series of specimens, but by learning about their habits and distribution which are factors that have been found to be basic in the accurate interpretation of a taxonomic entity. At the same time, the fishery biologist will benefit by the accurate taxonomic interpretation based on the information supplied by him.

Poor work on the part of systematists in the early days of fishery biology brought about the development of so-called "racial studies" in the field of that discipline, in order to obtain a better interpretation of populations below the species level. Great improvements in taxonomic methods resulted and these have been incorporated to the practice of modern taxonomy in many branches of zoology. At present, with the improvements and refinements available in systematic ichthyology, racial studies should be left to the taxonomist, releasing in this manner the fishery biologist to his more important duties of investigating the other phases of the biology of fishes.

Fishery biology and taxonomy are mutually complementary. Basic training in systematics is as important to the fishery biologist as basic training in the general biology of fishes is to the systematist. Fishery biologists and taxonomists have usually worked independently and have regarded each other as separate and inferior castes. It is necessary to realize that these two branches of ichthyology have a great deal in common and are dependent on each other.

The Effects of Underwater Seismographic Exploration

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THE PROBLEM of the lethal effect of underwater explosions to aquatic life has been accentuated by the necessity of the employment of this means of searching for oil deposits. These phenomena are paralleled by war use of underwater explosions for the destruction of enemy submarines.

The necessary employment of this technique in the onshore and offshore waters of the State of Louisiana caused deep alarm among those citizens who were concerned with five major marine enterprises, viz., recreational fishing, commercial fishing, the oyster industry, the shrimp industry and the crab fishery, both hardshell and softshell.

It was imperative that a sound basis be established that the use of these seismographic techniques would not seriously impair such aquatic resources.

Therefore, three series of controlled experiments were devised and executed to ascertain in what manner these highly important marine resources of Louisiana would be affected by the use of submerged explosive charges in exploration.

The problem proved to be extremely complicated.

The first series of experiments was executed in duplicate and involved the discharge of a top shot of 800 pounds of the explosive seismographically used which deviated less than 4 per cent from the impact of trinitrotoluol. Graded lesser charges were subsequently used. Shrimp (*Penaeus setiferus*), fish, croakers, (*Micropogon undulatus*) and oysters (*Ostrea virginica*) were used, the experimental animals being placed in carefully constructed cages at intervals of 50, 100, 150, 200, 300 and 400 feet. The most careful consultation was conducted with physicists to establish that these confining cages, constructed with extremely small slats, could not possibly cushion any explosive impact. As already stated, this series was fired in duplicate.

It was revealed that these relatively enormous charges, far in excess of anything normally employed, left completely unharmed shrimp at 50 feet, oysters

at 50 feet and fish at 200 feet. Dr. McCollum, foremost seismographist of the United States, very kindly provided specially designed recording instruments to measure explosion wave impact. The decrement in displacement, which is the critical element, provided a completely unexpected and amazing pattern. Several subsequent days were occupied in firing successive charges to establish data whereby a curve could be plotted.

It seemed quite unreasonable that an explosive discharge that flung water into the air more than 350 feet and shook an oyster lugger ten miles away with a violently perceptible impact could still fail to harm shrimp and oysters at a distance of fifty feet and fish at a distance of two hundred feet.

The initial experiments and the subsequent experiments performed for the purpose of delineating the impact curve showed that the fall in damaging displacement was astonishingly rapid. No measurements could be taken at shot point because of the violent reaction but the curve beyond shot point could be, with reasonable accuracy, calculated from the data actually obtained thereafter. Therefore, the first point (shot point) having been calculated, the stations were actually measured.

Thus stated, 1000 units at shot point, calculated by the extension of rapidly established curves, fell to the following values which were not calculated but actually measured: 100 units at 50 feet, 10 units at 100 feet, 4 units at 150 feet, 2.5 units at 200 feet, 1.9 units at 250 feet, 1.5 units at 300 feet, 1.4 units at 350 feet, 1.1 units at 400 feet and unity at 450 feet.

The slow response of oysters led the writer to carry out a completely separate and comprehensive investigation of oyster mortality due to seismographic explosions. Duplicate series again were used with a top charge of 400 feet of dynamite exploded in the center of the oyster beds with the top dynamite 25 feet below the oysters and with adequate controls. A radial series of oysters was secured with adequate controls and was transferred to the Pensacola Station of the Fish and Wildlife Service. They were there kept under observation for two and a half months and the experimental oyster beds were kept under observation for two and a half years. Briefly stated, results were that, quite surprisingly and beyond the experimenter's prediction, these violent explosions caused no significant mortality either on the animals present or on the animals that subsequently remained. The importance of this is that, quite contrary to the surmise of oyster men, such seismographic explosions caused no subsequent mortality to the oysters, no subsequent damage by the gas originating from the dynamite explosions and no subsequent diffusion of damaging hydrogen sulphide or other gases from the substratal mud.

A third series of experiments was conducted utilizing, in addition to previous experimental animals, the blue crab, *Callinectes sapidus*. It was found that there was no radial seriation in blue crab mortality but that the blue crab deaths were definitely a function of their physiological condition, primarily predicated upon whether or not such crabs had spawned and thus were subject to explosive impact upon vacant spaces in their anatomy.

Correlation of all of these results has been made with previous experimental work, particularly that of Dr. R. H. Draeger, and the results also accord with Dr. Draeger's observations concerning "Operations Crossroads," the Bikini bomb experiments in which Dr. Draeger had primary responsibility for safety. It should be pointed out that these results, some of which were published, were disregarded in a 1948 publication by the Chesapeake Bay Biological Laboratory.

John McDougall and Louis C. Rodrigue collaborated with the writer in the two earlier series of experiments and Dr. Malcolm Owen in the third.