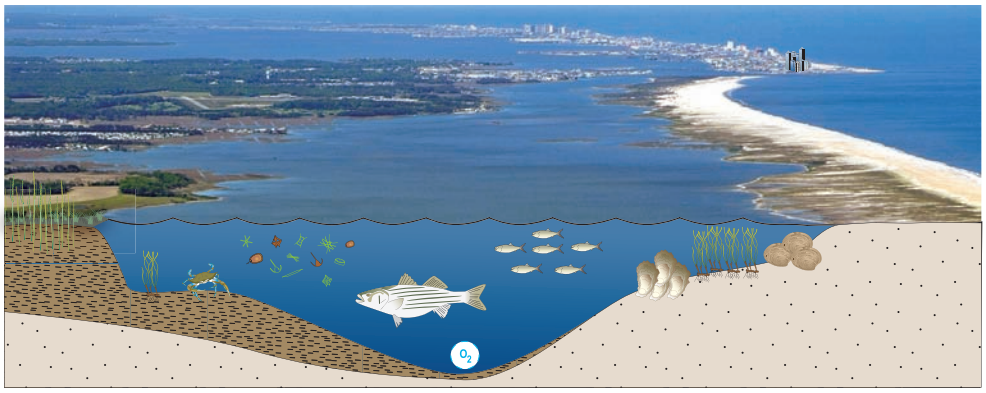
CONCEPTUAL DIAGRAMS:

TOOLS FOR SCIENCE COMMUNICATION

. . . visual language unleashes the full power of communication"
Robert E. Horn, 1999[1]

Science communication is an essential component of environmental problem solving. Effective scientific communication requires synthesis, visualization, and appropriate context. Conceptual diagrams are an excellent means of providing these requirements. The term 'conceptual diagram' comes from the Latin word *conceptus* meaning 'thought' and the Greek word *diagramma* meaning 'to mark out by lines.' Essentially, it is a diagram depicting the arrangement and relationships of key attributes within a system, by using a variety of appropriate symbols that are easily understood.



Our coastlines are becoming increasingly developed as more and more people live and recreate in coastal areas.

Seagrass abundance is declining globally. Physical disturbance and poor water quality threaten this valuable ecosystem.

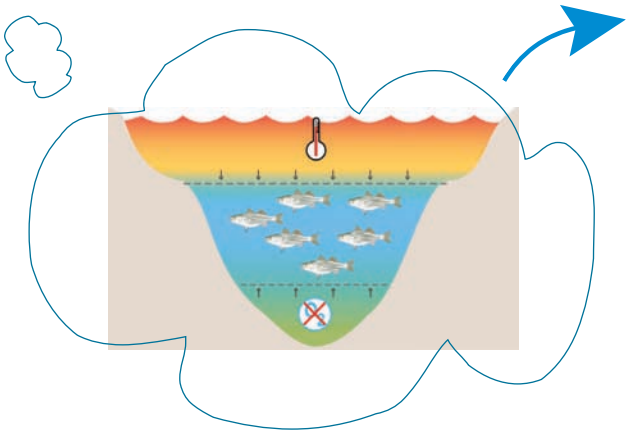
Many fish and shellfish species have been declining for the last few decades. Careful management can sustain populations of important commerical and recreational fisheries.

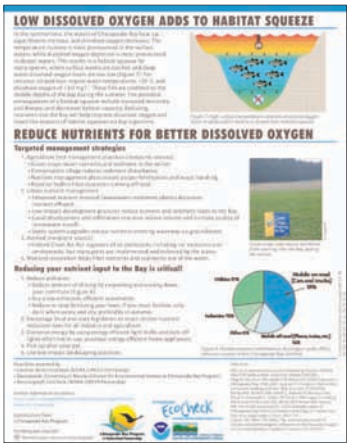
In our estuaries and coastal waters increased nutrient and sediment loads result in areas with little or no oxygen (dead zones), which cannot support life.

There are four important reasons to use using conceptual diagrams: **1.** To clarify thinking and avoid ambiguities; **2.** To provide a unique communication interface between scientific disciplines or between scientists and non-scientists; **3.** To identify gaps, establish priorities, and solicit an agreed synthesis; and **4.** To better define scales of processes and linkages within habitats and communities.

CONCEPTUAL DIAGRAMS ARE 'THOUGHT DRAWINGS'

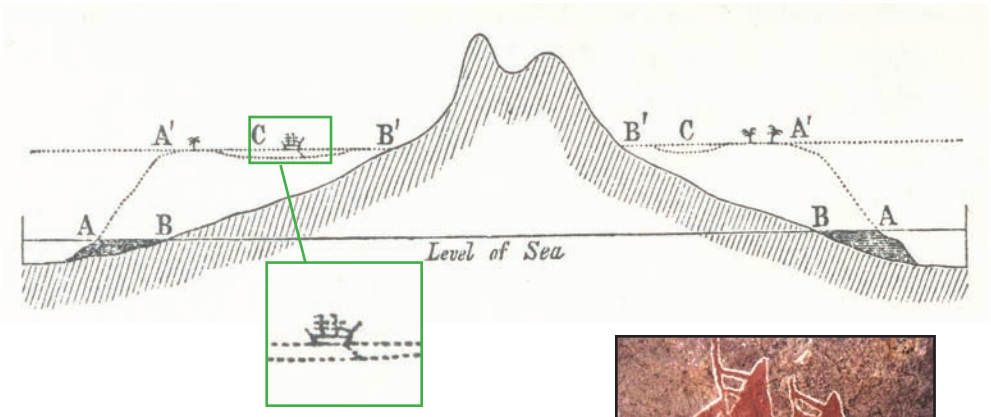
Based on the idea that a picture can say a thousand words,[2] conceptual diagrams provide visual representations of ecosystems in which key features and interactions can be illustrated. They serve to highlight the most important ecosystem features by communicating concepts, summarizing information, and depicting the processes and biota within an environment. A good conceptual diagram can be used in many ways, such as setting research agendas, developing scientific syntheses, designing monitoring programs, and identifying management priorities.





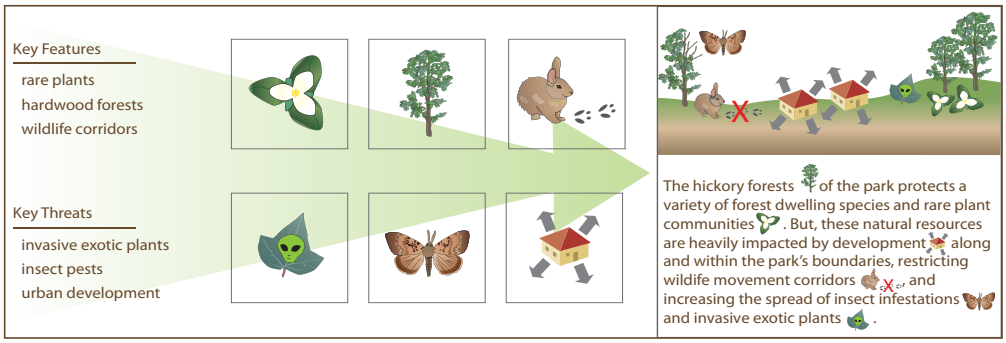
The creation of conceptual diagrams provides an interface for engagement of various stakeholders, including scientists, managers, and wider public partners. The creation process can serve to clarify thinking, facilitate communication, identify gaps, priorities, and essential elements, and develop and present syntheses.

SYMBOLS FORM A VISUAL LANGUAGE

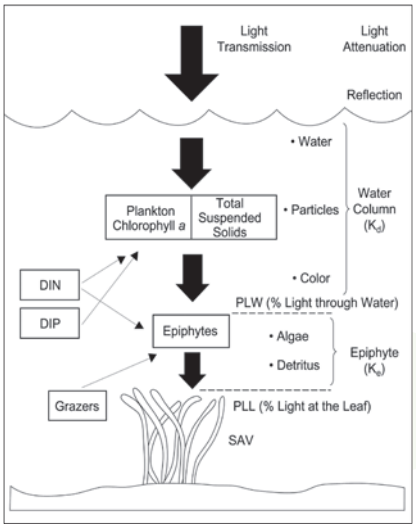


Charles Darwin's diagram (above) depicting his theory of coral reef formation has been reproduced thousands of times since it was first published in 1842.[3] The depiction of a sailboat is unequivocal, as is the image of a sailboat created centuries ago in a cave painting by an indigenous Australian (above right). The conceptual diagram (below right) captures key natural resource elements as information-rich symbols, which are combined to tell visual stories of park resources.

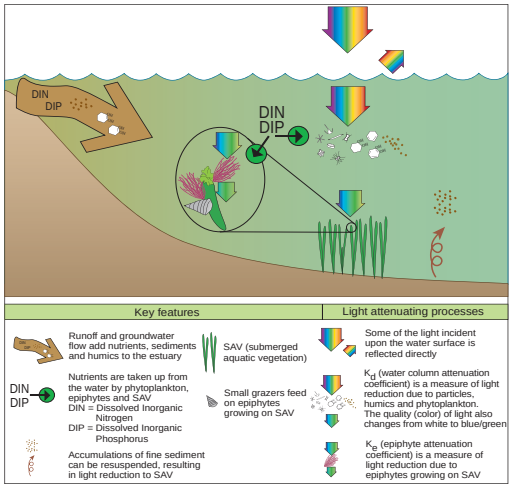
Symbols are one of the most ancient forms of human communication. Symbols are universally understood, language independent, and an important feature of everyday life ( ). Scale can be important in the use of symbols, as size can represent relative importance (vs.). Color and shape of symbols are also important (4 and 5). Symbols convey meaningful information, and when arranged into a diagram, they can augment or replace words. Conceptual diagrams use symbols to depict unequivocal messages.



MODELS VS DIAGRAMS



The visual dimension of science forms a language of its own: a visual rhetoric that is more than a mere handmaiden to the text. If designed effectively, graphics should offer a seperate vehicle for reading and understanding.[4] The difference between conceptual models and conceptual diagrams is apparent in the adjacent examples.



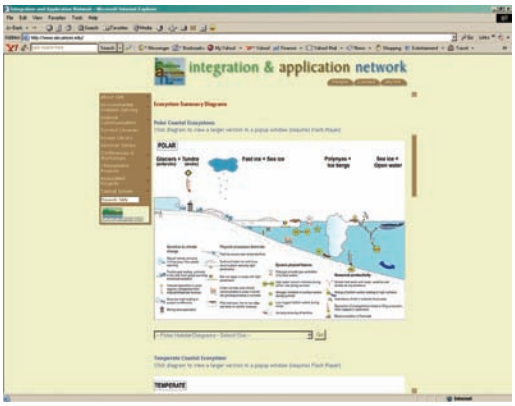
This figure showing light attenuation processes is not self-contained, and originally required two pages of accompanying explanatory text. There are acronyms that are not defined (DIN, DIP, SAV) and processes requiring explanations (K_e, K_d). It also uses text-and-box combinations to depict processes.[5]

This conceptual diagram is based on the figure on the far left. It uses a combination of symbols and color to depict processes. There is a self-contained legend which explains the processes and definitions. Well-constructed conceptual diagrams help the audience to visualize the message.[6]

CONCEPTUAL DIAGRAMS FIT MANY APPLICATIONS

Conceptual diagrams are not a replacement for strong, well-interpreted data; however, when that data exists, conceptual diagrams can be used to describe it in a number of different applications. Below are just a few examples.

WEBSITES



Conceptual diagrams are well suited for use on websites. They can be used as an interactive index with hyperlinks to further information.

SCIENTIFIC JOURNALS

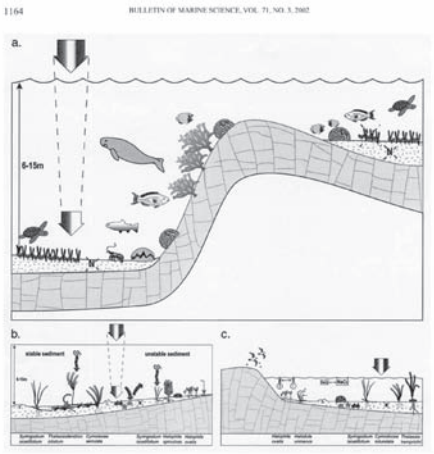


Figure 7. Model of Reef habitat – major control low nutrients: a.) general habitat model; b.) subtidal seagrass processes, separating areas of stable and unstable sediment; c.) intertidal seagrass processes.

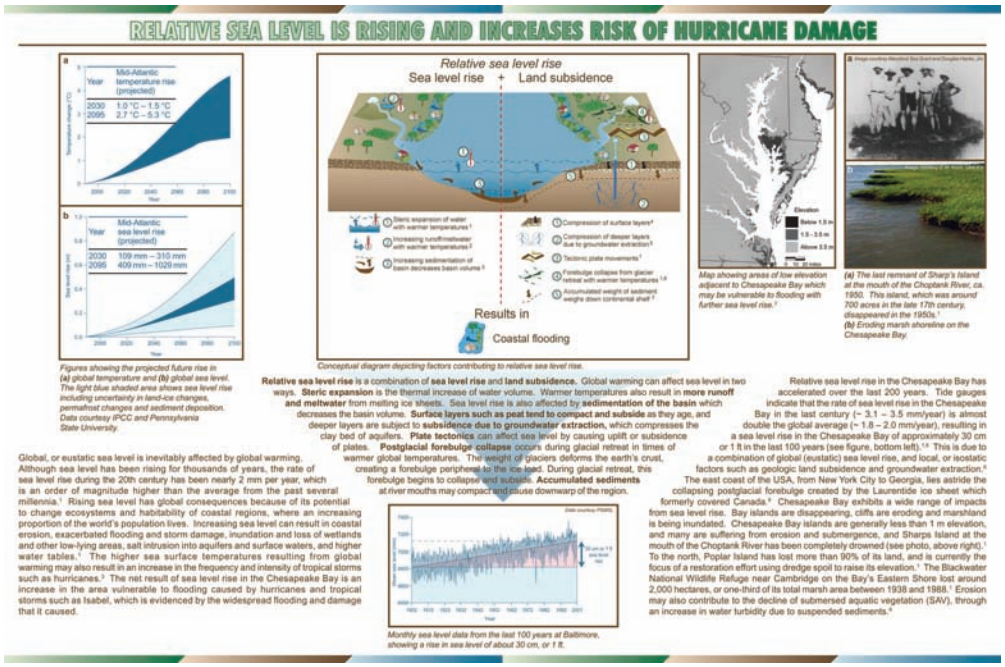
PROCESSES.—Nutrient concentrations are generally low[3] in reef habitats, however intermittent sources of nutrients are added by seasonal runoff reaching the reef (Gabric and Bell, 1993). In some localized areas, particularly coral cays, seabirds can add high amounts of phosphorus to reef environments[16]. In north east Australia, reef carbonate sediments are N limited[3] (Udy et al., 1999), however carbonate sediments vary in the primary limiting nutrient at different geographic locations around the world (Short et al., 1990; Fourqurean et al., 1992; Erftemeijer and Middelburg, 1993). Tight nutrient recycling strategies of *T. hemprichii*[19], by location of N in rhizomes when leaves are shed due to desiccation stress, aids in survival in the nutrient poor reef habitat (Stapel et al., 1997).

Reef seagrass communities have unique faunal interactions[13]. The Indo-Pacific has less fish and urchin grazing than the Caribbean, although low rates of grazing do still occur on many broad bladed species, such as *Enhalus* (Ogden and Ogden, 1982). Urchins have been reported to have periodic and large influences upon seagrass meadows[9] (Rose et al., 1999). In the Torres Strait, reduction in seagrass abundance correlated with an increase in

Conceptual diagrams can be used in peer-reviewed scientific journals to facilitate communication between scientists. They can effectively synthesize current knowledge, helping to identify gaps as well as key links and processes. These diagrams can be just as meaningful when printed in black-and-white or grayscale as they are in color.[6]

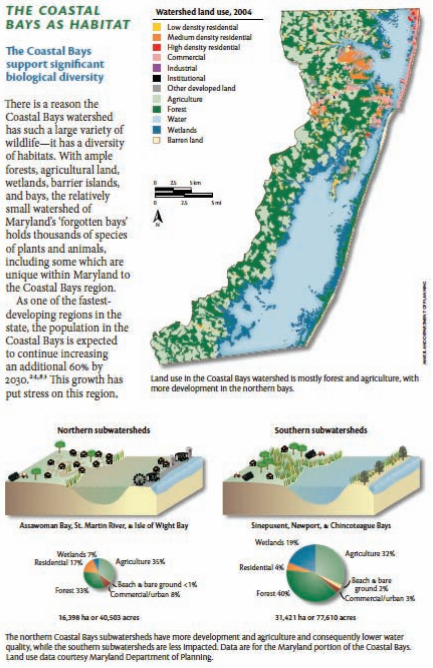
NEWSLETTERS AND POSTERS

The use of conceptual diagrams in newsletters and posters provides a communication interface between scientists, resource managers, community groups, and informed public. The use of universally understood symbols facilitates understanding among stakeholders with various levels of familiarity on the topic.



BOOKS

Books are another science communication product where the use of conceptual diagrams enhances communication between scientists and non-scientists by depicting ecosystem processes at different scales. Conceptual diagrams can stand alone in place of words and improve conmunicative text.[7]



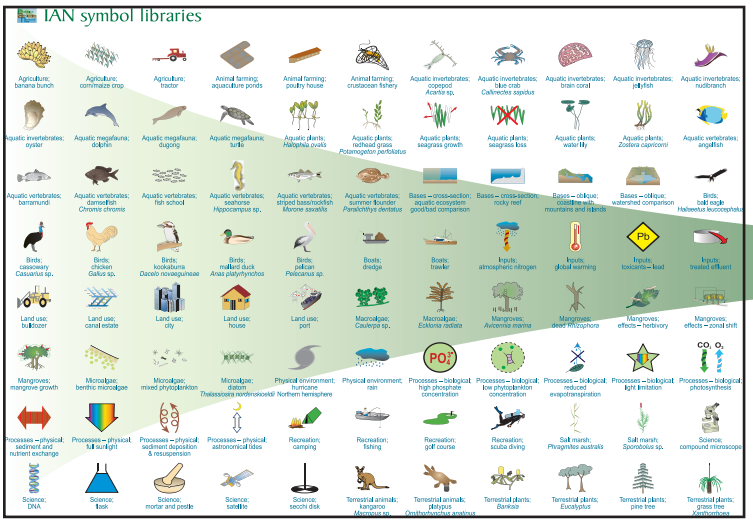
MAKE YOUR OWN CONCEPTUAL DIAGRAM

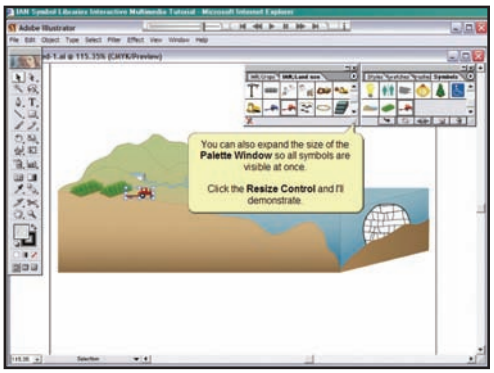
Generation of a conceptual diagram involves:

- Identifying the message
- Identifying the audience
- Listing elements and processes
- Experimenting with different ways to visualize the elements and processes
- Drafting 5–10 iterations to fully capture required messages.

The Integration and Application Network (IAN) has produced a series of scientific symbol libraries, for use with Adobe Illustrator software. The libraries contain over 2,500 custom-made symbols designed specifically for enhancing science communication skills. Diagrammatic representations of complex processes can be developed easily with minimal graphical skills. Our aim is to make them a standard resource for scientists, resource managers, community groups, and environmentalists worldwide. The IAN symbol libraries are available cost- and royalty-free. Also available for download is an interactive Flash tutorial on how to use the symbols with Adobe Illustrator. The IAN website also has a discussion forum about environmental problem solving and science communication techniques, as well as an image library for use in science communication publications.

Download the IAN symbol libraries from www.ian.umces.edu/symbols





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*The **I**ntegration and **A**pplication **N**etwork (IAN) is a collection of scientists interested in **solving**, not just studying environmental problems. The intent of IAN is to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. IAN is an initiative of the faculty of the University of Maryland Center for Environmental Science, but will link with other academic institutions, various resource management agencies and non-governmental organizations.*

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