W.G. Jackson and *D.J. Angus* Scientific Cruises
February 2008

The list below shows the High School Biology content expectations that are highlighted on the water quality sampling trips. Strong elements of the program are in the inquiry, reflection and social implications category. Plants and animals in aquatic ecosystems are studied along with threats to the integrity of aquatic ecosystems. The experience integrates chemistry with biology. Biology Content Expectations that are not specifically addressed are not on this list. For more information or to add more to this list contact GVSU Annis Water Resources Institute at 616-331-3048.

HSCE Code	Expectation	Current Instructional Materials and Activities
Standard B1	**INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS**	
Statement B1.1	**Scientific Inquiry** Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	Key to the cruises on the *W.G. Jackson* and the *D.J. Angus* is hands-on, inquiry science. The students practice the scientific method to make observations that allow them to evaluate water quality.
B1.1A	Generate new questions that can be investigated in the laboratory or field.	Students practice methods that can be applied to answer questions in their own projects.
B1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	Protocols are followed for sampling and analysis. The importance of replicates and careful measurement is stressed.
B1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	Students use a wide variety of tools and techniques including pH meters, dissolved oxygen kits, Secchi disks, grab samplers, turbidity meters, alkalinity kits, plankton nets, thermometers, etc.
B1.1D	Identify patterns in data and relate them to theoretical models.	Data generated are analyzed for patterns of the quality of a water body – eutrophic, mesotrophic, and oligotrophic.
B1.1E	Describe a reason for a given conclusion using evidence from an investigation.	During a summary on the vessel, students use evidence from their investigations to rate a water body.
B1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.	In the context of analysis and sampling, students can predict what would affect results. The summary emphasizes that variation in environmental conditions such as weather and time of year influence results.
B1.1g	Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.	In the summary, conclusions are draw based upon the information collected by the students.
B1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	As a follow-up to cruises, students are encouraged to design their own experiments. A data chart is used in our summary.

B1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	In an exploration of invasive species, the origin and effects of these species in the Great Lakes is the subject of active research.
Statement B1.2	**Scientific Reflection and Social Implications** The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	Great Lakes research is highlighted on trips. Examples of work by GVSU-ARWI scientists serve as models for research that has practical implications for the general public.
B1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence.	Students are introduced to the idea that protection of the Great Lakes is dependent upon individual decisions.
B1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	Multiple sources of information are used to evaluate the trophic status of the water body studied. There is critical evaluation of data collected.
B1.2D	Evaluate scientific explanations in a peer review process or discussion format.	The summary session addresses this.
B1.2E	Evaluate the future career and occupational prospects of science fields.	Students experience doing scientific research onboard an actual research vessel.
B1.2f	Critique solutions to problems, given criteria and scientific constraints.	Restoration and protection of aquatic ecosystems involve many actions, all of which are not feasible. Examples such as the quagga mussel invasion are explored.
B1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions.	See B1.2f
B1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.	Throughout the water quality analysis procedures, these distinctions become evident.
B1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions.	Students observe shoreline development (power plants, industry) in the context of effects on aquatic ecosystems.
B1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	Past decisions in these areas are linked with present day effects on water quality.

Standard B2	ORGANIZATION AND DEVELOPMENT OF LIVING SYSTEMS	
Statement L2.p1	**Cells *(prerequisite)*** All organisms are composed of cells, from just one cell to many cells. Water accounts for more than two-thirds of the weight of a cell, which gives cells many of their properties. In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of organisms for food, air, and waste removal. The way in which cells function is similar in all living organisms. *(prerequisite)*	Zooplankton, phytoplankton, and benthos are observed. Unicellular and multicellular plankton illustrate structure and function. When students analyze the Ponar Grab sample, they distinguish between living and non-living things. The importance of water is inherent in the experience as this trip is about aquatic ecosystems. Different sizes of mussels are observed. A variety of organisms are collected which illustrate different patterns in how systems work together. The feeding habits of mussels are contrasted with other aquatic organisms.
Statement L2.p2	**Cell Function *(prerequisite)*** Cells carry out the many functions needed to sustain life. They grow and divide, thereby producing more cells. Food is used to provide energy for the work that cells do and is a source of the molecular building blocks from which needed materials are assembled. *(prerequisite)*	Study of unicellular and multicellular plankton and benthos demonstrates this concept.
Statement L2.p3	**Plants as Producers (prerequisite)** Plants are producers; they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars, along with minerals from the soil, to form fats, proteins, and carbohydrates. This food can be used immediately, incorporated into the cells of a plant as the plant grows, or stored for later use. *(prerequisite)*	Phytoplankton are observed and their role as primary producers in an aquatic environment is discussed.
Statement L2.p4	**Animals as Consumers *(prerequisite)*** All animals, including humans, are consumers; they obtain food by eating other organisms or their products. Consumers break down the structures of the organisms they eat to obtain the materials they need to grow and function. Decomposers, including bacteria and fungi, use dead organisms or their products for food. *(prerequisite)*	Consumers such as bloodworms, zooplankton, and mussels are identified.
Statement L2.p5	**Common Elements *(prerequisite)*** Living systems are made of complex molecules that consist mostly of a few elements, especially carbon, hydrogen, oxygen, nitrogen, and phosphorous. *(prerequisite)*	Oxygen, nitrates, phosphates, and carbon dioxide tests are related to the needs of plants and animals.
Statement B2.1	**Transformation of Matter and Energy in Cells** In multicellular organisms, cells are specialized to carry out specific functions such as transport, reproduction, or energy transformation.	Chloroplasts for photosynthesis are observed in the phytoplankton, which are fed to live mussels. It is pointed out that low oxygen levels are detrimental to fish.

Statement B2.3	**Maintaining Environmental Stability** The internal environment of living things must remain relatively constant. Many systems work together to maintain stability. Stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.	With invasive species and VHS disease in fish as examples, challenges to current environmental stability is addressed.
Statement B2.3x	**Homeostasis** The internal environment of living things must remain relatively constant. Many systems work together to maintain homeostasis. When homeostasis is lost, death occurs.	Students observe the importance of water for maintaining homeostasis in aquatic organisms. Changes in pH, temperature, and dissolved oxygen are related to the survival of organisms.
Statement B2.4	**Cell Specialization** In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms**.**	The magnified internal structure of a bloodworm and zooplankton show specialized functions. Prokaryotic cyanobacteria and eukaryotic unicellular algae demonstrate cell differences.
Statement B2.5	**Living Organism Composition** All living or once-living organisms are composed of carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates and lipids contain many carbon-hydrogen bonds that also store energy.	Matter cycling through aquatic food chains is addressed.
Statement B2.5x	**Energy Transfer** All living or once-living organisms are composed of carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates and lipids contain many carbon-hydrogen bonds that also store energy. However, that energy must be transferred to ATP (adenosine triphosphate) to be usable by the cell.	Energy flow through aquatic food chains is addressed
Standard B3	**INTERDEPENDENCE OF LIVING SYSTEMS AND THE ENVIRONMENT**	
Statement L3.p1	**Populations, Communities, and Ecosystems *(prerequisite)*** Organisms of one species form a population. Populations of different organisms interact and form communities. Living communities and the nonliving factors that interact with them form ecosystems. *(prerequisite)*	Lake Michigan and inland water body communities and populations are contrasted.
Statement L3.p2	**L3.p2 Relationships Among Organisms *(prerequisite)*** Two types of organisms may interact with one another in several ways; they may be in a producer/consumer, predator/ prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other. *(prerequisite)*	Lamprey-lake trout, round goby-mussels, and plankton-fish interactions provide examples of this.
Statement L3.p3	**Factors Influencing Ecosystems *(prerequisite)*** The number of organisms and populations an ecosystem can support depends on the biotic resources available and abiotic factors, such as quantity of light and water, range of	Numbers and kinds of organisms are related to abiotic factors measured in the laboratory and on deck. Competition for food and space by invasive species is studied.

	temperatures, and soil composition. *(prerequisite)*	
Statement L3.p4	**Human Impact on Ecosystems *(prerequisite)*** All organisms cause changes in their environments. Some of these changes are detrimental, whereas others are beneficial. *(prerequisite)*	Human activities and their effects on aquatic ecosystems are pointed out through examples such as the invasive species problem and water quality impairments.
Statement B3.1	**Photosynthesis and Respiration** Organisms acquire their energy directly or indirectly from sunlight. Plants capture the Sun's energy and use it to convert carbon dioxide and water to sugar and oxygen through the process of photosynthesis. Through the process of cellular respiration, animals are able to release the energy stored in the molecules produced by plants and use it for cellular processes, producing carbon dioxide and water.	Photosynthesis in phytoplankton drives the aquatic ecosystem. Increased respiration in summer can deplete the dissolved oxygen in certain lakes.
Statement B3.2	**Ecosystems** The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in an ecosystem, some energy is stored in newly made structures, but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.	The impact of changes in links in a food web through introduction of invasive species is stressed.
Statement B3.3	**Element Recombination** As matter cycles and energy flows through different levels of organization of living systems—cells, organs, organisms, and communities—and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.	Aquatic food webs are developed with producers, consumers, decomposers, and trophic levels identified.
Statement B3.4	**Changes in Ecosystems** Although the interrelationships and interdependence of organisms may generate biological communities in ecosystems that are stable for hundreds or thousands of years, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. The impact of the human species has major consequences for other species.	Succession of types of plankton is seen throughout the spring, summer, and fall. Stability of the Great Lakes food webs in response to invasive species and climate change is illustrated.
Statement B3.4x	**Human Impact** Humans can have tremendous impact on the environment. Sometimes their impact is beneficial, and sometimes it is detrimental.	How humans have impacted the Great Lakes ecosystem is an underlying theme of the trip.
Statement B3.5	**Populations** Populations of living things increase and decrease in size as they interact with other populations and with the environment. The rate of change is dependent upon relative birth and death rates.	The consequences of an invading organism on the survival of other organisms are predicted.

Statement B3.5x	**Environmental Factors** The shape of population growth curves vary with the type of organism and environmental conditions, such as availability of nutrients and space. As the population increases and resources become scarcer, the population usually stabilizes at the carrying capacity of that environment.	The physical and chemical environment is characterized through scientific investigation on the vessel. These factors and biotic considerations are related to population dynamics in aquatic ecosystems. Reproductive strategies of selected species are described.
Standard B4	**GENETICS**	
L4.p1	**Reproduction *(prerequisite)*** Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually. *(prerequisite)*	Asexual reproduction is illustrated by plankton. The life cycle of the midge and zebra mussels are used as examples of sexual reproduction.
Standard B5	**EVOLUTION AND BIODIVERSITY**	
Statement L5.p1	**Survival and Extinction *(prerequisite)*** Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring. When an environment changes, the advantage or disadvantage of characteristics can change. Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the Earth no longer exist. *(prerequisite)*	Invasive and native species have traits that allow them to be successful in the Great Lakes.
Statement L5.p2	**Classification *(prerequisite)*** Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance. *(prerequisite)*	Identification of groups of plankton illustrates the concept of classification. Potential hybrids between zebra and quagga mussels make classification a challenge.