Opinion

Utility of controlled release semiochemicals in marine biology

Abstract

Controlled release of semiochemicals has been shown to be an effective technique for influencing the behavior of marine species. Examples are provided: sharks, lamprey, and trout. Identification of other marine semiochemicals is necessary for further exploitation of this promising technique.

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Introduction

Semiochemicals are defined as those chemicals that convey a message from one organism to another so as to modify the behavior of the recipient.[1] The definition can be expanded to include chemicals that convey a signal to the recipient but may not originate from another organism. Many semiochemicals cause chemotaxis – chemically oriented motion. There are attractants that bring other organisms toward the source of the chemical and repellents make other organisms move away. Among the attractants are pheromones, which usually bring together animals for mating. Among the repellents are necromones, which come from dead organisms and send a flight signal to conspecifics. A marine environment allows for a wide variety of semiochemicals – unlike atmospheric semiochemicals which must be sufficiently volatile to disperse in air, marine semiochemicals need only be soluble in water at relatively low concentrations. In combination with a variety of other scientists, we have developed methods to release semiochemicals into marine environments to attract and repel a variety of organisms.[2-6]

Shark repellents

Starting with an old fishermen's legend, our partners at SharkDefense and the College of the Florida Keys developed semiochemicals that act as shark repellents. Necromones were isolated from putrefying shark tissue, and other shark repellent chemicals were discovered by analogy to the chemicals in the necromone mixture. These materials were found to be effective when released from aerosol cans.[2] This delivery method was intended for surfers and scuba divers as an emergency measure. A controlled release system was designed with the repellent semiochemicals mixed into polyethylene glycol (PEG) in cardboard tubes. These were inserted into squid used as bait in longline fishing runs targeting swordfish. This resulted in reduction in shark bycatch of about 30%.[3]

Lamprey

Our partners at Michigan State University and the Great Lakes Fishery Commission isolated semiochemicals released by male sea lamprey to attract females,[7] including the primary attractant 3-ketopetromyzonol sulfate (3kPZS), a bile acid derivative. This pheromone was also incorporated into PEG, and used to fill plastic tubes. These were placed in a stream and the response of female lamprey recorded.[4] In unreported results, trapping of female lamprey using 3kPZS in PEG baits was as effective as pumped solutions of 3kPZS.

Trout

Our partners at the Great Lakes Fishery Commission, Michigan State University and the United States Geological Survey developed a theory about lake trout spawning behavior: that trout are imprinted on the odor of their hatching locale. This would explain why farmed trout do not find the spawning grounds in the Great Lakes. Mud removed from the bottom of the trout farm hatchery was mixed with PEG in special emitters designed to last for up to two weeks and placed in the spawning grounds in Lake Huron. The emitter design was successful, but a positive response of farmed trout was not observed.[6]

Future applications and challenges

Other marine species might be prime targets for controlled release of semiochemicals into marine environments. The species targeted to date have mostly been fish. We have also investigated the potential for planktonic larvae of commercially valuable species such as spiny lobsters and oysters, and also of invasive species such as zebra mussels. The difficulty is in identifying the specific semiochemical signal that generates an attractive or repellent response in the target species. Once such semiochemicals are identified, controlled release systems can be constructed and inserted into the environment to produce the desired behavioral response. However, each target species requires intense attention, which is a challenge. Another challenge is developing systems for controlled release. PEG has been the workhorse polymer in our efforts, but has limitations. Molecular weights above 10,000 are not approved for release into the environment, but dissolution of lower MW polymers can be more rapid than desired. Carbohydrate polymers such as starch, pullulan, or cellulose derivatives have been investigated, but high melting points compared to PEG make them more difficult to use. Hydrogels based on carrageenan or alginic acid have also been evaluated as controlled release matrices: release from hydrogels is less linear than from slow dissolving polymers like PEG. Research into new semiochemical systems for marine species and new controlled release systems is strongly encouraged.

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None.

Conflicts of interest

We declare that there is no conflict of interest of any kind.

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