

Evaluation of Measures in Reducing Attacks

All things considered, the most effective protection is by sharks. It appears to be a reasonable solution for decreasing the probability of shark attack. There is some evidence that control programs in Hawaii have been documented in Hawaii (Parker and Mac 1961; Balazs 1969; Chaffin 1970; and Balazs 1971) and that after the fatal attack on Billy Weaver in 1970 (Balazs 1971).

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RECOMMENDATIONS FOR FUTURE RESEARCH**

have been documented in Hawaii (Parker and Mac 1961; Balazs 1969; Chaffin 1970; and Balazs 1971) and that after the fatal attack on Billy Weaver in 1970 (Balazs 1971).

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for an average of 1.0 attacks per year. In the year following the

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attacks were 0.9 attacks per year.

over the 10 year period since the start of the shark control

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program (1970) 2.2 attacks per year.

According to the International Shark Attack File, an

incident is considered a shark attack if considered as either a

provoked or unprovoked attack on a live human in the shark's

natural environment (Parker pers. comm.). Many of the attacks

occurring after 1970 are listed in the detailed records involve

victims that apparently drowned and that were bitten by sharks,

and were not attacks on living humans. If incidents that do not

meet the criteria of an attack as established by the

International Shark Attack Committee are deleted from the list.

## Evaluation of Success in Reducing Attacks

Although reducing coastal shark populations by fishing may appear to be a reasonable solution for decreasing the probability of shark attack, there is little evidence that control programs in Hawaii were successful in significantly reducing the rate of shark attack. Although shark attacks dating back to the 1700's have been documented in Hawaii (Balazs and Kam 1981; Balazs 1992) abatement programs were not initiated until after the fatal attack on Billy Weaver in 1958. According to Balazs (1992) 15 attacks were documented during the 15 years prior to abatement, for an average of 1.0 attacks per year. In the years between the first shark abatement program (1959) and the last in 1976, 16 attacks were documented, for an average of 0.9 attacks per year over the 18 year period. Since the end of the last shark control program (1976) through 1991 a total of 33 attacks had been documented, 2.2 attacks per year (Balazs 1992).

According to the International Shark Attack Committee, an incident is considered a shark attack if confirmed as either a provoked or unprovoked attack on a live human in the sharks natural environment (Burgess pers. comm.). Many of the attacks occurring after 1979 included in the Hawaiian records involve victims that apparently drowned and then were bitten by sharks, and were not attacks on living humans. If incidents that do not meet the criteria of an attack as established by the International Shark Attack Committee are deleted from the list,

the rate of shark attack drops to less than 1.3 per year for the post-abatement period (Figure 4). Thus, the average number of shark attacks per year does not vary significantly when rates prior to control efforts (0.6), during control programs (0.6) and after control programs (1.3) are compared (Kruskal-Wallis,  $p = 0.10$ ).

The apparent increase in attacks after control programs had ended may be attributed to an artifact of record keeping. It is highly likely that there is a correlation between the implementation of an "official list" of Hawaiian shark incidents in 1979 and the rapid increase in number of attacks. The increase in the number of attacks may have been due in part to the greater effort and interest in documenting shark attacks since 1979. Therefore, shark control programs and the associated reduction in coastal shark populations appear to have had little or no effect in decreasing the rate of shark attack in Hawaii.

The number of people visiting the Hawaiian Islands annually has increased exponentially from 15,000 in 1946 to nearly 7 million by 1990 (Hawaii Visitors Bureau pers. comm.) (Figure 4). This rise in the number of visitors, along with the increasing popularity of water related activities such as scuba diving and surfing, has undoubtedly resulted in an increase in the proportion of visitors entering the water. Given this tremendous rise in the number of humans in the ocean, a concomitant increase in the rate of shark attack might also be expected. However, the rate of shark attack in Hawaiian waters has remained remarkably

constant at less than one attack per year over the past 48 years.

In addition, previous recommendations of past control programs to fish only along developed areas of coastline may be inappropriate since most attacks have occurred in more remote areas. Furthermore, the extreme expense of fishing along all of Hawaii's vast coastline (1,282,373 km; Kirch 1985) make it ridiculously unfeasible as an option.

### CONCLUSIONS

Success of the control programs in decreasing shark populations and eliminating large sharks in coastal waters appears to have been overestimated. The assumption that sharks are territorial was based on limited tag and recapture data and contributed to the conclusion that sharks can be eradicated from a specific area. However, territoriality has not been documented for any species of shark (McKibben and Nelson 1986; Myrberg and Nelson 1990).

There is little evidence that the extensive shark control programs conducted in Hawaii were successful to any extent in reducing the rate of shark attack. The low incidence of shark attack coupled with the high cost of extensive control programs indicates that these types of programs are no longer a feasible endeavor.

Only a small portion of the results of research conducted during control programs has been published in reviewed journals

and made available to the scientific community. Had the data been analyzed more rigorously, efforts to control sharks might have been viewed as less successful and recommendations advocating continued control efforts would probably have been less favorable.

Control programs have contributed information on sharks including diet, reproduction, species composition and seasonal distribution. In addition, diet of Hawaiian sharks has been examined extensively during subsequent studies (Taylor and Naftel 1978; DeCrosta et al. 1984). Further examination of large numbers of dead sharks is unlikely to reveal new information and does not appear to be an appropriate objective for future control programs.

The control programs have failed to adequately address questions concerning shark behavior as it pertains to shark-human interactions. It is necessary to understand home range, diurnal activity, feeding periodicity, depth distribution and social interactions to effectively reduce the probability of shark attack. Little of this information was reported for the tiger shark, although these sharks have been implicated in most attacks in Hawaii. Future studies should be concentrated on this species of shark. The above mentioned aspects of shark behavior can be investigated using modern techniques such as acoustic telemetry and remote sensing (Tricas et al. 1981; Nelson 1990; Holland et al. 1993).

Because sharks are important apex predators and play a vital

role in the marine ecosystem, removal of large numbers of sharks from an area may have detrimental effects on the ecological balance. The control programs did not consider the ramifications of removing large numbers of sharks from the coastal environment of Hawaii. More extensive tag and release studies can provide information on population size, sexual segregation, seasonal, inter-island, and long term movements and are far less destructive than eradication (Casey and Taniuchi 1990).

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#### LITERATURE CITED

- BALAZS, G. H. 1992. Annotated list of shark attacks in the Hawaiian Islands 1779-1991. Unpubl. report. 25pp.
- BALAZS, G. H., and A. K. H. KAM. 1981. A review of shark attacks in Hawaiian Islands. *Elepaio* 41:97-106.
- BECKWITH, M. 1970. *Hawaiian Mythology*. University of Hawaii Press, Honolulu, Hawaii.