has fewer fish species than the main islands, despite being closer to Japan, where many Hawaiian fish seem to originate?

Not as many different kinds of habitats on an atoll, smaller reef area, cooler water because it is further north

#4 — Hawaiian Endemics

About 25 percent of the fish found in Hawai‘i are endemic to Hawai‘i. This is the greatest percentage of endemic marine fishes in the world. Why would this be the case?

Hawai‘i is very isolated. Fish arriving here would be separated from others of their species and changes would occur in their DNA over time.

#5 — Missing Fish Species

Some fishes, such as shallow-water snappers and groupers, are common on reefs in Pacific islands to the south and west of Hawai‘i, yet they are almost non-existent in Hawai‘i. What could cause this pattern of dispersal?

Some researchers have suggested that they must have short larval lives, meaning the time a larval fish can stay alive in the plankton is limited. The distance it can be dispersed would be similarly limited.

Teacher Version

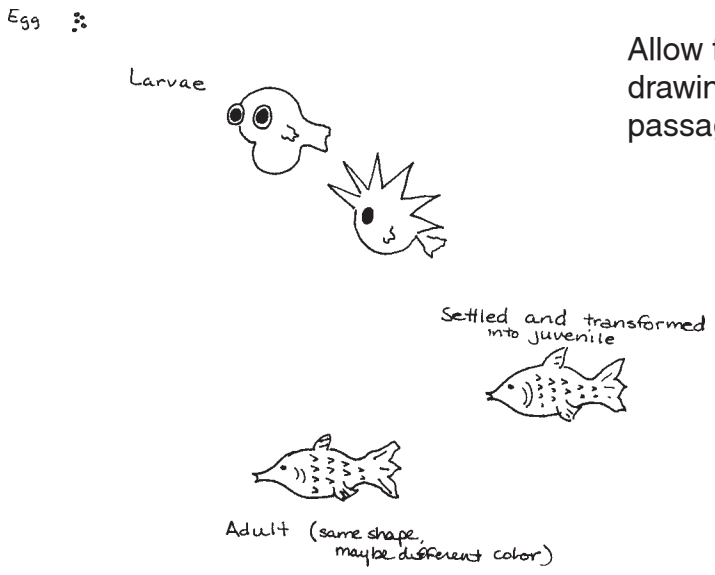
Marine Life on the Move

Reproduction among reef fishes is highly varied and often quite complex. The vast majority of fishes lay eggs. The birth of fully developed young is extremely rare among bony fishes and common only among cartilagenous fishes [fishes such as sharks and rays whose skeletons are largely composed of cartilage rather than bone]. Eggs of fishes are typically small (about 1 mm in diameter) and generally take about a week to hatch. The eggs hatch into larvae which bear little resemblance to the fishes familiar to most people. Larvae start out as tadpole-like creatures with large eyes, without pigment or scales, and often with an external yolk sac to nourish them until their gut develops.

Larvae are adapted to a pelagic life, drifting with the [ocean] currents and feeding on phytoplankton to progressively larger zooplankton as they grow. Some larvae actively swim, guided by environmental cues that may help them find a suitable settling site. In many species the larvae develop enlarged bony plates or spines that help protect them from predation [and make them more buoyant]. In some species larvae settle and transform into juveniles within days of hatching while in others they may go through a prolonged late larval stage that may last up to two months or more. Once they locate a suitable place to settle, larvae become bottom-oriented and rapidly acquire the pigments, scales, and full complement of fin rays characteristic of juveniles. Juveniles usually resemble adults in form but, in reef species, may often have a color pattern entirely different from that of adults.

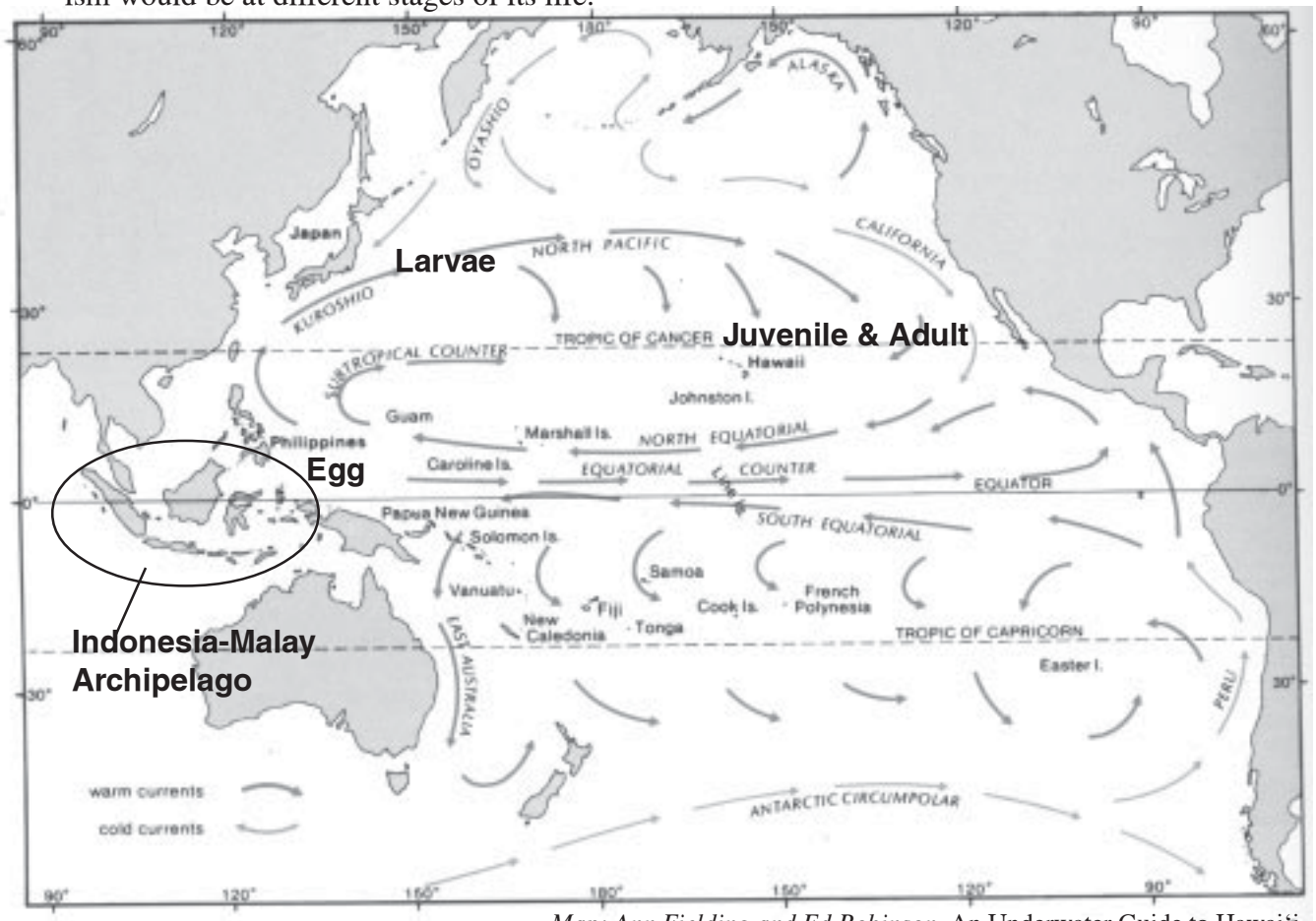
— Robert F. Myers, *Micronesian Reef Fishes: A Guide for Divers and Aquarists* 3rd ed., Sea Challengers, 1999, pp. 19-20.

1) In the space below, make a drawing that represents each phase of the reproductive cycle of most marine fishes, as described in the passage above.



Allow for creativity, as long as the drawings cover the stages listed in the passage, and fit with the descriptions.

2) Assume that your drawing represents a species of fish native to the Philippines that dispersed to Hawai‘i. Label each part of the reproductive cycle on the map below to indicate where the organism would be at different stages of its life.



Map: Ann Fielding and Ed Robinson, An Underwater Guide to Hawai‘i, *University of Hawai‘i Press, Honolulu, 1987*

3) Formulate a hypothesis to explain the difference in the rate of endemism in Hawaiian marine invertebrates and Hawaiian insects. Species that are “endemic” to Hawai‘i are found only in Hawai‘i and nowhere else on earth.

	Rate of endemism
Hawaiian marine invertebrates such as mollusks, sea stars, and brittle stars	Approx. 20 percent of species are endemic
Hawaiian insects	Approx. 94 percent of species are endemic

Endemism among Hawaiian terrestrial fauna, including invertebrates, is often linked to the islands’ isolation from other land masses and therefore from regular influxes of new organisms and genetic material. In contrast, marine invertebrate species receive more regular influxes of new organisms and genetic material arriving on ocean currents.

4) Do ocean currents favor the dispersal of marine life from the South Pacific to Hawai'i? Why or why not?

No, because the equatorial currents and counter currents run east-west and west-east, not from the south to the north

5) What part of the world has the greatest concentration of marine species and has acted as the center for dispersal for marine life in the tropical Indian and Pacific oceans, from Africa to Hawai'i?

The Indonesia-Malay Archipelago

Circle and label this area on the map of the Pacific on the previous page.

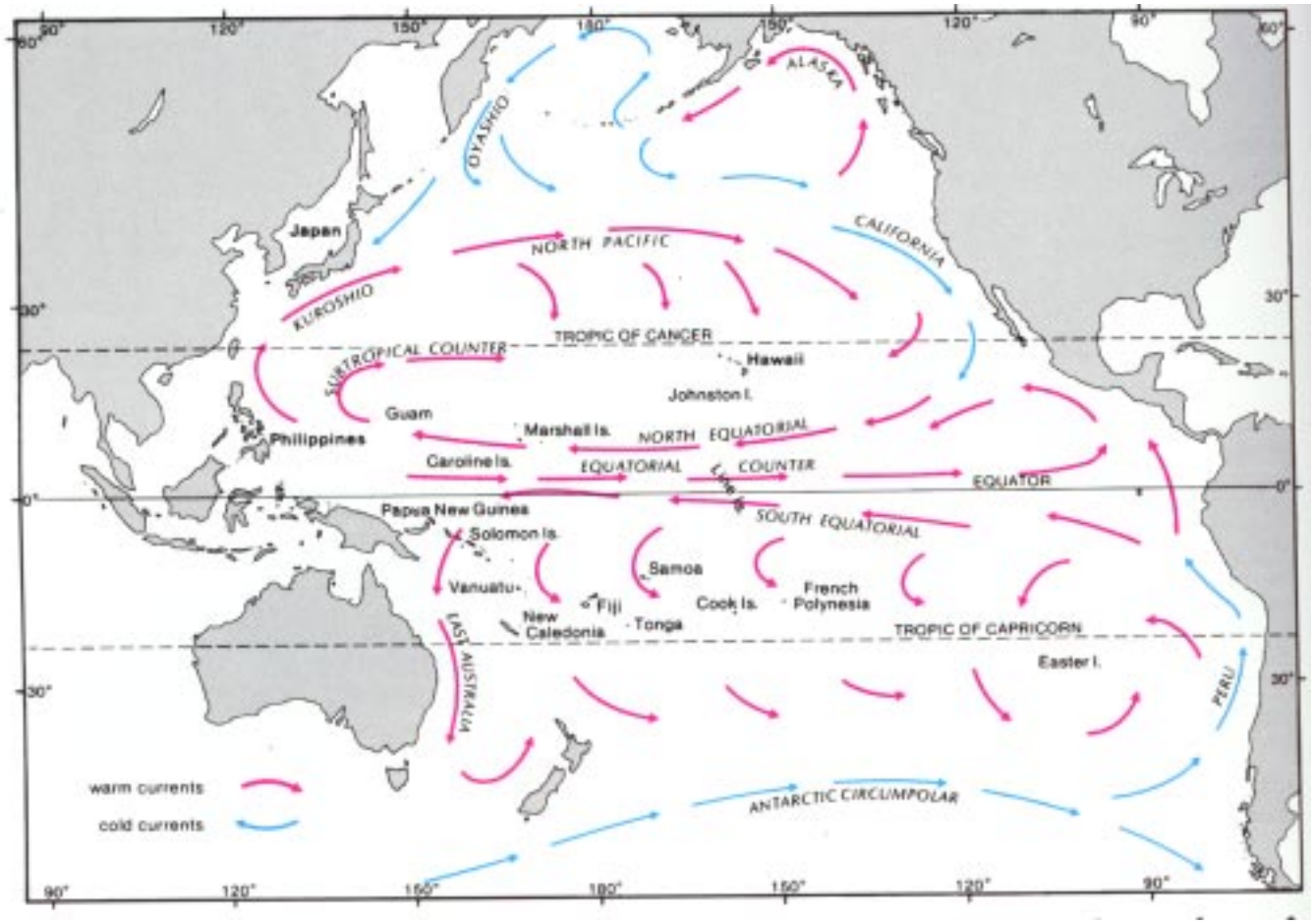
6) Name three factors that influence whether a coral species from Indonesia would be able to successfully colonize Hawaiian waters.

Factors could include:
- Whether their larval stage lasts long enough for viable larvae to reach Hawai'i adrift on the currents,
- Whether the larvae survive predation,
- Water temperatures within the current or different water temperatures within Hawaiian waters,
- Whether the current they are taken up in takes the larvae close to the islands or not,
- Whether there is appropriate habitat for the larvae to settle and metamorphose, and
- Whether the parent corals produced enough offspring that some would survive the trip to the islands.

7) Compare and contrast the means by which Polynesian voyagers and planktonic marine organisms travel on ocean currents to reach Hawai'i.

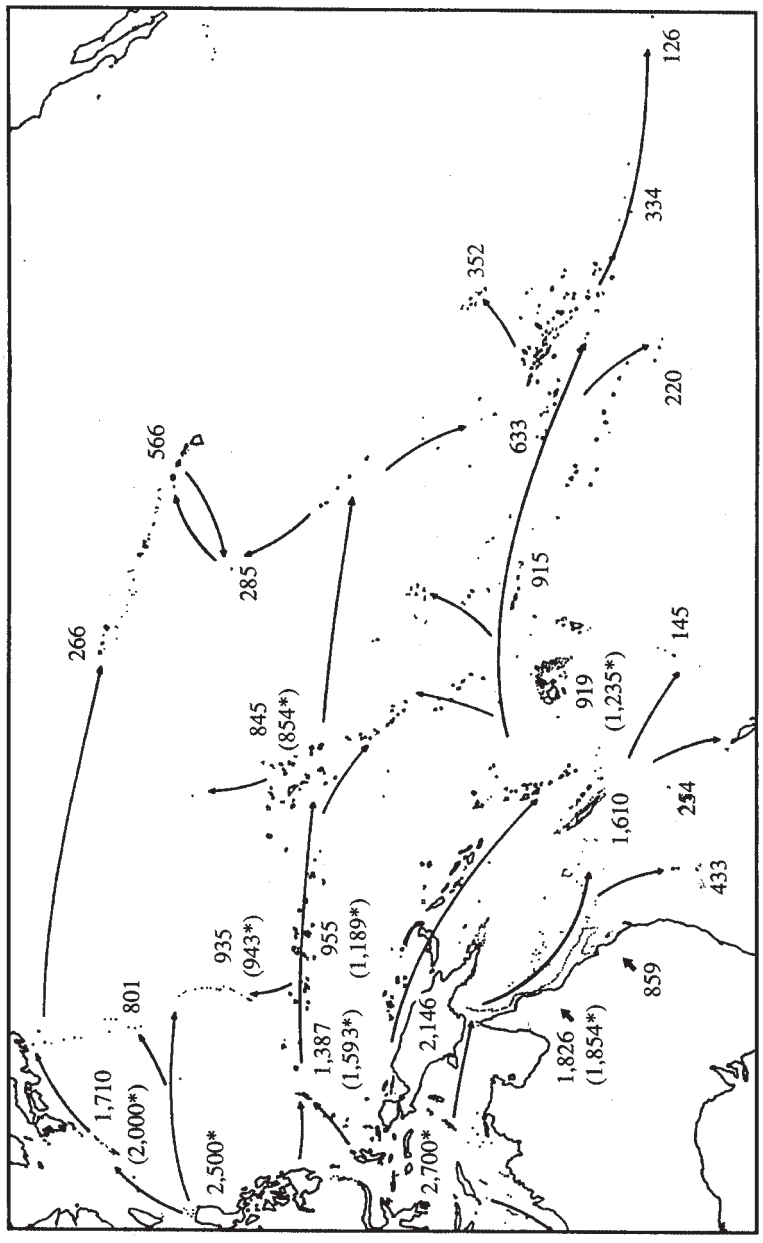
Polynesian voyagers navigate in canoes that use sails and winds as well as ocean currents to power their travels. Unlike planktonic marine organisms, the voyagers navigate, guiding their own travels along a particular course.

Map of Pacific Ocean Currents



Map: Ann Fielding and Ed Robinson, An Underwater Guide to Hawai'i, *University of Hawai'i Press, Honolulu, 1987.*

Known and Estimated Numbers of Inshore Fish Species by Area and Likely Routes of Colonization



Map of the Pacific showing most recent known and estimated numbers of inshore fish species by area and likely routes of colonization. An asterisk indicates an estimate. Figures for the Marquesas, Pitcairn group, and the Hawaiian Islands provided by J. E. Randall.

Map: Robert F. Myers, Micronesian Reef Fishes: A Field Guide for Divers and Aquarists *3rd ed., Sea Challengers, 1999, p. 11.*

Current Conundrums Cards

Cut along dashed lines

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#4 — Hawaiian Endemics

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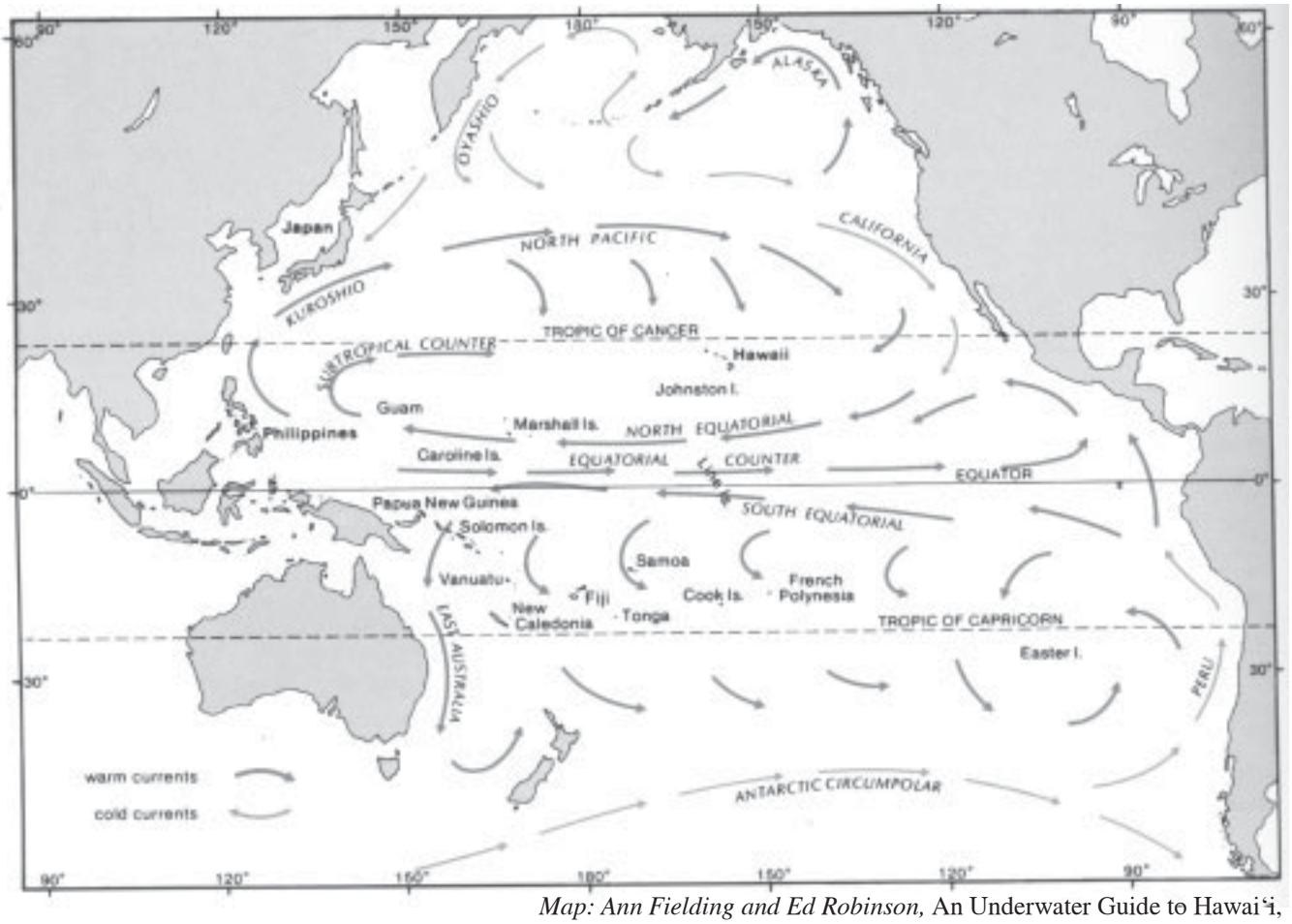
3) Formulate a hypothesis to explain the difference in the rate of endemism in Hawaiian marine



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