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THE CALIBRATION OF PHOTOGRAPHIC AND SPECTROSCOPIC FILMS

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The Utilization of the Digital Image Processor in the Determination of Aging of the Surf Clam (Spisula solidissima)

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ABSTRACT

The age of the surf clam, (Spisula solidissima) can be determined with the use of the Digital Image Processor. This technique is used in conjunction with a modified method for aging, refined by John Ropes, of the Woods Hole Laboratory, Woods Hole, Massachusetts. This method utilizes a thinned sectioned chondrophore of the surf clam which contains annual rings. The annual rings of the chondrophore are, then, counted to determine the age. By digitizing the chondrophore, the Digital Image Processor is clearly able to separate these annual rings for accurate counting. This technique produces an easier and more efficient way for counting annual rings to determine aging in the surf clam (Spisula solidissima).

INTRODUCTION

The determination of aging of the surf clam and other marine organisms has become a major concern to marine biologists, ecologists and the fishing industry. The major reason for their concern is for population assessment studies of marine organisms in areas that are fished. As a result of ocean dumping and other pollution related problems, an assessment of various marine populations are needed for study to determine the affects of pollution on marine organisms. Associated with these population studies are the following: size-age relationships, longevity of various species of organisms, the rate of growth of organisms, and finally, growth differences among certain species of organisms. By close examination and analysis of aging of various populations, many unanswered questions concerning the affects of pollution on marine environments can be explored.

The surf clam, Spisula solidissima, is a marine organism that has great economic value, that habitats along the Atlantic coast of the United States. This organism's age has been determined using a modified method for aging, refined by John Ropes, of the Woods Hole Laboratory, Woods Hole, Massachusetts. This method utilizes a thinned sectioned chondrophore of the surf clam which contains annual rings. The annual rings of the chondrophore are, then, counted to determine the age of the surf clams by projecting the image of the chondrophore on a screen or making a photograph of the chondrophore.

This technique has been found to be very useful in determining the age of a sample of clams taken from Ocean City, Maryland, and Atlantic City, New Jersey. Although this technique has proven its usefulness, there are several problems associated with it. One problem seems to be finding the first annuli, or ring, which in many cases is faint. Another problem is associated with older clams in which the annuli rings become crowded, and thus, more difficult from which to get an accurate count.

The methodology utilized in the conduct of this research is called Digital Image Processing. By definition, Digital Image Processing is a computerized technique used by scientists of various disciplines to enhance and analyze various images, or pictures, produced either by a camera or a nonphotographic imaging sensor. This technology has been used in a number of ways, such as monitoring crops, forecasting weather, facilitating radio astronomy, supporting remote sensing, enabling medical ultrasound, and in a host of other scientific and industrial applications.

In an attempt to improve the current methodology for aging techniques of the surf clam for the purposes of population assessment, Digital Image Processing was examined, using a thinned sectioned chondrophore which contains annual rings to determine the age of several clams.

The principal results of this research demonstrates that Digital Image Processing technology provides a practical application in the determination of age in the surf clam.

Thus, the purpose of this disscussion is to report the results of research that indicates that Digital Image Processing has a practical application for determining the age of surf clams.

MATERIALS

The materials needed for the completion of the research were the following:

1. Gould IP8500 Digital Image Processor
2. Conrac monitor (512 x 512) used to reproduce images
3. Mti series 69 High Resolution Camera
4. Nikon F 35 mm camera with 50 mm lens used to take pictures and slides from the Conrac monitor for analysis
5. Ten thinned sectioned chondrophores of the surf clam used in order to determine age

METHODS

At the outset, this process involved four basic steps, which will be described below.

First, the digitizing of the thinned sectioned chondrophore was conducted. When an image or picture is digitized, it is represented by a regularly spaced array of samples of this picture or image function. These samples are quantized, so that the numbers take on a discrete set of possible values, generally integers. The elements of a digital picture array are called "pixels," The chondrophore was placed underneath the lens of a high resolution television camera and focused into the vidicon, where the image was digitized. The high resolution camera was attached electronically to the Digital Image Processor (DIP) which transformed the digitized image of the chondrophore into picture elements, or pixels. Moreover, it should be noted that the DIP is able to distinguish between 256 different levels of the color gray. Within the DIP, the pixels are transformed into the various levels of gray. In addition, the computer also contains "look up tables," which assign color values to each pixel. Finally, the DIP is, then, able to sense subtle changes in the levels of gray of the chondrophore and assigns false color, however programmed.

Secondly, the pixels were averaged by a program within the DIP. This process was performed for enhancement purposes. Averaging pixels is used to improve the enhancement of an image by increasing and or decreasing the contrast.

Thirdly, the image of the chondrophore on the monitor was magnified with the zoom capability of the DIP. The maximum zoom capability of the DIP is seven times. The purpose for enlargement of the image was to magnify the annual rings of the chondrophore for separation of outer rings and for accurate counting to determine the age of the particular surf clam studied. Digital image enlargement simply adds pixels to the input image to increase the scale of the output image either to improve the scale of a display for interpretation, or to match the scale to another image.

Finally, a 35 mm camera was used in order to take slides and pictures of the chondrophore from the high resolution monitor. This procedure was necessary for documentation purposes and for further analysis.

RESULTS

From careful photographic observation and analysis of several digitized, thinned sectioned chondrophores, the data clearly indicate that there is an increase in the ring separation as each photograph was enlarged and enhanced. The addition of false color to the images also shows varying degrees of contrast between each annual ring or band. This process can be clearly demonstrated in Figures 1 and 2. Figure 1 is the monochromatic image of a thinned sectioned chondrophore, and Figure 2 shows the addition of false color.

Figure 2 clearly shows greater contrast in color. Figure 3 represents an increase in the magnification of the chondrophore and also an averaging of the pixels. (It should be noted that Figures 1, 2, and 3 are of the same specimens). One can clearly see even greater contrast as a result of this method. Figures 4, 5, and 6 show the results of enlargement by the zoom capability of the DIP. Here in these photographs, the ages can be easily determined by counting the rings. Figure 4 appears to be six years of age. Figures 5 and 6 appear to be nine and five years, respectively.

Finally, the problems of crowding of rings for older clams was explored. Several different techniques were applied which gave satisfactory results. First, defining an area of interest in the DIP was explored using an older, thinned sectioned chondrophore. The chondrophore was subdivided into two halves as demonstrated in Figures 7 and 8. Figure 7 represents the outer boundaries of the chondrophore where crowding of rings is a problem. Figure 8 represents the opposite end where the first annuli occurs. Next, each image was zoomed, and there is clearly adequate separation for the determination of age. This chondrophore appears to be about thirteen years of age.

DISCUSSION

Examination of photographed, digitized, and thinned sectioned chondrophores of the surf clam demontrates that Digital Image Processing technology can be applicable in the determination of the age of the surf clams. The initial implication of this research indicates that this technology can be used not only with the determination of the age of the surf clams, but with other shellfish or marine organisms that contain annual rings, or growth bands. Additionally, this research, again, emphasizes the many practical applications of Digital Image Processing in a plethora of interdisciplinary fields.

In the course of the research, there were several conclusive observations that demonstrated that, although this technique for aging is very promising, there was one limiting factor. That is , that for complete accuracy in age determination, the initial thinned sectioned cut is most important. If the chondrophore is not cut evenly as to capture all of the annual rings, then the DIP can not enhance or enlarge the rings that are undetected or invisible.

Finally, observation of the digitized chondrophore showed that annual rings vary with each respective ring. Careful study of the various rings could possibly reveal information regarding the rate of growth during various seasonal and environmental changes that the organism undergoes.

ACKNOWLEDGMENTS

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ORIGINAL PAGE IS
OF POOR QUALITY

DIGITIZED CHONDROPHORE SECTIONS

FIGURE 1
MONOCHROMATIC IMAGE

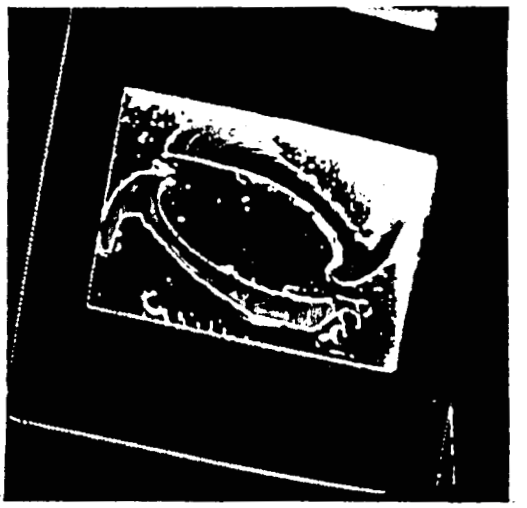

FIGURE 2
FALSE COLOR

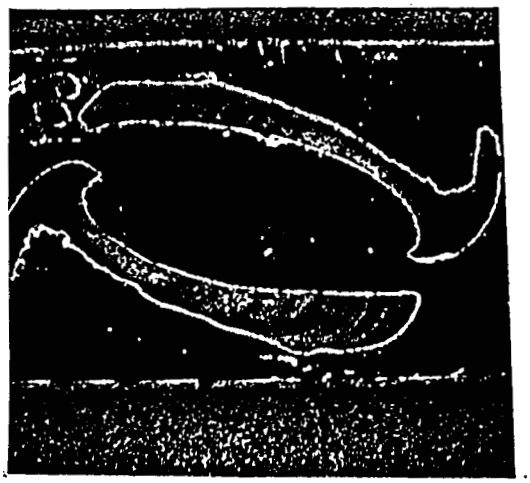

FIGURE 3
ENLARGEMENT AND AVERAGING OF PIXELS

OF POOR QUALITY

DIGITIZED CHONDROPHORE SECTIONS

FIGURE 4
SIX YEARS OF AGE

FIGURE 5
NINE YEARS OF AGE

FIGURE 6
FIVE YEARS OF AGE