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# Understanding the Behavioral Biology of the Wild Dolphin

By Denise Herzing with Andrew Davis

A twenty year long research project to understand the behavioral biology of the wild dolphin is using digital signal processing and multimedia tools to archive and retrieve data. The goal is to understand how dolphins use sight, sound, touch, and even taste to communicate with other members of their family.

The Wild Dolphin Project studies friendly dolphins near the Bahamas.

## Introduction

The Wild Dolphin Project (WDP), a nonprofit organization founded by marine zoologist and behavioral biologist Denise Herzing in 1985, has been unraveling the subtleties of spotted dolphin social life, using high technology audio, video, and computer equipment to record and study dolphin behavior and communications patterns. To date, most dolphin research has focused on acoustic communications and on isolating meaningful patterns from dolphin noises emitted under varying conditions. The WDP study is going further by cataloging how dolphins use sight, sound, and touch to interact with other members of their group.

Dolphins can live 40 to 50 years, and like humans, are capable of forming long-term bonds with other individuals. In order to provide a complete understanding of their communications and behavior patterns, the WDP is planning on carrying out its research for 20 years, studying in detail a group of nearly one hundred friendly dolphins residing in a forty square mile area of the ocean off the Bahamas.

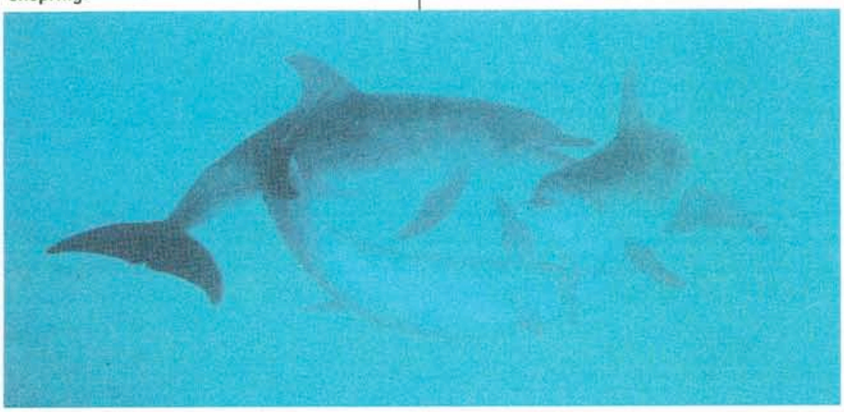
Atlantic spotted dolphins live and communicate in groups of up to fifty for protection from predators and possibly to aid in cooperative foraging. Recent findings suggest that nuances of body positioning and body movement correlate to acoustic emissions and message content. In addition, these vary according to social and behavioral contexts ranging from warnings of danger to playful desires to amorous intentions. Hence the problem of documenting dolphin behavior and communications is multidimensional. Audio, video, and text information must be organized and combined in meaningful ways to fully understand the data. The WDP research team is evaluating Apple's QuickTime multimedia extensions to the Macintosh operating system as a means to integrate, coordinate, archive, and present data from different spectra.

## Audio Data Capture and Analysis

The basic data capture equipment used by Herzing and other team members is an underwater video camera/recorder with a hydrophone for sound input. Dolphins move fast under water and their communications and behavior is complex and rapid. Video recordings capture the many facets of the animals behavior and provide the basic data which is studied, cataloged and broken down into components off-line. Herzing spends most of her research time drifting along the surface of the water in the Bahamas, in snorkel gear, with camera in hand. The warm water allows extended periods of filming, and the Bahamas' school of Atlantic spotted dolphins has grown accustomed to humans in the water, allowing Herzing to film up close.

We tend to think of dolphins as primarily acoustic communicators. Sound travels very effectively under water up to 4 to 5 times as far as it does in air. In the Bahamas, the salinity temperature and density of the water allow dolphins to stay in contact acoustically for miles. One of the few things known about dolphin vocalizations is that each individual has a unique signature whistle the equivalent of a human name. A dolphin may use the whistle to broadcast its identity or to initiate contact with other individuals.

Touch is an important form of communication between mother dolphins and their offspring.



The WDP data analysis system is a Macintosh IIci equipped with a digital signal processing board from Spectral Innovations (San Jose, CA) to capture process and display dolphin vocalizations. The DSP board has an analog-to-digital converter front end to directly accept audio signals. Acoustic data is typically captured via a hydrophone (bandwidth = 76 kHz) connected to the underwater video camera (audio bandwidth 20 kHz). A single channel of sound is digitized at 30,000 to 60,000 samples per second for approximately 10 seconds creating an individual data file of 600 K to 1.2 MB for each signature whistle. The Macintosh on board the research boat has a 160 MB hard disk but data is offloaded to 45 MB removable hard drives when the system is on shore. Several gigabytes of data have already been archived since 1985 and the experiment is planned to run for another 13 years.

The DSP board is controlled by Spectral Signal Analyzer software package which provides the user with an icon-driven front end for both time domain and frequency domain data analysis and display. The software supports frequency analysis of both signals received via real time and data recorded previously on disk. The basic tool for audio analysis used by WDP researchers is the spectrogram created when the MacDSP board converts the time versus amplitude data in real time to frequency versus amplitude data which is then scrolled vertically on the Macintosh display. Time is represented by the vertical axis, frequency by the horizontal axis and amplitude is mapped into color.

Researchers at sea use the on-board Macintosh to look at new signature whistles and compare them to archived versions of the signal. Having a visual display of the sound signal's frequency content allows Herzing to "see" utterances both within and above the human hearing range and to distinguish subtle differences between various beeps, chirps, and whistles. WDP researchers make note of the duration and frequency range of signals and the intensities of special frequencies of interest and use this data to catalog and archive various animal sounds. An annotated text file stores these observations, the identity of the individual dolphin if known, as well as observed correlations to dolphin behavior and activities (noted from video frames). All observations from audio and video inputs together with dates and environmental conditions are kept in a Double Helix data base on the Macintosh. Besides signature whistles, dolphins also commonly emit echolocation signals which are cataloged in order to better understand how these broad band "click" sounds correlate to their behavior and their ability to find food and avoid objects. The spectrogram is used to determine and catalog the number of "clicks" per unit time the duration and frequency content of the echo pulse and the inter-signal interval.

### Correlating Video to Audio

Video data is often key to understanding dolphin sounds. It is not always easy to identify the animal that created a specific sound. A signature whistle is often accompanied by the expulsion of air from the blow hole so that if this event is captured on video Herzing can be reasonably confident of the sound source.

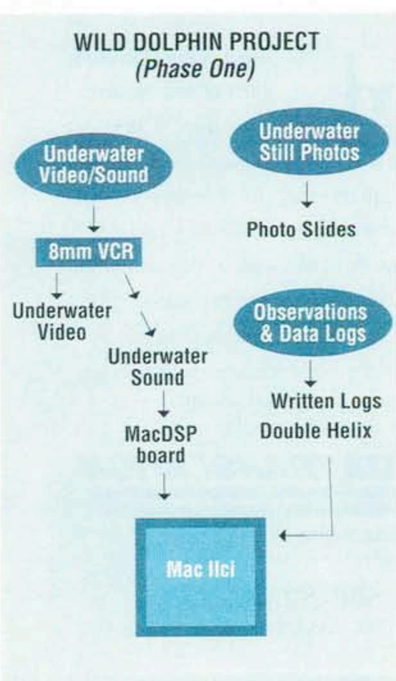
Moreover, dolphins use other communications besides audio. For instance, touch is an important way for a mother to guide her offspring. A brush of the pectoral fin is used when the pair reunite or when the infant is preparing to depart briefly. Touching is also part of the complicated process of dolphin courtship and mating. Non-contact visual clues are used as well. A mother may rotate her pectoral fin to signal her offspring to come closer. Dolphin infants learn behavioral patterns by observing those of older members of the group. Chases, head-to-head confrontations, sparring, and other behavior patterns are often explored in the form of friendly competition. These activities are typically accompanied by audio signals. Furthermore, the sound emanating from an individual dolphin appears to have different functions depending on with whom it is interacting, what the relationship is, what their ages are, and what other events are under way. For instance, young dolphins are extremely excitable and often lose control of their sound apparatus creating an erratic vocalization that is accompanied by rapid excited swimming. If this event is captured on video the sound is easily correlated to a specific behavior pattern. Hence while the spectrogram provides details about the audio emission, video information correlated with audio signals and the spectrogram is crucial to making the links between specific sounds behaviors and message content.

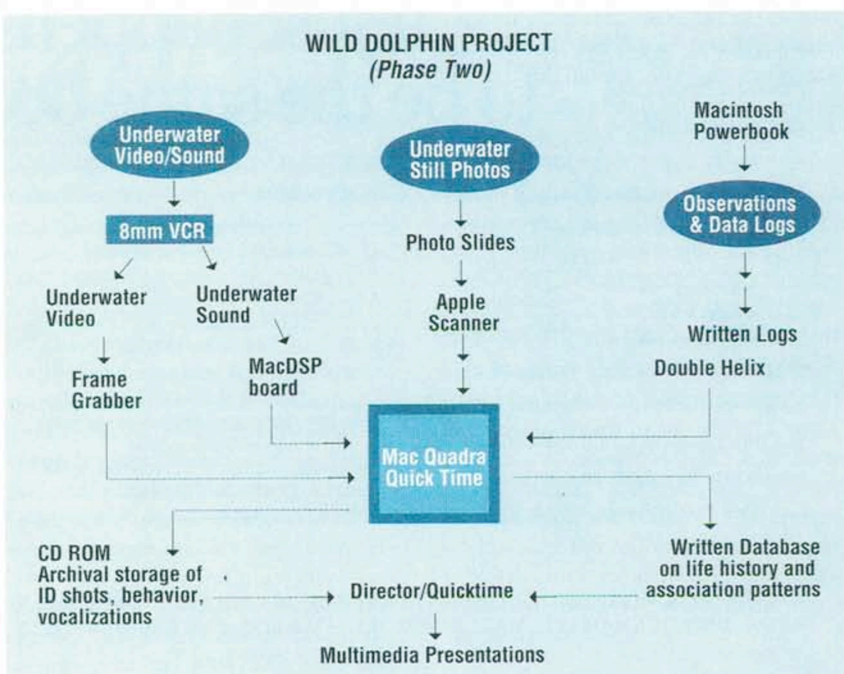
### QuickTime Integrates Data Types

Because audio, video and text information must be correlated to understand dolphin behavior the WDP is migrating to a multimedia-based research approach. According to Herzing, the next phase of the project will coordinate video images, still photography, audio spectrogram analysis and written logs of observations into a unified research tool and presentation report. Two major enhancements to the computer system make this possible. The first is a frame grabber for the Macintosh that will digitize and compress video images, store them on the disk and enable the WDP researchers to manipulate video data much as they now do audio and text information.

The second is Apple's QuickTime software, an extension to the Macintosh operating system that integrates time varying dynamic data such as sound video and animation in a consis-

The two phases of the Wild Dolphin Project.



tent fashion. QuickTime-compatible software can create movies from laboratory data and QuickTime-compatible word processors and spreadsheets will make it easy to publish reports with embedded movies as well as graphs, charts, and tables. Readers will be able to click on a section of a document and witness an audio/video playback of results. The difference of course is that while static data can be distributed in hard copy form (paper), dynamic data must be played back on a QuickTime capable medium, typically another Macintosh.

The WDP plans to use QuickTime not only for multimedia presentations but also as a multimedia data editing tool. QuickTime enables audio, video, still imagery, and text notes to be cut and pasted and dynamically synched for playback. QuickTime compression schemes for audio and video data will enable the team to store more data on their hard disks while shielding the applications level software from the compression details. According to Herzing, multimedia research tools are critical to the WDP to maximize the research value of the data.

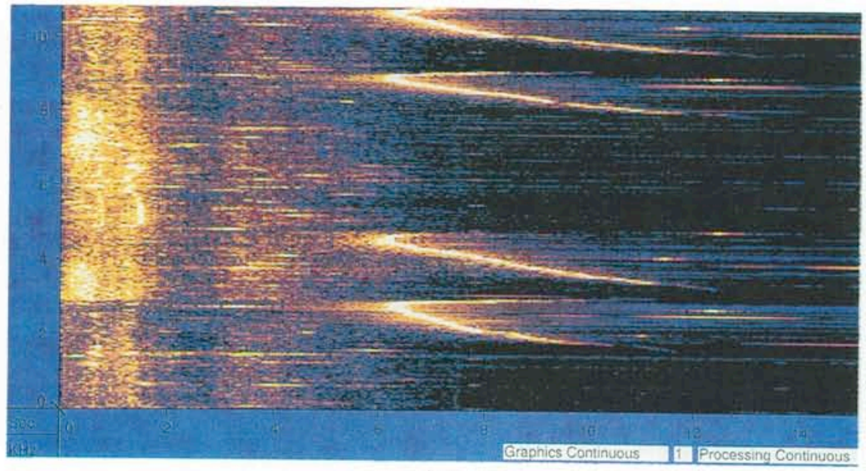
### Preparing for the Future

QuickTime is scalable and hardware independent. The same QuickTime movie will run on a plain Mac LC, a Quadra or a IIci equipped with a MacDSP accelerator. However, there are few computer applications that are as demanding as digital video and multimedia. A QuickTime movie strains the capabilities of processors, memory, disks, video and audio circuitry and the various pathways that join them, even on a high end Macintosh. Full motion, full screen, full color video represents a data rate of approximately 27 MB per second. One minute of video would require over 1.5 GB of storage. Therefore compression is a requirement.

Herzing is still evaluating several image processing boards, all of which come with QuickTime compatible software. QuickTime provides its own support for still images and text files. She expects to be able to compress, manipulate and display digital video and audio in real time in order to better document and understand the multimedia aspects of dolphin behavior.

And while QuickTime presents a hardware independent software standard for multimedia data due to the demanding data streams and the performance constraints of ordinary CPUs, she anticipates using a MacDSP board as a QuickTime hardware accelerator in addition to its real-time signal processing functions. Hardware acceleration will greatly enhance the ability to edit data and do research. On the other hand, the research team expects to be able to distribute QuickTime movies of research results which can be viewed on any Macintosh.

**A spectrogram with amplitude mapped in color is the main analytical tool.**




*Denise Herzing is currently the research director of the Wild Dolphin Project in Jupiter, FL. She received her undergraduate training in marine zoology at Oregon State University and her graduate training at San Francisco State University in behavioral biology. She has authored and co-authored papers in the areas of whale biology, animal communication and human consciousness. Her work has been reported on in Nature and National Geographic magazines. Her areas of special interests are animal consciousness, behavior and communication of cetaceans and environmental ethics. She can be reached at the Wild Dolphin Project, a nonprofit scientific organization which conducts research on dolphin communication and inter-species interaction, at 21 Hepburn Ave., Suite 20, Jupiter, FL 33480. Tel: 407-575-5660. Andrew Davis is a frequent contributor to SC&A.*

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