Studying HAMMERHEA in HAWAII

High school students work with biologists to study sharks as part of a partnership research collaboration

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Students often form vocational interests by tenth grade, at which time they become resistant to changing their occupational pursuits (Williams 1991). This early adoption of vocational interests has poor implications for scientific disciplines because by middle school many students have lost interest in science, and by high school many are bored and find it irrelevant (Young 1997). Many research scientists in the United States acknowledge this dilemma and agree that K–12 science education needs significant improvement (Druger and Allen 1998).

When asked to describe how scientists could assist K–12 science education in the United States, scientists suggested they could give presentations, host students as interns, and work with teachers (Druger and Allen 1998). We argue that professional scientists need to expand these suggestions by developing partnerships with K–12 students. Partnerships should include project-centered instruction with collaboration on scientific research (Evans et al. 2001). Partnership research collaborations help K–12 students gain scientific knowledge in addition to critical-thinking skills.

The High School Scalloped Hammerhead Shark Tagging Program in Hawaii is an example of a successful partnership research collaboration. As part of the program, high school students and teachers worked with biologists from the University of Hawaii–Manoa (UHM) to conduct research on the life history of scalloped hammerhead sharks (*Sphyrna lewini*). The educational goal of the program was to inform current and future generations about the importance of maintaining healthy ecosystems.

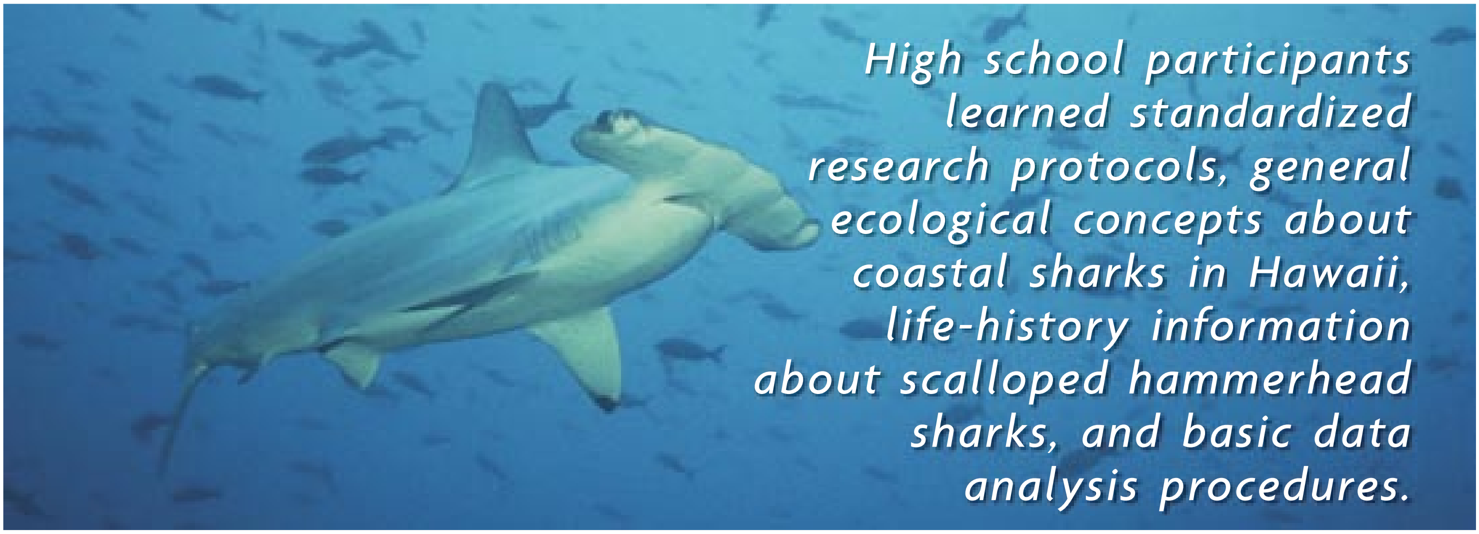
Conducting research

The shark pups inhabit coastal nurseries where they are apex predators and may seasonally dominate vertebrate biomass. These estuarine nurseries are often places of high recreational use, port areas, and destinations of sewage outfall (Blaber 1999).

Starting in June 2002, 45 high school students worked for over 5 months alongside biologists in Kaneohe Bay, Oahu, Hawaii, to better understand the role that coastal areas play in the life cycle of hammerhead sharks. Students were recruited via presentations at various high schools and through postings on the Hawaii Science Teachers Association website. Participants received no academic credit for their involvement. The program was started by UHM researchers in an effort to include high school students in authentic scientific research and increase data collection on sharks. The group was very heterogeneous in terms of ethnicity, culture, age (all high school), socioeconomic status, gender, and level of academic achievement. Mark-recapture and captive-growth studies were used to investigate patterns of shark distribution, residency, growth, and survivorship within the nursery. The primary goal was to concentrate shark mark-recapture efforts over short time periods to estimate population size and survivorship.

For two weeks during June and August, three portions of the bay were fished for three hours a day. Shorter fishing efforts were conducted in July, September, and October. With the assistance of scientists, students caught, sexed, measured, weighed, tagged, and determined umbilical scar condition of juvenile sharks. Students were in charge of preparation and cleanup of the fishing boats as well as the equipment needed on the research vessels. Students were also responsible for recording daily weather conditions, preparing bait for fishing, measuring depth of the water column, and taking GPS readings. Data collection efforts consisted of 280 boat hours and 1,174 hook hours; 1,618 shark pups were tagged, and of these 40 were recaptured. Students assisted with all aspects of data collection, but the scientists made numerical measurements and tagged each shark to ensure accuracy and safety.

Because of the nature of the research and the work environment, time was spent during the orientation lecture on the first day of each program session covering proper research and safety guidelines. Researchers also closely guided student participants on that first day in preparing and cleaning the fishing boats. Program leaders guided high school participants in preparation and cleanup activities less and less during a particular session with the expectation that students would eventually take full responsibility for these processes. While on the boats, students wore Coast Guard–approved life vests and were familiar with all boat safety guidelines. Students were also not allowed to swim in the bay and a high level of supervision was maintained



at all times. Scientists leading the program had medical training ranging from basic first aid to extensive wilderness first-responder certifications.

To be successful, student participants in a study like this must be introduced to background information concerning the topic, scientific methods, and the data-collecting procedures (Lawless and Rock 1998). High school participants learned standardized research protocols, general ecological concepts about coastal sharks in Hawaii, life-history information about scalloped hammerhead sharks, and basic data analysis procedures. Development of these skills facilitated ease and accuracy of data collection during the research project and led to project success.

Research findings

This study confirmed that juvenile hammerheads show a preference for the deeper water zones in areas of higher sedimentation and nutrient flow. This correlates with Bush and Holland's (2002) finding that food is a limiting factor for juvenile sharks and with Smith and Kukert's (1996) evaluation of the trophic efficiency of Kaneohe Bay. Data collected in this study also corroborated hypotheses of shoaling behavior in juvenile sharks. As adults, hammerhead sharks are often observed in large schools (Klimely 1993). Juvenile hammerhead pups are also suspected of schooling; however, because the water they inhabit is turbid, it is difficult to assess this behavior. Data from the high-school shark tagging program have now provided evidence supporting the schooling hypothesis. For the high school students, participating in a study that produced significant new evidence for understanding this behavior was an exciting outcome.

Movement patterns of sharks during this study also validate earlier unpublished data, indicating that juvenile sharks remain within Kaneohe Bay for at least a few months. During the short capture intervals used in the high-school program, the population was believed to be closed and population size was constant. Yet very few sharks were recaptured, suggesting that rather than emigrate at very small sizes as Clarke (1971) hypothesized, hammerheads stay within the bay. Low recapture rate is likely due to the large size of the bay in relation to the fishing effort, compounded over the long term by the high mortality of shark pups. The drop in winter population size seen in previous studies can be attributed to attrition and spatial distribution of sharks rather than emigration from the nursery. This information supports hypotheses that nurseries are important habitat for newborn hammerheads during their first year; fishing activities and water quality of the nursery are concomitantly important.

Developing a sense of ownership

Students and teachers can effectively engage in quality research studies if the study is appropriate (Handler and Duncan 2006). Appropriateness is based on student ability to understand the scientific questions, costs of including students, and the need for workers or a large geographic distribution of observers (Tinker 1997). Scientists should also consider whether K–12 students will be able to collect reliable data after adequate training. Students need to understand that data must always be collected in the same way, with the same equipment, and under the same experimental conditions (Lawless and Rock 1998).

The shark case study shows that collaborations can be successful when large amounts of assistance are needed, accessible questions are available, and scientists are willing to work in partnership projects (Handler and Duncan 2005). This program worked to make students responsible for their own learning by combining the concepts of stable and fluid inquiry. Stable inquiry uses accepted ideas to guide accumulation of new knowledge. Fluid inquiry promotes the expansion of ideas by questioning, reinventing, expanding, modifying, and extending current boundaries (Young 1997). This combination of inquiry methods is what makes scientist–student partnerships quite exciting; a solid knowledge and research base is given new life in the hands of students whose thinking is not as structured as most career researchers.

Providing these hands-on scientific learning experiences demonstrates to students that science is more than dry, irrelevant facts. Various assessment strategies used throughout the course of the shark-tagging program showed definitively that students gained concepts and skills taught in the program (Handler and Duncan 2005). Students learned a great deal about coastal ecology and coastal marine biology. Pre- and post-paper surveys were used to assess concepts and skills gained by student participants. Concepts and skills in this analysis included: bait preparation, fishing, assisting in shark handling, reasons for murky waters in Kaneohe Bay, what is a shark, sharks of Hawaii, similarities and differences among shark species, effect of shark body form and functions on movement, captive shark movement and behavior, and sharks' roles in food webs. Knowledge retention was also measured through surveys of a subset of high-school student participants (n = 9) who assisted shark biologists after the conclusion of the summer tagging program in leading a science-teacher workshop later that year.

Comparison of pre- and post-surveys showed that positive percentage shifts in concepts and skills gained by students attending this program were statistically significant in all categories except for "what is a shark" (Handler and Duncan 2005). A statistically significant shift was probably not found in this category due to participant prior exposure to sharks through various forms of media. The shifts in percentage gains were further validated through assessments made by science teachers participating in an October follow-up workshop who were asked to evaluate high school students involved in the workshop on their ability to teach specific concepts and skills. Not surprisingly, there was a very strong relationship between the amount of time students spent performing a certain skill or learning a new concept and their retention level (Handler and Duncan 2005).

Student participants were also affected in unexpected ways. Because the shark research was an authentic scientific endeavor rather than a contrived exercise, students developed a sense of ownership, pride, and purpose. One student voluntarily wrote an essay about her shark tagging experience and submitted it to her teachers to show them what she had done during the summer. Another student continued assisting with hammerhead research the following summer. Four other students volunteered for entomology research with another K–12 project. Importantly, the students who contributed beyond the set program and sought extra activities were not individuals who had been considered to be stereotypical "good students" (Handler and Duncan 2005). We hope that these experiences will encourage students to consider possible careers in scientific research. In conclusion, we feel that both K–12 science education and scientific research in the United States can benefit from professional scientists who develop partnerships incorporating K–12 students and teachers. ■

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