Protein Expression in Gobies as Biomarkers of Exposure to Persistent Organic Pollutants

Lars Tomanek, Cal Poly San Luis Obispo

SUMMARY

Morro Bay in Central California is considered a relatively pristine waterway with little urban or agricultural pollution. In this project, however, scientists show a high incidence of primordial gonadal and liver tumors in arrow goby, *Clevelandia ios*, collected from the bay's mudflats. Large tumors were found in about ten percent of 150 arrow gobies sampled from the area. Subsequent testing at UC Davis revealed signs of abnormal liver cell growth, associated with the early stages of liver cancer, in even apparently healthy fish. These tumors are usually indicative of exposure to persistent organic pollutants: chemicals that accumulate in organisms but evade detection through traditional water-quality testing. In the case of the bay, the fish were shown to be riddled with an endocrine disruptor known as nonylphenol, the degraded form of a group of petroleum products known as alkylphenol ethoxylates. Ethoxylates, added to detergents, cosmetics and spermicides, have both hydrophilic and hydrophobic chemical groups, which make them highly effective at dissolving organic chemicals in water.

L. Tomanek/Cal Poly

Cal Poly students Megan Segal (left) and Sarah Johnson collect arrow gobies in Morro Bay.

Reflecting the ubiquity of their use in household products, high levels of nonylphenol were measured not only in fish but also in sediment and water from the bay, as well as in farm-raised oysters. There is some evidence, collected by other researchers, that nonylphenol can also turn male fishes into hermaphrodites. Because of the compound's potential toxicity, the European Union has effectively banned ethoxylates for almost all uses; Canada's allowable levels of nonylphenol in waterways, meanwhile, are about half those of the United States.

PROJECT HYPOTHESIS

The working hypothesis of the project: Protein expression in arrow goby liver tissue reflects exposure to nonylphenol. Scientists are testing this hypothesis by exposing fish to the pollutant and quantifying changes in several proteins simultaneously, using proteomics. This work is ongoing.

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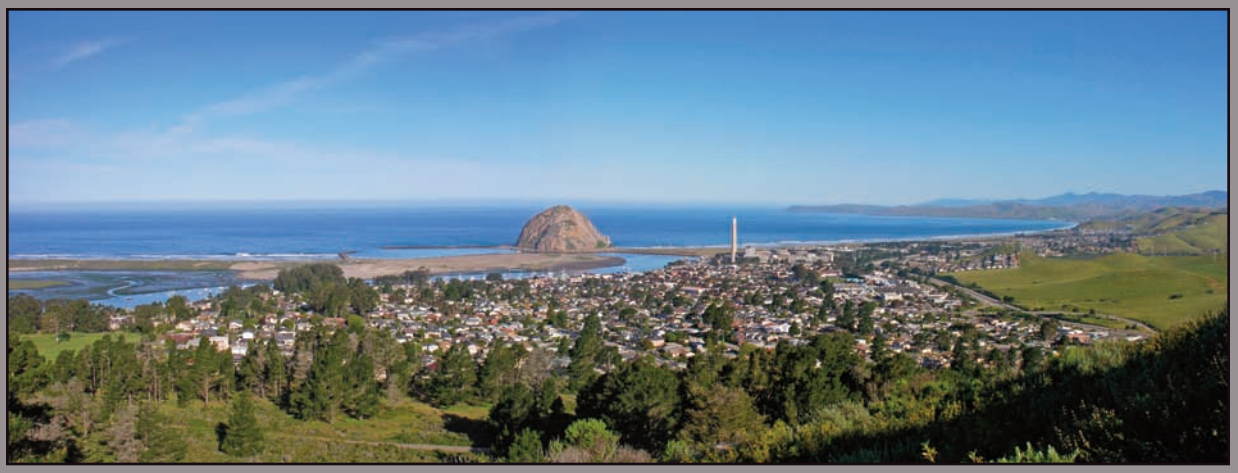
Morro Bay arrow gobies with tumors.

DISCUSSION AND RESULTS

The original proposal of this yearlong project was to expose, in the laboratory, a group of pollutant-free fish to nonylphenol and assess changes in protein expression through two-dimensional gel electrophoresis and mass spectrometry of proteins.

After collecting fish from several urban and relatively pristine estuaries in California and Oregon, scientists were unable to find a single goby population free of nonylphenol contamination. That is, they could not find a control group. They decided to re-focus the project on understanding the exposure threat in Morro Bay and identify possible sources of contamination. The preliminary result is that the toxin is coming from municipal sewage treatment plants. In other words, the chemicals are not removed in the treatment of household wastewater. They have started to characterize sources of contamination from surrounding watersheds.

The scientists also decided to conduct an exposure experiment on a contaminated goby population to study the progression of protein expression with higher toxin concentrations. They are now analyzing changes in protein expression in these fish. There is some preliminary evidence that changes in oxidative stress proteins may reflect toxin exposure.



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The city of Morro Bay, California.

CONCLUSIONS

This project strongly suggests that current levels of nonylphenol contamination are having a measurably detrimental effect on marine life in California. The ubiquity of this contamination further underscores concerns about whether existing regulations adequately protect marine and human health.

"If the known physiological effects and the distribution of nonylphenol in California are an indication for the potential threat, we suspect that it will pose one of the major environmental problems to our marine environment and its life," the lead scientist wrote in a report to California Sea Grant. "It also poses a threat to our food supply and safety.... Several of the bays and estuaries sampled for the project are places where shellfish are cultured for human consumption. The project's results may have major implications for how we assess the health threats to our marine life and how we manage land-based pollution of our coasts."

TOOLS

Data on persistent organic pollution is lacking, in part, because of an inability to measure low concentrations of contaminants through standard water-quality monitoring techniques. In this project, researchers are using proteomics to identify biomarkers of chemical contamination. In this way, they are potentially developing a new tool for monitoring the presence and effects of marine pollutants.

OUTREACH

Researchers are working closely with resource managers and stakeholders in Morro Bay to disseminate their findings. Results were, for example, shared at meetings of the advisory committee of the San Luis Obispo Science and Ecosystem Alliance (SLOSEA), whose members include the Regional Water Quality Board, fishermen and elected officials.

STUDENTS

Sarah E. Johnson, Master's

COLLABORATORS

Regional Water Quality Board
Morro Bay National Estuary Program
San Luis Obispo Science and Ecosystem Alliance (SLOSEA)

REPORT

San Luis Obispo Science and Ecosystems Alliance (SLOSEA) – Strategic Plan, November 2008

CONFERENCE PROCEEDING

Linking organic pollutants to tumor growth in arrow goby, *Clevelandia ios*, in Morro Bay: Proteomics as a tool for biomarker discovery. Johnson, S. E.; West A. E. and L. Tomanek. Society for Integrative and Comparative Biology, Boston, 2009.

CONTACT

Lars Tomanek
Environmental Proteomics Laboratory
Center for Coastal Marine Sciences
California Polytechnic State University, San Luis Obispo
(805) 756-2437
ltomanek@calpoly.edu

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California Sea Grant, University of California, San Diego, 9500 Gilman Drive, Dept. 0232, La Jolla, CA 92093-0232
Communications Phone: (858) 534-4446