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Efficiency of Pound-Net Cull Panels: A Comparison of Size Selectivity and Relative Release for Weakfish (Cynoscion regalis) and Summer Flounder (Paralichthys dentatus)

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Efficiency of Pound-net Cull Panels
A Comparison of Size Selectivity and Relative Release
for
Weakfish (*Cynoscion regalis*) and Summer Flounder (*Paralichthys dentatus*)

A Thesis
Presented to
The Faculty of the School of Marine Science
The College of William and Mary
in Virginia

In Partial Fulfillment
Of the Requirements for the Degree of
Master of Science

By
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Approval Sheet

This thesis is submitted in partial fulfillment of
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TABLE OF CONTENTS

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The cooperative efforts of all of these individuals contributed to a sound cooperative effort between the academic arena, management, and the commercial sector. By working together as a cohesive entity applicable solutions that promote resource conservation can be realized.

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

LIST OF GRAPHS

ABSTRACT

Abstract. --- Although numerous studies have documented the bycatch for pound-net gear and a few have attempted to reduce this bycatch through the use of passive escape panels, none have met with measurable great success until now. Three different types of panels were alternately tested in a passive BRD in order to assess their size selectivity and release efficiency during the Pound-net Bycatch Reduction Device (BRD) Study of 1998 sponsored by the Potomac River Fisheries Commission. Greatest release efficiency was attained from a panel that was constructed from a combination of rings and slots, 73% of the sub-legal gray trout and 86% of the sub-legal flounder were allowed to escape. The rings effectively culled trout to 360mm but because the current legal size in the Potomac River is 305mm, this lack of discrepancy permitted the release of 6% of the legal fish. No legal flounder escaped through the rings but the slots released flounder up to 407mm. The legal size limit is 355mm and this allowed a release of 39% of the legal flounder. Size selectivity problems were preliminarily examined at the end of the fishing season. A new panel was constructed of rings and slots with reduced dimensions. The number of possible escape routes was also reduced. A seasonal decline in the trout abundance weakened the predictive value of this work for this species. Flounder numbers remained high enough and 50% of the undersized flounder still used the panel. No legal fish escaped. Field trials suggest strongly that release efficiency is not affected by these size reductions and that problems of size selectivity can be adequately addressed.

A Comparison of Size Selectivity and Relative Release Efficiency of Pound-Net Cull Panels

Introduction and Literature Review

Since man's first organized harvest of marine resources, catches have consisted of a combination of organisms in a variety of sizes. During colonial times creatures that were too small to be consumed or had no other value were often composted for agricultural purposes or used as feed supplements for domesticated animals. In fact, native Americans showed early European settlers how planting corn and menhaden together could improve their crop yields. Under subsistence conditions bycatch simply did not exist.

Over time, our approach to natural resource use has changed. Today most fisheries are exceedingly industrialized and their methods streamline. Increasingly, these fisheries attempt to target only the higher valued species in order to maximize profit. Any other organisms that are captured are done so incidentally. The conglomerate of unwanted discards remaining after targeted species are removed is collectively referred to as bycatch. It may consist of undersized-targeted fishes and/or non-targeted species such as birds, aquatic mammals, or turtles. Some of these unintentionally harvested animals may already be managed or endangered due to overfishing and/or other anthropogenic factors; therefore, the increase in mortality due to bycatch may significantly influence their population dynamics.

Advancements in technology, equipment, and methods continue to focus on and enhance gear efficiency. "The problem of actually harvesting the stocks has been efficiently solved often to the point that unrestricted fishing would virtually eliminate them" (Hamilton 1987). Increasing gear efficiency without improving gear selectivity inherently carries with it an enhanced potential to overfish due to an augmentation of bycatch. Such pressures have made overfishing of many targeted species the norm while the impact on many non-targeted species is unclear.

Modernization of the fisheries is not the only factor that has significantly affected the composition and quantity of bycatch. As the fisheries' management continues to evolve, the designations that define what is and is not legal change. All illegal fishes, whether this definition is due to size restrictions or quantities in excess of legal bag limits, are considered bycatch. Therefore, in some cases bycatch-per-unit-effort (BPUE) may be augmented solely by expanding regulations and not by changes in catch composition. However, in most fisheries the BPUE is growing too quickly to be explained away by managerial limit revisions.

The reason for these changes in catch composition is biological and two-fold. First, recruitment overfishing selectively removes the older more fecund individuals, the stock's structure changes (e.g. year class composition) and overall biomass is reduced (Murawski 1995). As these larger fishes are removed, the fishery becomes increasingly dependent on the successful recruitment of younger year classes that provide the remaining stocks of legal fishes. In order to maintain profit margins an increase in effort also often follows. Because smaller year classes consisting of fewer legal size animals are being targeted, each unit of effort harvests a greater proportion of sub-legal fishes. Bycatch is expanded, total mortality increased, and potential recruitment reduced. At this point, growth-overfishing results from the targeting of these remaining younger year classes, which have not maximized their growth potential. This type of systematic overfishing has been a major contributing factor to the significance of the bycatch problem (Alverson et al.1993).

The reauthorization of the Magnuson - Stevens Fishery Conservation and Management Act (MCFCMA) of 1996 mandates “that any fisheries management plan prepared by Council, or by the Secretary of Commerce, with respect to any fishery, shall assess and specify the present and probable future condition of, and the maximum sustainable yield and optimum yield from, the fishery, and include a summary of information utilized in making such specifications” (MSFCMA 1996). Integral to this new management approach are the new national standards for fishery conservation and management that now require by law that, to the extent practical, measures shall minimize bycatch and, to the extent bycatch cannot be avoided, minimize the mortality of such bycatch (MSFCMA 1996). Quantification of a living resource’s maximum sustainable yield requires identification of all factors affecting the species’ survival and recruitment. Exploration into these factors has highlighted bycatch as a primary source of underestimated mortality for many fishes. At times bycatch may equal or exceed what is legally harvested (Austin et al 1996, Alverson et al 1994, Graham 1995). Studies reveal, for example, that the average shrimp trawl catch per hour in the South Atlantic contains a mass ratio of 2.3 pounds of juvenile sub-legal finfish for every pound of shrimp. This ratio increases to 4.3:1 in the Gulf of Mexico (Graham 1995). The threat of collapsing fisheries and our new goal of realizing and maintaining sustainable fisheries have made bycatch the management issue of the decade (Alverson et al 1994).

In order for population dynamics models to be realistic and useful they must be expanded to include factors such as bycatch. Most fishery scientists believe that discarded bycatch is a significant cause of mortality in North America (Alverson et al. 1994); and recent studies have suggested that the mortalities, imposed as a result of fishing gear and its use, are far greater than suggested by landing reports (Alverson et al. 1994, I.C.E.S. 1995). Models that take such a wide array of factors into consideration are an aggregate of unaccounted for fish mortalities. I.C.E.S. has partitioned a formula of fish mortalities in this comprehensive list of potential sources (I.C.E.S.1995).

$$F \text{ (fishing mortality)} = F(cl) + F(rl) + F(sl) + F(b) + F(d) + F(o) + F(a) + F(e) + F(g) + F(p) + F(h)$$

F Sum of all direct and indirect mortality due to fishing

F (cl) Commercial landing mortalities

F (rl) Recreational landing mortalities

F (sl) Subsistence landing mortalities

F (b) Illegal and misreported landing mortalities

F (d) Discard mortalities

F (o) Drop-out mortalities

F (a) Mortalities resulting from fish that avoid gear but are injured and die as a result

F (e) Mortalities resulting from fish that contact gear but escape and then die

F (g) Mortalities resulting from fish that die in ghost gear

F (p) Mortalities of fish that escape gear but are subsequently eaten because of stress due to gear interaction

F (h) Mortalities due to gear habitat alterations

Management for the better part of this century has ignored or operated largely in ignorance of most of these mortality coefficients. This may in part explain why many of the world's fisheries are in trouble and why there is growing support for risk aversion management (Alverson and Hughes 1995). In order to maintain functionally stable ecosystems that can yield sustainable returns, management must first assess the ecological impacts each fishery imposes on each ecosystem. The unique gears, methods, areas, and seasons of operation inherent to each fishery will distinctively contribute to the equation's coefficients. Scaling these coefficients removes insignificant terms and highlights those upon which management should focus. This method has revealed that the northeast Atlantic's largest source of unknown mortality is frequently due to the landing of illegal fishes and misreporting (ICES 1995).

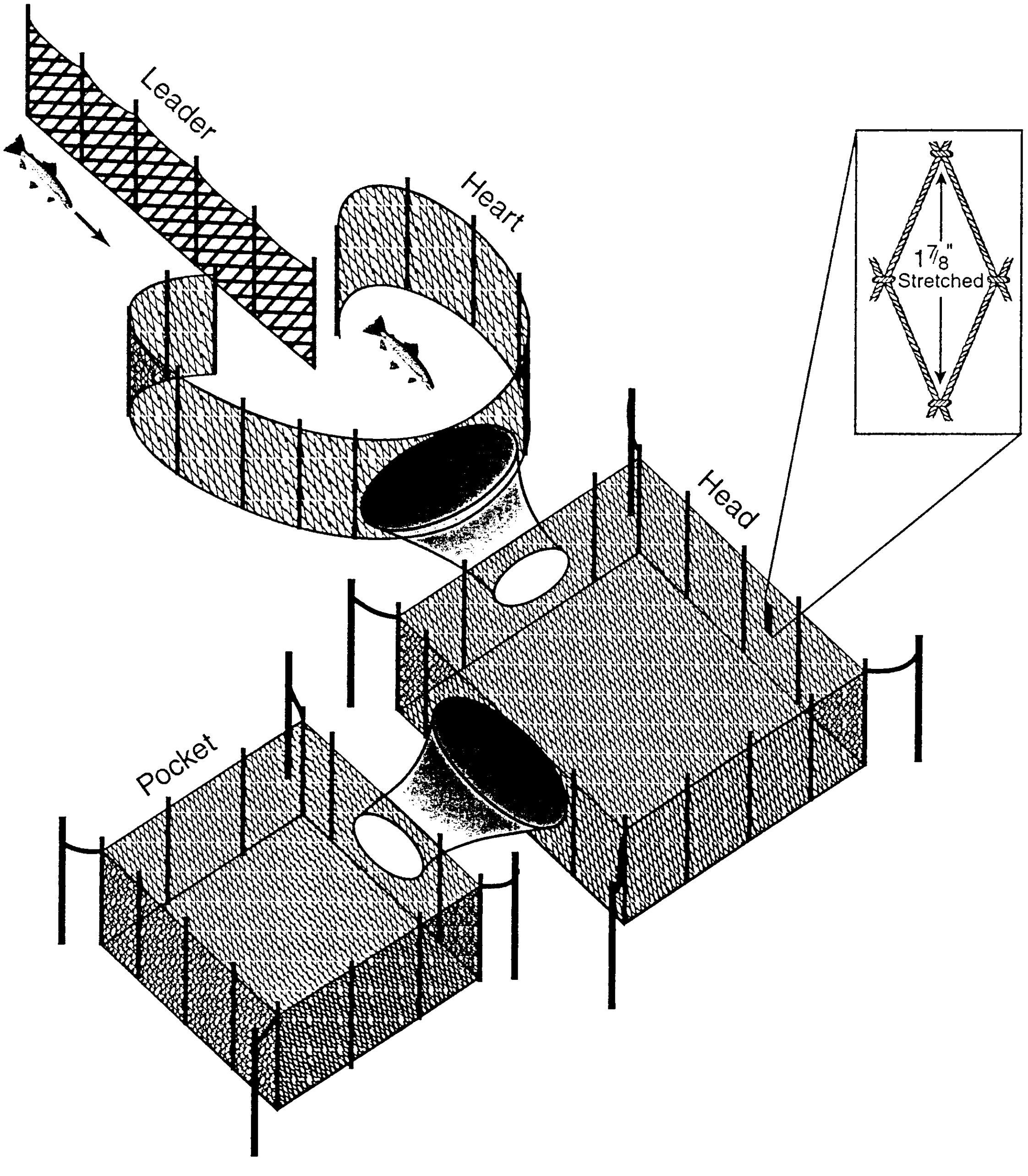
Gear improvements and/or alteration of fishing methods can effectively reduce lethality of some gears. This is especially true if the gear is stationary and does not entangle fishes but, instead, acts like a trap. The pound-net or weir is a good example of such a gear type.

The pound-net catches more food fish in a wider range of sizes than any other gear in the Chesapeake Bay. Its fixed construction harkens back to the fish weirs used by the Native Americans of the east coast of North America. Its method of trapping fishes, but not harming them, offers a perfect opportunity to improve gear efficiency by means of increasing gear selectivity. The first true pound-nets appeared in the Chesapeake Bay sometime in the 1850s (True 1887), but it was not until the 1870s that the fishery met with any success. By 1880 the profit was so great that 162 nets occupied Virginia waters (Reid 1955, Austin 1987). Between the World Wars more than 2,000 nets were being fished in the Bay (Austin et al 1996). Since then numbers have declined greatly.

The typical pound-net consists of a leader, a bay or bays, a funnel, and a head (Fig. 1). All of the net's compartments are suspended from poles driven into the river's bottom. Poles provide rigidity to support the net's structure as well as a secure point from which to work. The leader, which is constructed of large 76.2-279.4mm (3-11") stretched mesh, is set perpendicularly to the shoreline and extends from shallow to deep water. It intercepts fishes swimming up- or down-river and directs them into the top end of the heart. The heart consists of a reduced mesh and acts like a giant funnel continually directing fishes towards its deep-water end where a smaller funnel leads into the pound's head. The head consists of a greatly reduced mesh, usually no larger than 47.6 mm (1 7/8") stretched, and it is constructed like a box. It contains four sides and a bottom all made of webbing. In some cases, a smaller head or pocket may be connected via another funnel to the main head (Fig. 1). This smaller head can be fished with less labor thus economically streamlining the operation.

The small mesh that makes up the head is a necessary attribute upon which the efficiency of the gear depends. The pound-net is essentially a funnel trap designed to impound fishes in its box-like head. The head's reduced mesh enables the walls of the net to act like a solid boundary, preventing gilling and directing the fishes' movements. When the net is fished, the head is gradually pulled from the water. As it is pulled, fishes are corralled into an increasingly reduced area. When the pocket's area is sufficiently reduced, the fishes are brailed into the boat using hand nets. Gradually pulling the net tighter

Figure 1. Potomac River pound-net containing reduced meshes going from leader to head; culminating with 4.76 mm (1 7/8") mesh in the pocket.


Leader
Heart
Head
Pocket
1⅞"
Stretched

continually decreases the head's volume (Fig. 2). Reduction continues until the remainder of the catch can be rolled into the boat by lifting the head itself. If the catch is large enough, hydraulically assisted hand nets are employed.

Though the small mesh of the head is necessary to maintain the gear's efficiency, it unavoidably retains large numbers of sub-legal, commercially, and recreationally important fishes (Fig. 3). Pound-nets have been cited for this flaw historically (Houston 1929, McHugh 1960, Meyer 1976, Austin et al 1996). Some authors have gone so far as to single out the gear and blame it solely for declines in weakfish (*Cynosion regalis*) stocks (Higgins and Pearson 1928). Although today blaming a single gear type for the decline of an inshore species is considered myopic, pound-nets do catch a large number of undersized weakfish and other species that are often too small to be marketable (Hildebrand and Schroeder 1928, Reid 1955, Massman 1963, Austin et al 1996).

Harvest method plays a crucial role in pound-net discard mortality. Physiological stresses induced when fishes are captured and then allowed to remain on deck while the catch is being sorted can cause substantial mortality (Beamish 1966, Howell and Langan 1992). When these stresses were eliminated, mortality for released weakfish was determined to be 18% (Swihart et al 1995). This figure represents the highest survival rate attainable because fish were removed from

Figure 2. Pocket being pulled into skiffs in order to allow for brailing using hand-nets.

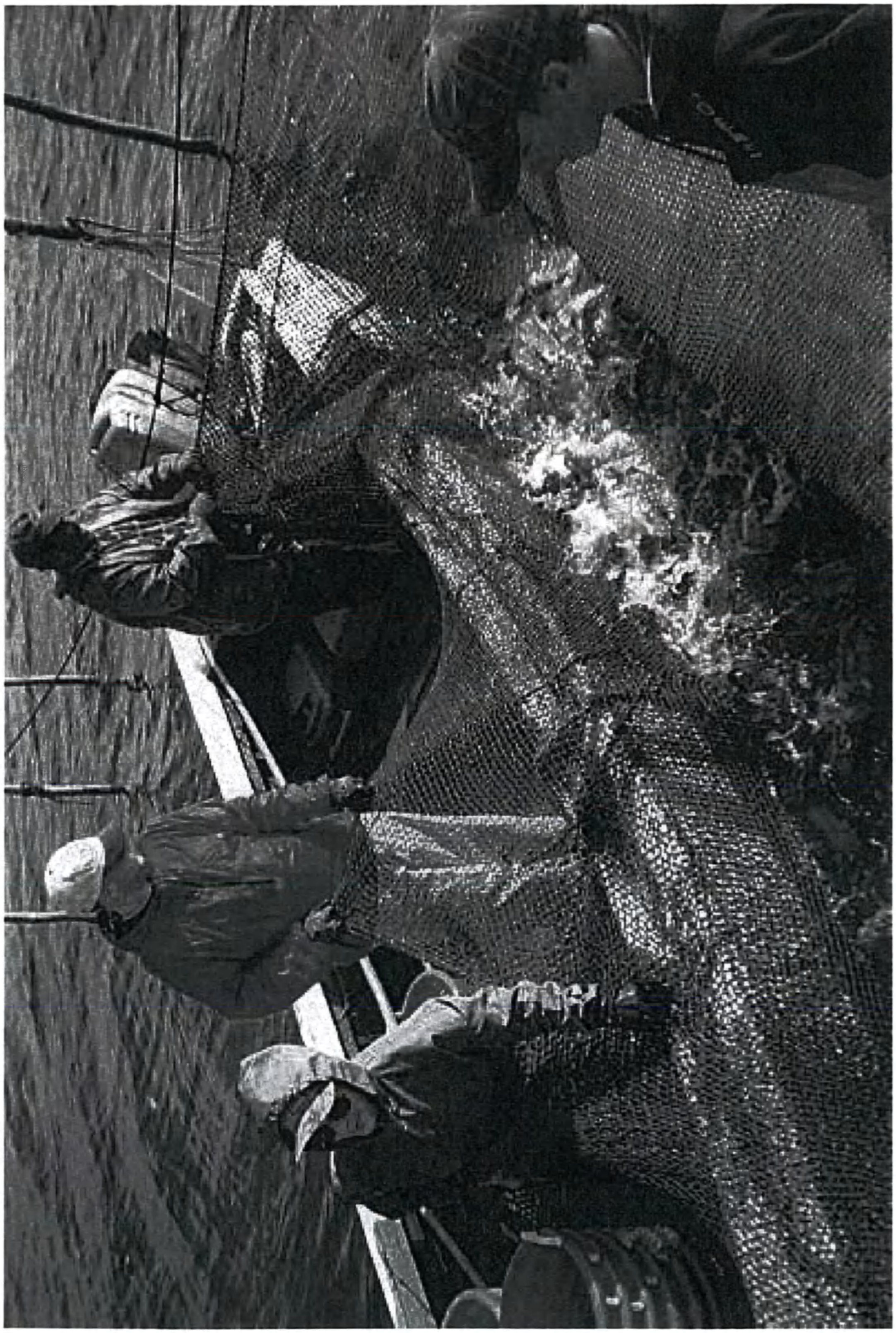


Figure 3. After brailing, catch is sorted off the deck. Sub-legal flounder (*Paralichthys dentatus*), weakfish (*Cynoscion regalis*), bluefish (*Pomatomus saltatrix*), red drum (*Sciaenops ocellatus*) are evident.

the gear and immediately returned to the water. This special handling promotes survival, but it does not realistically characterize standard gear operation.

Normally the whole pocket of the net is emptied before any release or sorting of the catch takes place. The larger the catch size, the greater the time required for harvest. Sorting time is also amplified and bycatch mortality is increased. Currently most pound-netters apply this one-step-at-a-time method in order to maximize their catch-per–unit-effort (CPUE), and this results in a bycatch mortality of 100%.

Bycatch studies conducted under normal commercial conditions provide reliable quantitative data and methodological insight from which applicable reduction solutions may result. Some species and/or different ages of a given species are naturally more resilient to handling (Ross and Hokenson 1997). Biological and environmental conditions during harvest play a pivotal role (Ross and Hokenson 1997). Only by randomly sampling a given gear throughout the commercial season can a reasonable estimate of bycatch be attained. This estimate and its associated mortality can then be used to improve the management of a single fishery or be combined with bycatch data from other gear types operating in the region to formulate more comprehensive management plans.

Altering trap-like fishing gear so that it passively releases undersized fishes may prove to be one of the best means of bycatch reduction. Passive release minimizes or eliminates handling and exposure stresses; therefore, greater survival of released fishes results. Recruitment may be improved and the threat of growth overfishing reduced (Pollack 1994, Hadden 1994). If the small mesh of the net's pocket retains too many sub-legal fishes, it would seem that enlarging the mesh size would allow small fishes to escape and yet retain the larger ones for harvest. Unfortunately, numerous studies have shown that this is not the case (Higgins and Pearson 1928, Houston 1929, Meyers 1973).

The North Carolina Division of Marine Fisheries (NCDMF, Gearhart 1998) is currently conducting research into methods of bycatch reduction for their sciaenid pound-net fishery. To enhance escapement of undersized fishes, they modified a Virginia Marine Resources Commission bycatch reduction device (BRD) design (VMRC, Boyd 1996). VMRC placed a 1.22 x 1.22m (4' x 4') escape panel in a pound measuring 10.67 x 12.19 x 10.67m deep (35' x 40' x 35' deep). NCDMF's 3.05 x 3.05m (10' x 10') panel was placed in a pound that measured 6.1 x 6.1 x 6.1m deep (20' x 20' x 20' deep). Increasing the amount of large mesh, which acted as the BRD in this case, intrinsically increases escape potential. Because the mesh incorporated in the NCDMF's design was not rigid, gilling remained a problem at first. Increasing the strand to # 84 and the mesh size to 76.2 mm (3 in) effectively addressed this problem. The combination of these alterations resulted in a larger percentage of escaped weakfish; 25% of the undersized weakfish (<10") escaped. Length frequency distributions of the weakfish that escaped demonstrated that 20% were legal fish (Gearhart 1998).

Pound-nets on the Potomac River, like those in the rest of the Chesapeake Bay, catch large numbers of undersized fishes. The Potomac River Pound-Net Survey during the summer of 1997 provided evidence that a large number of these small fishes were being retained and sold as crab bait (Austin et al 1997). The mean size of the weakfish harvested was 287.2 mm, well below the legal limit of 300mm (Fig. 4). The mean size of summer flounder was 354.4mm, also below the legal minimum size limit (357mm) (Fig. 5). Minimum sizes and possession tolerances were either ignored by most fishermen, or a few renegade watermen severely skewed the mean.

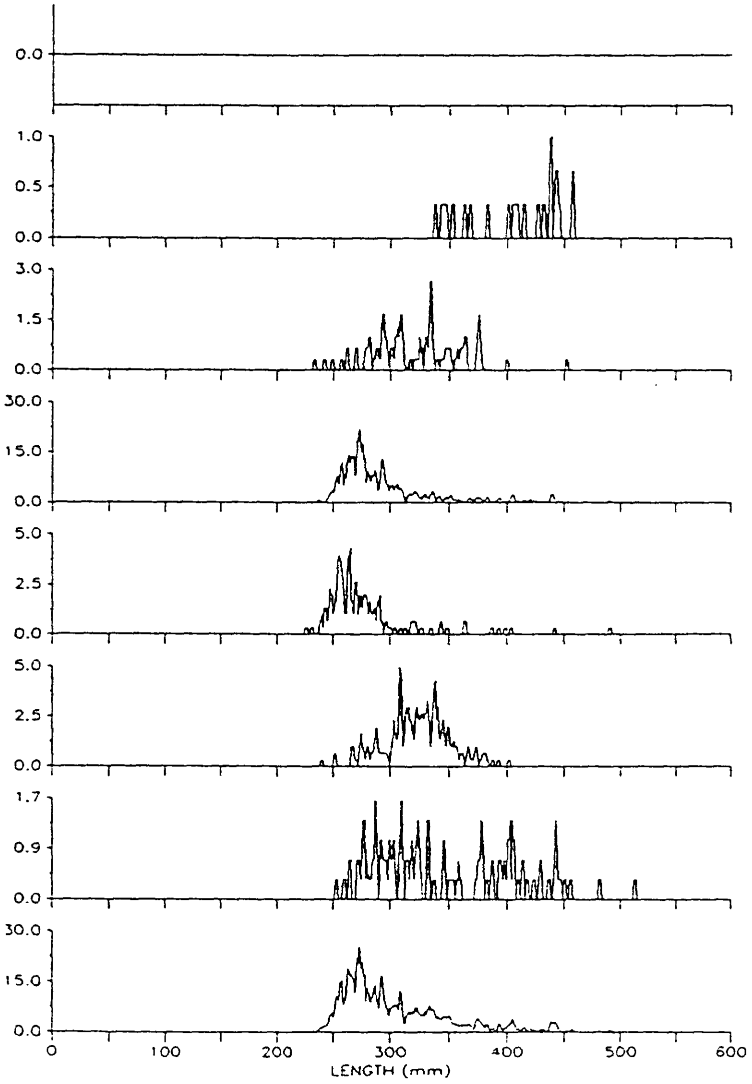
In the spring of 1998 managers from the Potomac River Fisheries Commission, scientists from the Virginia Institute of Marine Science, and commercial pound-netters came together to alter traditional pound-net gear in an effort to reduce bycatch and improve compliance with the Atlantic States Marine Fisheries Commission's (ASMFC) weakfish and summer flounder management plans. Current plans dictate minimal size requirements and bycatch restrictions in the form of tolerances. Continued failure to comply with ASMFC's mandates could result in closure of the river's pound-net fishery. To gain acceptance, gear modifications would have to satisfy both the managers' goal of reducing juvenile fishes mortality and the fishermen's goal of increasing legal catch-per-unit-effort. Undersized fishes must be released prior to harvest to achieve both objectives.

Current culling methods employed after harvest increase effort to an unreasonable level and result in high mortality of released fishes due to exposure and handling, therefore, a new solution must be found.

This study explored a means to improve pound-nets so that they are largely self-culling. Modifications allowed for the passive release of undersized fishes so that they escaped unaffected. The objectives of this study were to: (1) update and expand bycatch estimates for the Potomac's pound-net fishery; (2) develop, refine, and evaluate a passive bycatch release mechanism that will reduce the mortality of undersized weakfish and flounder by at least 33% and retain most legal fishes; (3) record the ability of variations of such a device to meet these goals in situ; (4) calculate the significance of release compared to normal gear operation for undersized flounder and weakfish; and (5) show how this release improves the pound-net's catch-per-unit-effort of legal fishes.

Figure 4. 1997 Potomac River Pound-net Survey – Weakfish Length Frequency. Top 7 graphs show size distributions of catch seasonally. Bottom graph shows large number of sub-legal (<305 mm) fish retained.

1997 Potomac River Pound Net Survey – Weakfish Length Frequency



APRIL	000000 – 000000		
NO. CGHT.	0	MEAN SIZE	
NO. MEAS.	0	S.E. SIZE	
NO. SITES	0	MIN. SIZE	
CAT./SITE	.	MAX. SIZE	

MAY	970506 – 970513		
NO. CGHT.	21	MEAN SIZE	404.9
NO. MEAS.	21	S.E. SIZE	8.8
NO. SITES	3	MIN. SIZE	336
CAT./SITE	7	MAX. SIZE	456

JUNE	970610 – 970626		
NO. CGHT.	74	MEAN SIZE	317.8
NO. MEAS.	74	S.E. SIZE	4.6
NO. SITES	8	MIN. SIZE	231
CAT./SITE	9.3	MAX. SIZE	450

JULY	970701 – 970729		
NO. CGHT.	1687	MEAN SIZE	290.7
NO. MEAS.	691	S.E. SIZE	1.6
NO. SITES	18	MIN. SIZE	235
CAT./SITE	93.7	MAX. SIZE	488

AUGUST	970804 – 970806		
NO. CGHT.	125	MEAN SIZE	277.8
NO. MEAS.	125	S.E. SIZE	3.7
NO. SITES	2	MIN. SIZE	224
CAT./SITE	62.5	MAX. SIZE	489

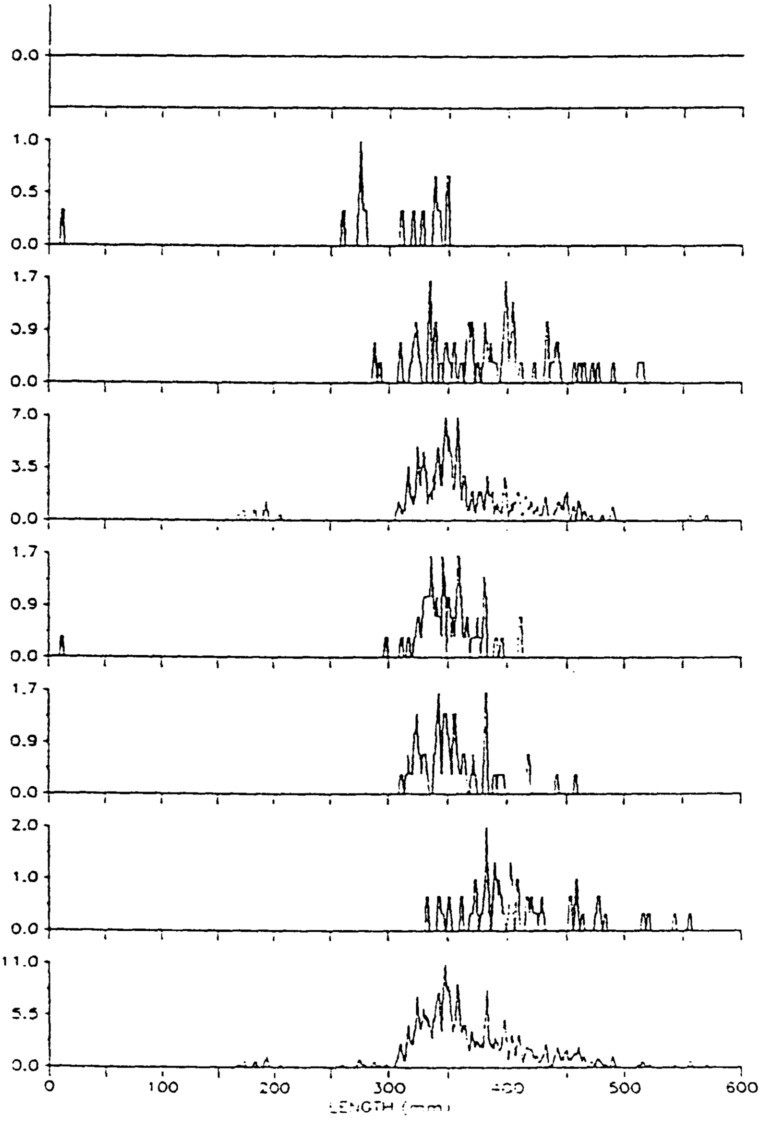
SEPTEMBER	970905 – 970930		
NO. CGHT.	172	MEAN SIZE	321.6
NO. MEAS.	172	S.E. SIZE	2.2
NO. SITES	5	MIN. SIZE	238
CAT./SITE	34.4	MAX. SIZE	400

OCTOBER	971003 – 971024		
NO. CGHT.	93	MEAN SIZE	347.2
NO. MEAS.	93	S.E. SIZE	6.3
NO. SITES	6	MIN. SIZE	251
CAT./SITE	15.5	MAX. SIZE	511

MAY–OCT	970506 – 971024		
NO. CGHT.	2172	MEAN SIZE	302.1
NO. MEAS.	1176	S.E. SIZE	1.4
NO. SITES	42	MIN. SIZE	224
CAT./SITE	51.7	MAX. SIZE	511

Figure 5. 1997 Potomac River Pound-net Survey – Flounder Length Frequency. Top 7 graphs show size distributions of catch seasonally. Bottom graph shows large number of sub-legal (<355 mm) fish retained.

1997 Potomac River Pound Net Survey – Summer Flounder Length Frequency



APRIL		000000 – 000000			
NO. CGHT.	–	0	MEAN SIZE	–	
NO. MEAS.	–	0	S.E. SIZE	–	
NO. SITES	–	0	MIN. SIZE	–	
CAT./SITE	–	.	MAX. SIZE	–	

MAY		970506 – 970513			
NO. CGHT.	–	13	MEAN SIZE	–	308.7
NO. MEAS.	–	13	S.E. SIZE	–	9.2
NO. SITES	–	3	MIN. SIZE	–	258
CAT./SITE	–	4.3	MAX. SIZE	–	347

JUNE		970610 – 970626			
NO. CGHT.	–	68	MEAN SIZE	–	383.7
NO. MEAS.	–	68	S.E. SIZE	–	7.4
NO. SITES	–	8	MIN. SIZE	–	285
CAT./SITE	–	8.5	MAX. SIZE	–	514

JULY		970701 – 970729			
NO. CGHT.	–	673	MEAN SIZE	–	361.2
NO. MEAS.	–	296	S.E. SIZE	–	3.2
NO. SITES	–	18	MIN. SIZE	–	166
CAT./SITE	–	37.4	MAX. SIZE	–	558

AUGUST		970804 – 970806			
NO. CGHT.	–	52	MEAN SIZE	–	349.9
NO. MEAS.	–	52	S.E. SIZE	–	3.3
NO. SITES	–	2	MIN. SIZE	–	296
CAT./SITE	–	26	MAX. SIZE	–	409

SEPTEMBER		970905 – 970930			
NO. CGHT.	–	51	MEAN SIZE	–	360.3
NO. MEAS.	–	51	S.E. SIZE	–	6.9
NO. SITES	–	5	MIN. SIZE	–	309
CAT./SITE	–	10.2	MAX. SIZE	–	625

OCTOBER		971003 – 971024			
NO. CGHT.	–	56	MEAN SIZE	–	409.3
NO. MEAS.	–	56	S.E. SIZE	–	5.9
NO. SITES	–	6	MIN. SIZE	–	331
CAT./SITE	–	9.3	MAX. SIZE	–	554

MAY–OCT		970506 – 971024			
NO. CGHT.	–	913	MEAN SIZE	–	366.6
NO. MEAS.	–	536	S.E. SIZE	–	2.4
NO. SITES	–	42	MIN. SIZE	–	166
CAT./SITE	–	21.7	MAX. SIZE	–	625

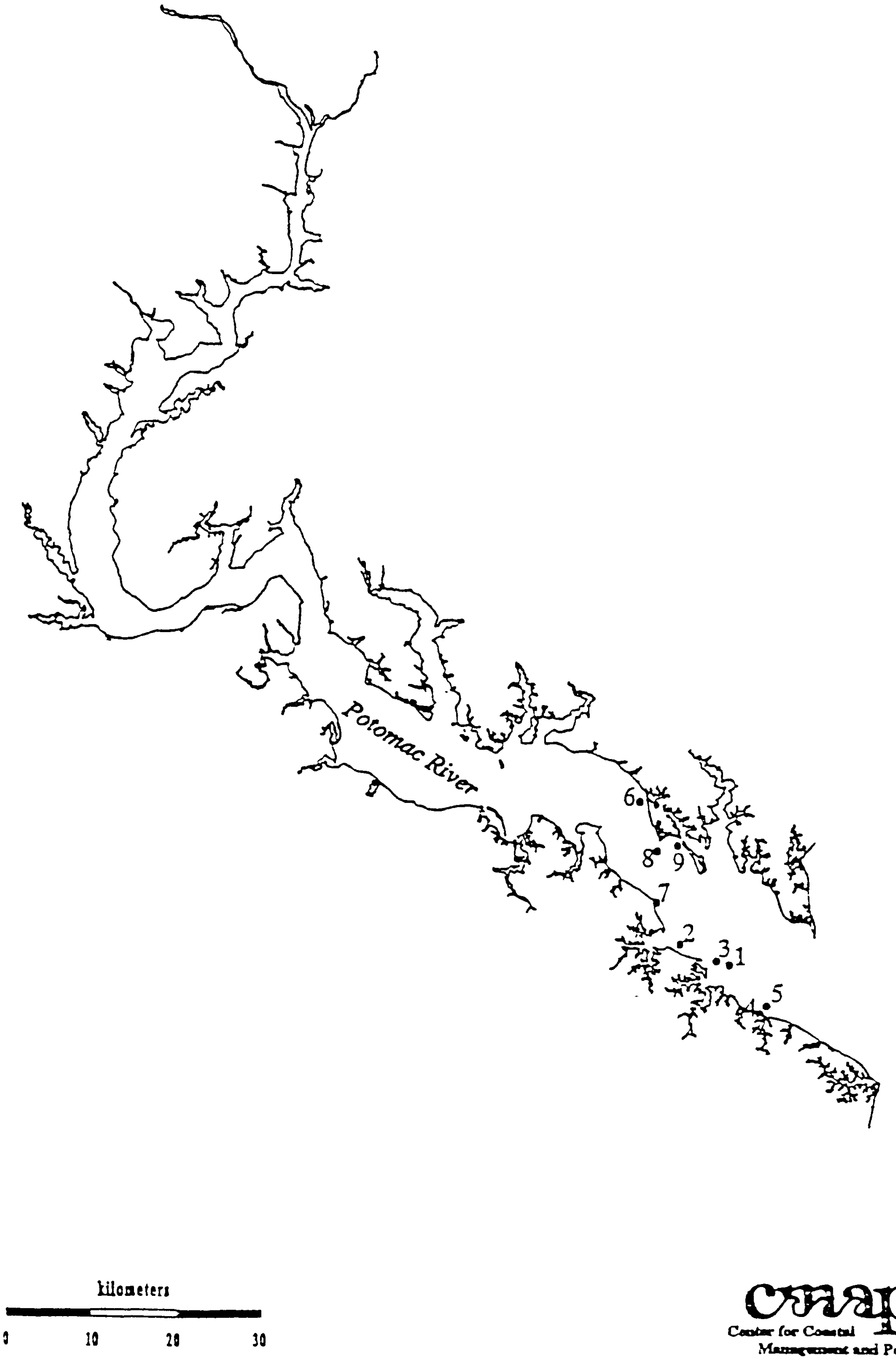
Study Site and Methods

The Potomac River, which forms the border between Virginia and Maryland, is the northern most Virginia-bounded tributary to the Chesapeake Bay (Fig. 6). The Potomac River's fishery has included pound-nets since they appeared in the Chesapeake around 1860. Records from the Potomac River Fisheries Commission (PRFC), an administrative body created to manage the Potomac River's fisheries jointly between Virginia and Maryland, indicate that the number of pound-nets has fluctuated from between 70 and 180 since 1963. These fluctuations reflect both declining catches and varied management practices. The number of nets is fixed at 100 today due to a limited entry regime implemented in 1994. Pound-nets are especially important in the Potomac River because they are the primary commercial-gear type used to harvest food fish. The only other fishery makes use of large mesh gill-nets and it targets striped bass.

The Potomac River 's location in the middle of the Chesapeake Bay and its extensive watershed tend to make most of the river considerably less saline than the main stem of the Bay. These conditions perfectly suit the needs of anadromous fishes, offering a diversity of spawning and nursery habitats. A physically dynamic environment characterizes the lower river, where the

Figure 6. Map of Potomac River's pound-nets showing nets used during the study (number 1 and 5).

Potomac River Pound–Net Survey



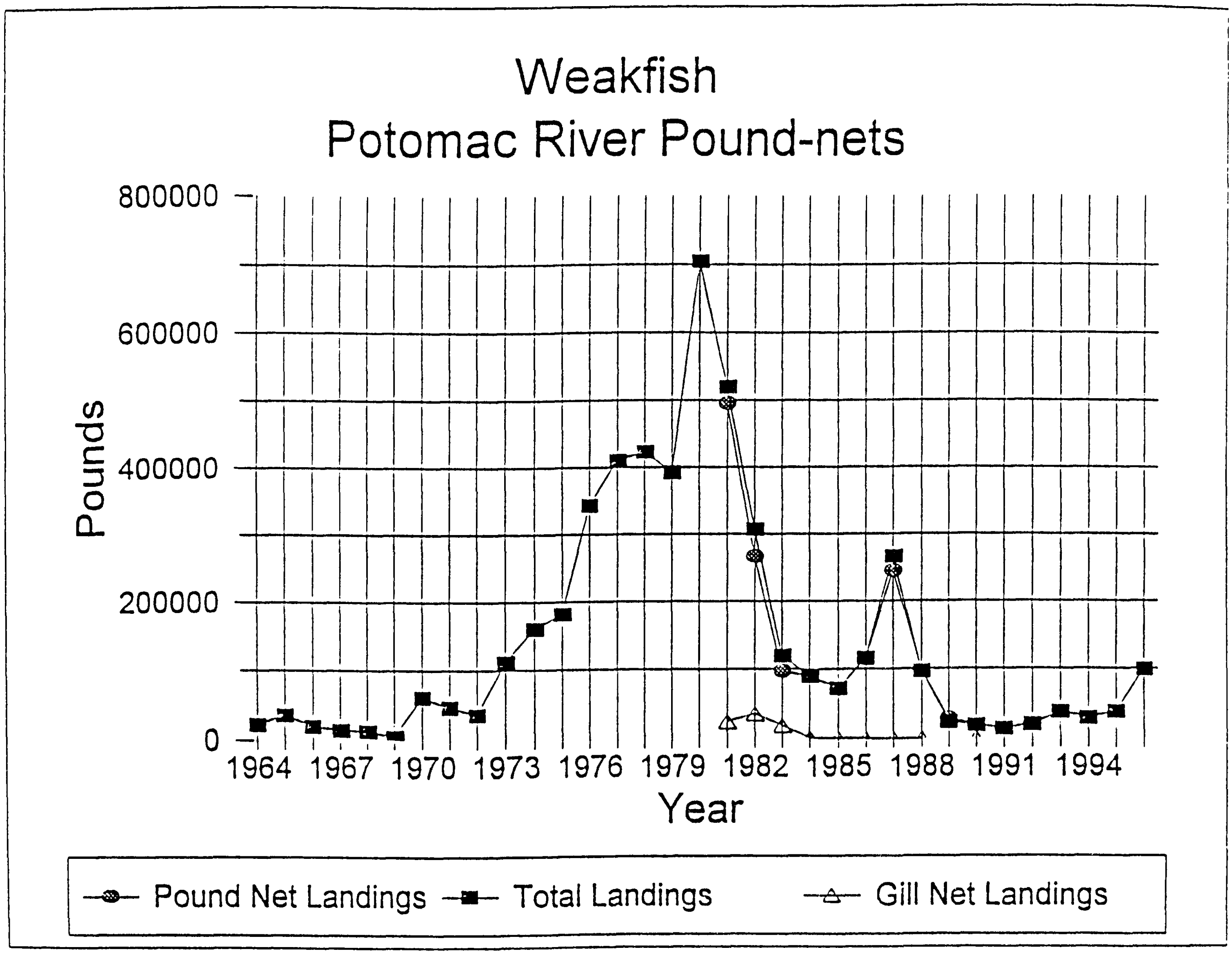
CMAP
Center for Coastal
Management and Policy

Potomac mixes with the more saline Bay. This mixing zone is utilized seasonally by a host of different species that take advantage of the biological productivity of the area. Weakfish and flounder have historically occupied the area and played an important role in the pound-net fishery. Both species forage on plentiful schools of baitfish that congregate at the river's mouth. Most of the flounder present in the area are sub-legal juveniles that use the area as a nursery (ASMFC 1998).

The pound-nets involved in this study are located in this rich mixing zone at the river's mouth (Fig. 6, net 1&5). The physically dynamic character of this environment affects species availability on a temporal scale and is forced primarily by meteorological variability. Pound-net catch composition will respond to these physical changes (Joseph, 1962). The Potomac's long-term catch data illustrates great variability in weakfish and flounder harvest (PRFC Fig. 7 and Fig. 8). These trends are also evident for the Bay as a whole (CBAY STATS, VMRC MD).

Net location is intrinsic to catch composition and its accompanying bycatch (Joseph, 1962). Reliable bycatch reductions can only be formulated if they are based on realistic bycatch estimates obtained from specific sites that typify regional harvests. A host of environmental and gear-induced variables must be considered before net sites are selected. These include location, net

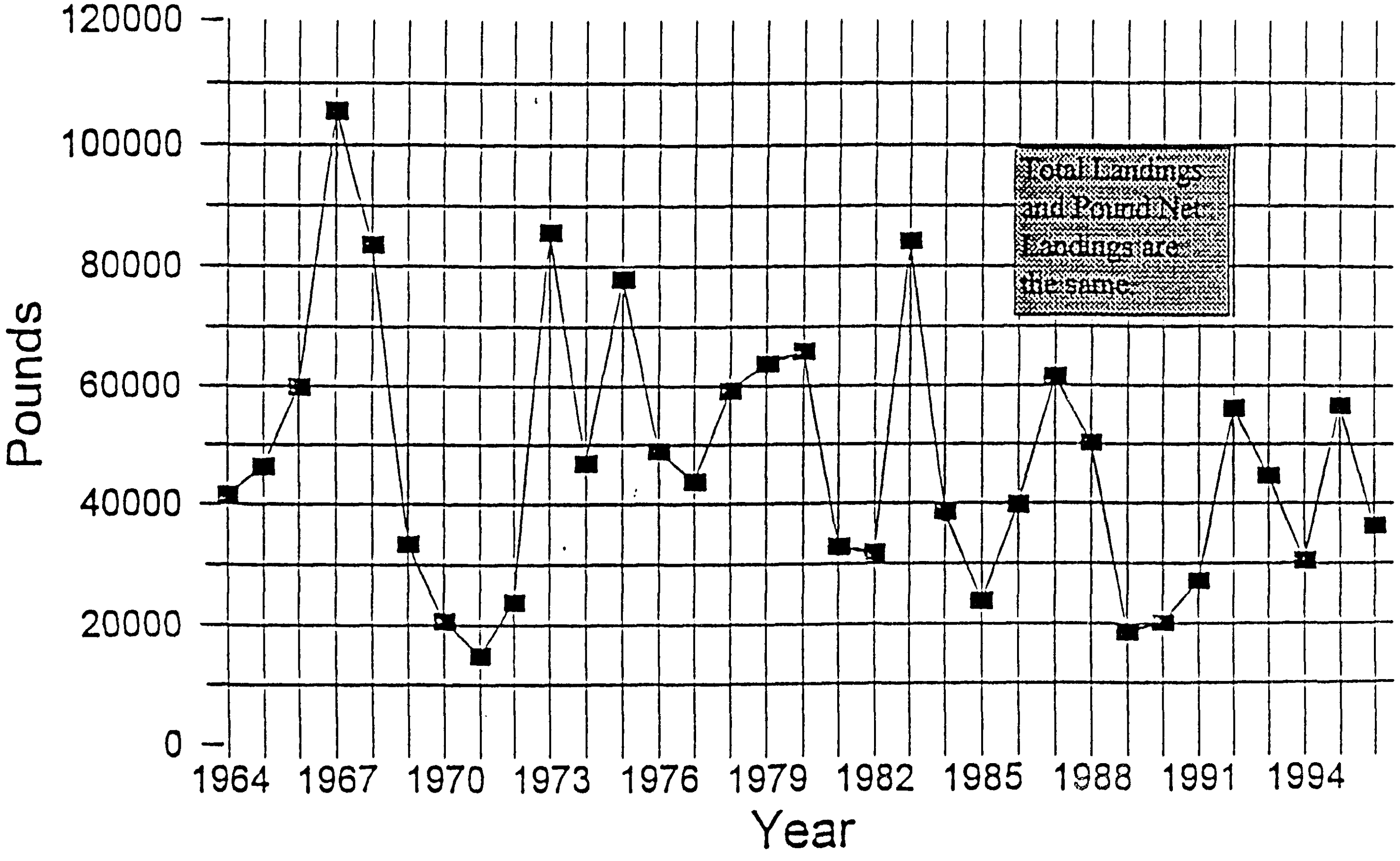
Figure 7. Weakfish landings on the Potomac River showing great variability over time.



Weakfish
Potomac River Pound-nets

Figure 8. Flounder landings on the Potomac River showing great variability over time.

Summer Flounder
Potomac River Pound-nets



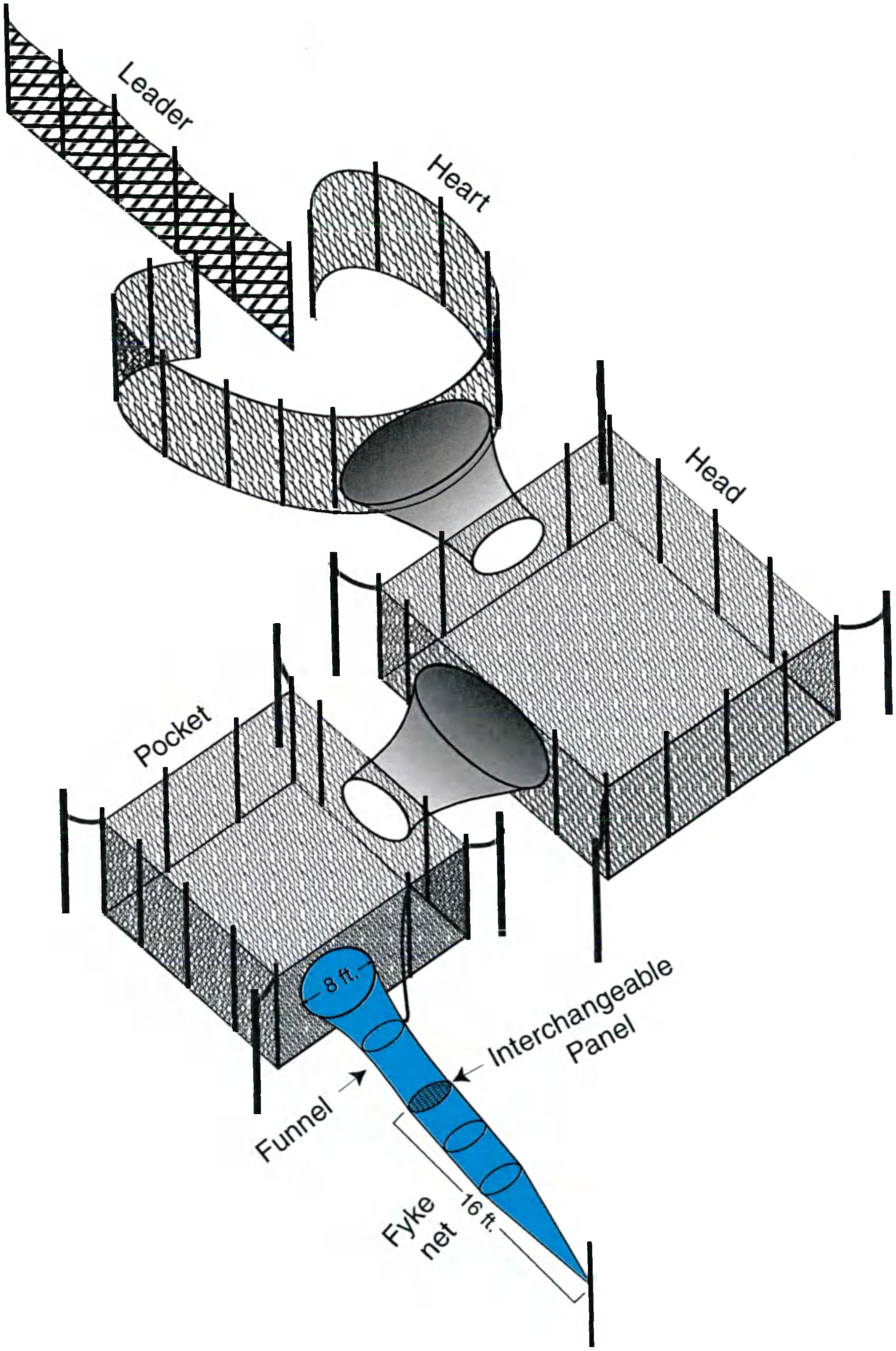
dimensions, net construction, riverbed sediment type, historic productivity, water depth, and fishing methods. Variables were minimized in an effort to homogenize gear selectivity and productivity. This standardization allowed data sets from different net sites to be combined, eased economic outlay, and minimized inconvenience to the fishermen.

The two nets that were selected are very similar in dimensions and net construction. Nets traditionally vary slightly between fishermen, but both nets in this case consisted of components of the same lengths and mesh sizes. As is the case with gill nets, the size of the fish the pocket retains varies according to the pocket's mesh size. Both pockets in this study were constructed of 4.76cm (1 7/8") stretched mesh. Each measured 6.1 x 6.1x 6.1m (20' x 20' x 20'). Dimensional variability due to construction was minimal. The nets selected varied with regard to their location and the orientation of the pocket off the main pound. Mr. Bradley, a Virginian, constructed his net with the pocket set on the down-river side of the main head. His net was located at the mouth of Hull Creek at N 37 57.874, W 076 22.796 in 5.79m (19') of water (Fig. 6, net 5). Mr. Bradley was kind enough to allow us to use his landing and facilities as a base of operation. Mr. Dean, a Marylander, constructed his net with the pocket in line with the main head. His net was also located on the Virginia side of the Potomac, just north of Bradley's at N 37 59.608, W 076 25.214. It was set in 6.4m (21') of water (Fig. 6, net 1). It was hoped that these nets and their proximity to one another would provide catches of similar composition and yet not too close as to interfere with each other's performance. Both nets were also set on similar sediment types. This may be significant only in that some fishes or year classes of fishes may prefer certain benthic environments and thus may be caught more readily over such sediments.

The pound-net BRD tested in 1998 was the culmination of suggestions and efforts of fishermen, scientists, and managers (Fig. 9). Fishermen are the heart of the industry and in the past have had keen insight into improving their gear and its selectivity. In this instance, concerned fishermen suggested the use of 50.8 mm (2") inner diameter rings in the pockets' side panels. They had long observed that fish gilled in any broken mesh as they attempted to escape during harvest. It was hoped that by using a rigid ring of smooth circular metal as a means of release that gilling would be minimized and continual release provided. The ring's diameter was selected in order to provide for the release of sub-legal weakfish because they are most economically important fusiform fish to the pound-net fishery. Naturally, any small fishes with similar diameters would also escape through the rings. Large numbers of juvenile flounder use the Bay and the mouth of the Potomac as a nursery, and it was felt that with a little modification to the shape of the release opening the BRD could benefit them as well.

Testing the BRD in two different nets expedited the study, reduced the burden to participating fishermen's normal operations, and demonstrated how well the

Figure 9. Illustrates pound-net with BRD attached to pocket. Funnel placed as close as possible to pocket's corner and intersecting with pocket's bottom.


Leader
Heart
Head
Pocket
8 ft.
Interchangeable Panel
Funnel
Fyke net
16 ft.

device would work in normal operation regardless of who used it or how the pound-net was constructed. Installing the BRD in two different nets owned by different fishermen from opposite sides of the river also provided a sociological advantage through increased participation. Increasing participation, it was hoped, would enhance future acceptance of the BRD by the pound-net fishing community as a whole.

The BRD takes advantage of the funneling design inherent to pound-net and uses it to passively cull the catch (Fig. 9). A large funnel consisting of 4.76 cm (1 7/8") stretched mesh and having a 2.44m (8') diameter mouth that tapers to a 1.22m (4') diameter terminal ring in a distance of about 3m (10') is sewn to the pocket's wall. Fishes exiting the pocket are directed through the funnel towards a 1.22m (4') diameter panel, which consists of rings and/or slots. These openings are perpendicular to the funneling fish's approach and fish that are small enough exit freely. All fishes leaving the pocket were recaptured during 1998 and retained for analysis by a 1.22m (4') diameter, 4.88m (16') long fyke-net, made of 50.8mm (2") stretched mesh containing two retention funnels. The fyke-net was attached to the funnel's terminal end via plastic pull ties and the release panel was placed between the fyke and funnel. This design allowed 1.22m (4') diameter panels consisting of different size and shape culling holes to be interchanged between nets using plastic zip-ties (Fig. 10).

Figure 10. BRD set up showing interchangeable panel junction.

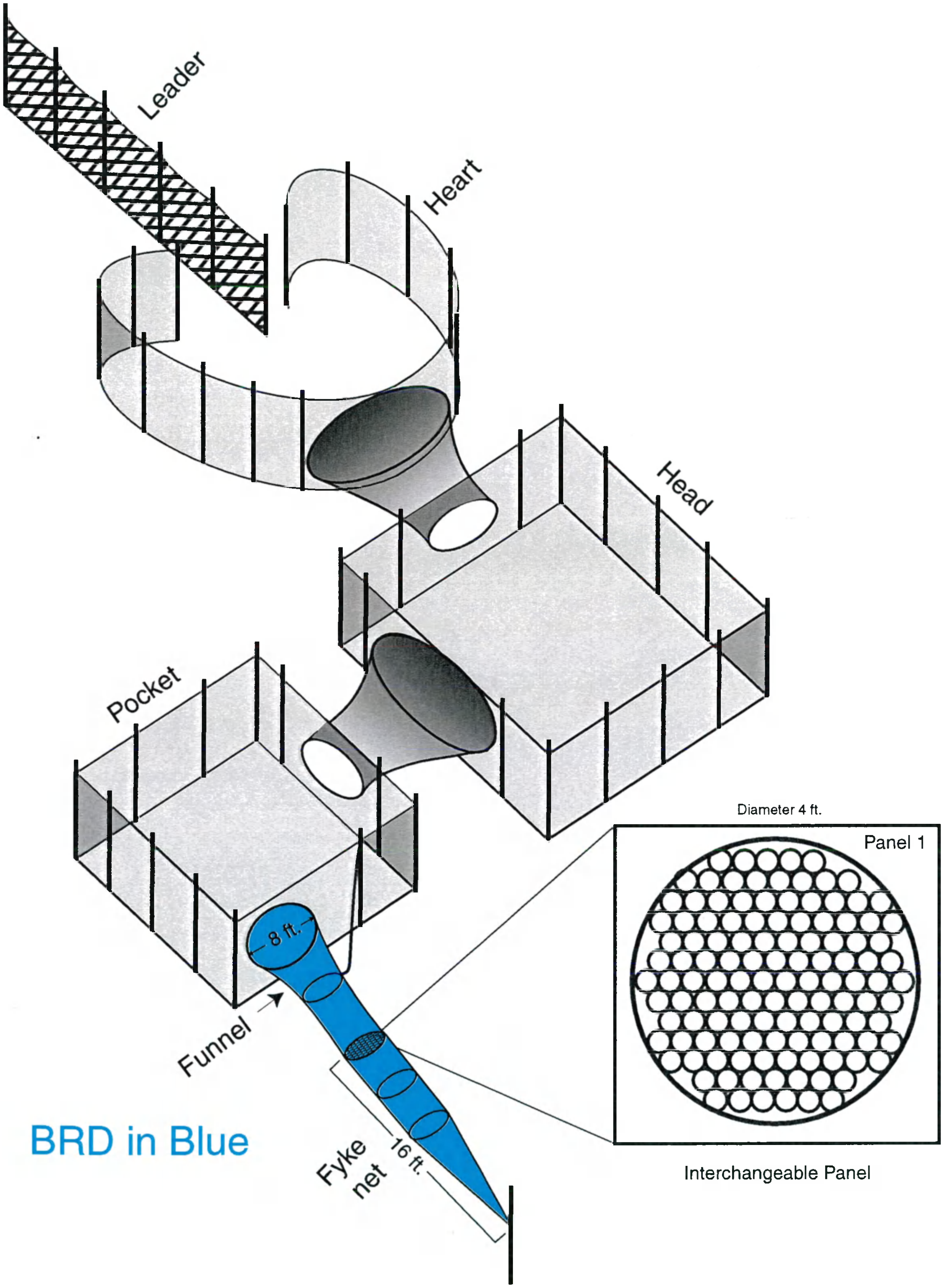
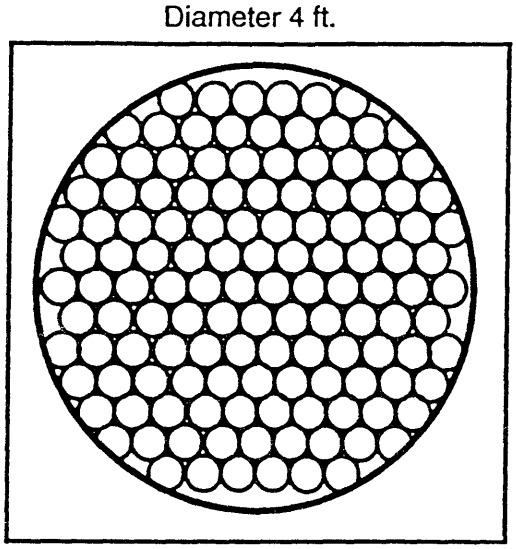

Leader
Heart
Head
Pocket
Funnel
8 ft.
Fyke net
16 ft.
BRD in Blue
Diameter 4 ft.
Panel 1
Interchangeable Panel

Figure 11. Illustrations of panels 1, 2, and 3 including dimensions.

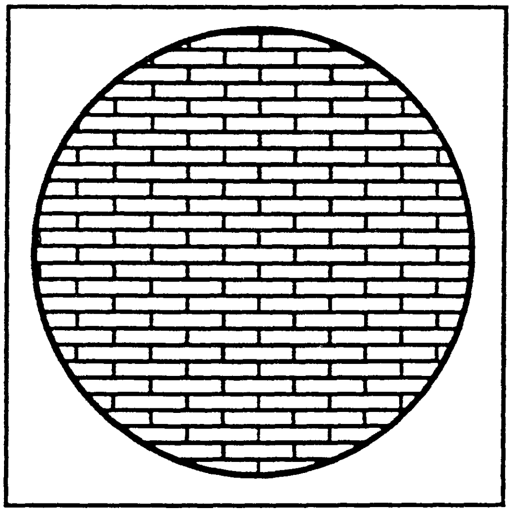
Panel 1

298
2" Diameter rings



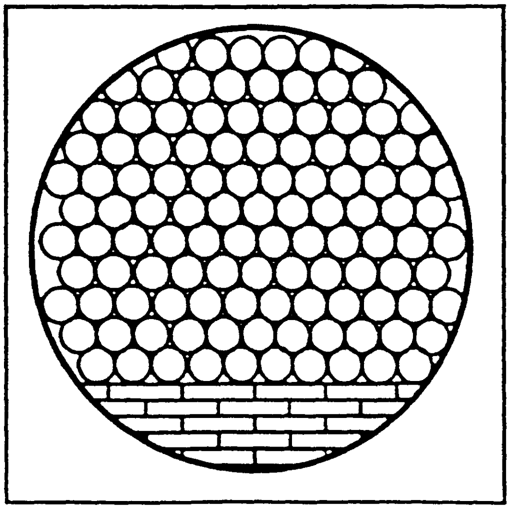
Panel 2

210
5 1/8" x 1 1/8" slots



Panel 3

266
2" Diameter rings
and 18
5 1/8" x 1 1/8" slots



Initially, there were to be three panels tested: one all rings, one all slots, and the third a combination of the two (Fig. 11). It was important, however, not only that the panels allowed a significant number of fishes to escape, but also that these fishes were culled to the desired sub-legal sizes. Testing of the original slot size soon led to concerns over the release of legal fishes of both species. In an effort to refine and perfect the slot's culling, its dimensions were altered twice during the study. These changes resulted in the creation of two additional panels. Four of the five panels were tested for their effectiveness. The larger of the slots was excluded from the final analysis due to poor culling performance. Testing this slot size, however, was beneficial because it dictated dimensional modifications that were incorporated into the later slot design.

Panel number 1 consisted of 298 50.8 mm (2") diameter rings (Fig. 11). Panel number 2 consisted of 210 130.18 x 28.58 mm (5 1/8" x1 1/8") rectangular slots designed to allow flounder to escape. Panel number 3 was a combination of these rings and slots consisting of 266 rings and 18 slots. Panel 4 was also a combination but its 14 slots measured 152.4 x 38.1 mm (6" x1.5"). These dimensions, ascertained from dead flounder, allowed far too many legal fishes to escape. Panel 4's poor culling performance led to the size refinements evident in panel 2. Panel 4 can be considered a pilot study leading to size modifications retained for the remainder of the study. Panel 5 was designed in order to test the effect of further size reductions to both rings and slots. It also reduced the number of rings and panels in order to examine the effect of such a reduction.

Figure 12. Illustration of panel 5 containing a reduced number of rings with decreased diameters and slots containing reduced dimensions. This panel was designed to improve length discrimination abilities for flounder and weakfish and to test the effect of number reduction.

Panel 5 (Fig. 12) consisted of 45 rings with a diameter of 47.63mm (1 7/8") and 17 slots that measured 130.18 x 23mm (5 1/8" x 29/32").

Procedural methods of harvest were unique to each fisherman but the handling of the bycatch release device (BRD) was uniform. In every case the device was isolated from the pocket before harvest. This prevented any forced escapement through the release device due to harvesting activity and guaranteed that any fish that exited the pocket did so passively. The location and test dates for data collection were chosen randomly each month. All fishes were measured and counted unless their numbers prevented timely handling, in which case at least 35% were recorded. Once the desired panel was in place, the tail of the fyke was secured to a drop chain that was connected to a pole driven approximately 10.67m (35') from the pound (Fig. 9). To set the BRD into operation the rope attaching the fyke to the pole was pulled taught. This pulled the funnel away from the pocket and provided the tension that supported the BRD's structure. Each time this procedure was performed the BRD was visually inspected to insure that it was properly functioning.

The location of the funnel relative to the pocket varied slightly between nets. In Mr. Bradley's net the BRD was placed on the deep-water side of the net; and in Mr. Dean's net it was on the down-river side. These locations were selected due to design differences inherent to the fisherman's pocket placement. Placement was consistent with respect to the BRD and its orientation to the funnel connecting the pocket to the pound. The location of the funnel's mouth intersected the bottom of the pocket so that the transition from pocket to funnel was seamless and even in both nets. All parties involved felt that this intersection was especially important in order to encourage flounder release. In an effort to maximize funneling, the BRD was placed as close as possible to the corner of the pocket in both nets as well. It was hoped that the pocket's sides would act like the wings that are commonly attached to fyke-nets and direct fishes towards the funnel's mouth (Fig. 9).

Statistical Analysis

A two-way loglinear model was run to compare catches between nets. This comparison examined the effect that net location and/or design had on harvest. Location and net construction were inseparable because the nets varied slightly in design with regard to pocket orientation. The analysis was based on the number of total fish (weakfish) captured by the pound-nets during the month of September. September was chosen because this analysis requires a minimum sample size, which could only be met by using weakfish catches during this month. The analysis did not distinguish as to whether the fishes used the BRD or not, so BRD location was not examined. The two nets were tested for variance based on their total weakfish fishing performance; the null hypothesis is important only with regard to testing the independence of location (net design) and the number of legal fish caught.

Pound-net catches were considered random subsets sampled from an unknown populations of fishes residing in the river at the time. Fishes escaping into the fyke were a subset of that subset. The statistical tests applicable in such a case are extremely restrictive. A jack–knife (Manley 1991) Monte Carlo like simulation was the most appropriate method of examining the significance of the BRD's' release efficiency. These simulations were used to test the null hypothesis that the BRD did not discriminate against fish released based upon size.

Jack-knife simulations examined panel 1, 2, and 3's release efficiency for weakfish and flounder. For each species-panel combination a distribution was generated by repeatedly randomly sub-sampling the number of fish that entered the fyke from all of the fish that entered the pound-net. Each time the pound's catch was sub-sampled a fraction that expressed the number of illegal fish out of the total number released into the fyke was produced. Repetitive sampling formed a distribution that expressed all the possible fractions (illegal/released total) and how often each would naturally have occur. Each distribution contained 10,000 of these randomly generated sub-samples. The probability of each ratio's occurrence was expressed to the nearest 0.0001. The null hypothesis tested was that the BRD had no influence on the size of fish released. Therefore, the fraction of illegal fishes released would be one that would naturally occur given the ratio of illegal to legal fish contained in the pound. Comparing the ratio of illegal to legal fish that occurred during the deployment of each panel to the ratios that would occur randomly if the panel did not discriminate against larger fish denotes how unusual the panel's ability to discriminate against legal fish was.

Jack-knife simulations contrasted panel performances as well: panel 1 to 2, 2 to 3, and 1 to 3. The null hypothesis for each comparison was that there was no difference in performance between panels. Evaluations of panel performances were based upon distributions formed by repeatedly randomly sub-sampling the number of fish that entered the fyke for one panel from the pound's catch during another panel's deployment. Simulations were repeated 10,000 times in order to generate probabilities of occurrence to 0.0001. Distributions expressed how often a ratio (illegal fish /released total) would naturally occur given a specific pound-net's catch composition. Panel performances were compared in part based upon the fraction of illegal fish each panel released.

Results

A two-way loglinear model was applied to September's weakfish data in order to examine differences in net function. Net construction varied slightly at each location; therefore, inconsistencies due to construction and/or location were inseparable. The model tested whether these differences in construction affected net performance with regard to the number of legal fish captured. If the nets performed differently without the BRD attached, this variability may have affected the BRD's function at each location.

The model reveals that fish were not equally distributed over the variable location (construction) or the number of legal fish taken (Table 1). This outcome was expected due to normal catch variability. Most importantly, the variables location (construction) and number of legal fish captured showed no interaction; i.e., they were independent of one another. If BRD release efficiencies, based upon legal to illegal fish ratio differences, varied between nets, it was not due to inherent gear efficiency differences caused by minor alterations in net construction. Data collected from either site can be combined without fear of introducing any uncontrolled variables.

Maximum-Likelihood Analysis – of –Variance

Source	DF	Chi-Square	Prob
Location	1	87.82	0.0000
Legal	1	123.41	0.0000
Location *Legal	1	0.09	0.7643

(Table 1)

Table 2 below contains the raw data upon which all the remaining statistics are based.

Species	**Panel**	**Fish Total**	**Legal Total**	**Illegal Total**	**Fyke Total**	**Illegal Fyke**	**Legal Fyke**	**% Illegal in Fyke**	**% Legal in Fyke**	**Largest Fish Fyke (mm)**
Weakfish	1	550	321	229	218	107	111	47	35	360
(legal = 305mm)	2	1557	917	640	209	152	57	24	6	355
	3	210	148	62	122	45	77	73	52	355
	5	10	4	6	7	6	1	100	25	310
Flounder	1	499	46	453	77	77	0	17	0	205
(legal = 355mm)	2	437	39	398	387	364	23	91	59	385
	3	138	23	115	109	100	9	86	39	407
	5	62	14	48	24	24	0	50	0	330

(Table 2)

PANEL 1- 3

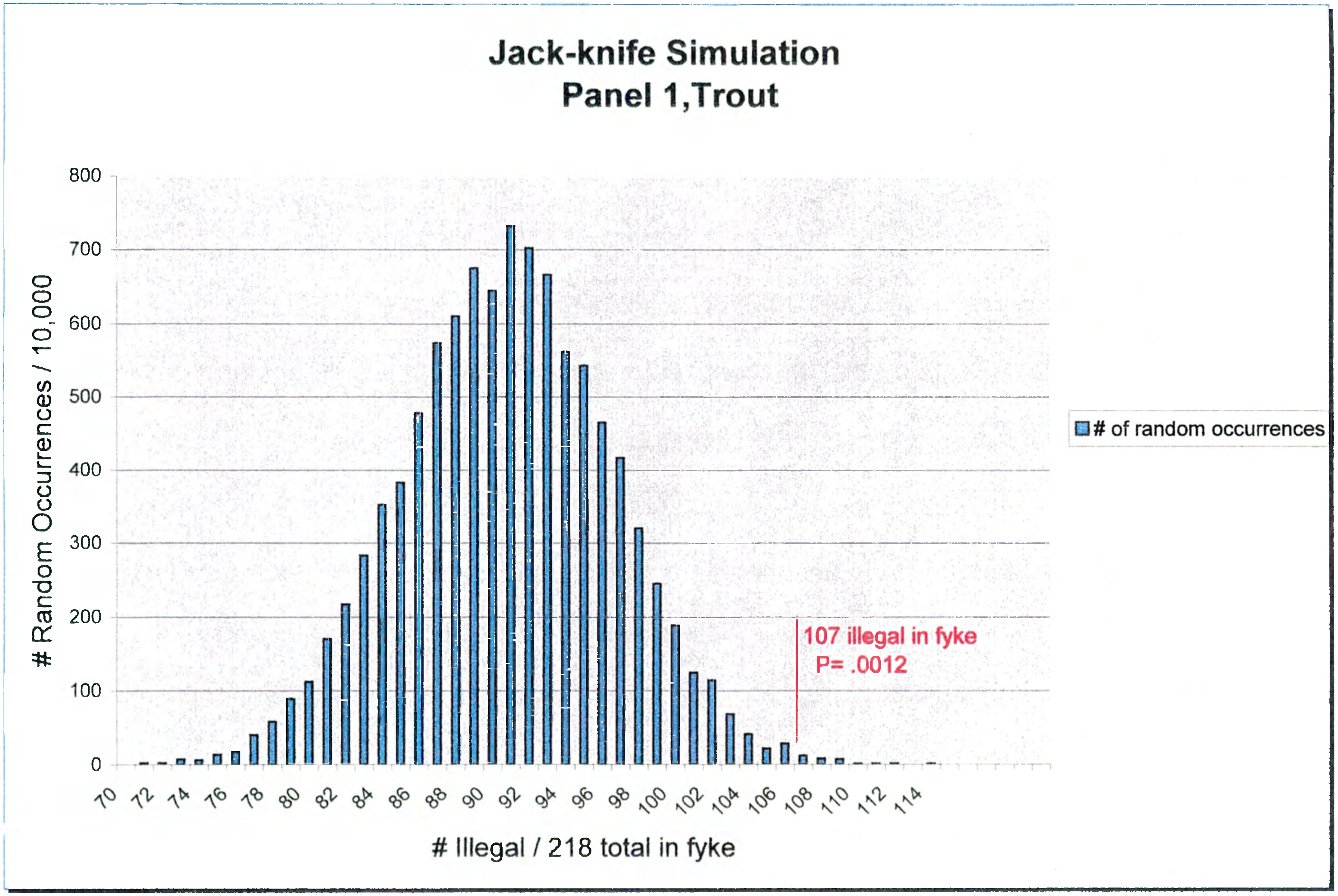
Weakfish:

Simulations revealed that panel 1 discriminated against the release of larger weakfish. Out of the 218 weakfish that were released, 107 were sub-legal. The probability of this outcome randomly occurring is 0.0012 (Graph 1). Table 2 also indicates that the largest weakfish recorded using panel 1 was 360 mm. This fish was 55 mm larger than our culling release goal of 305 mm, indicating that the ring's 50.8 mm diameter was too large to cull only sub-legal fishes. Panel 2 released 152 sub-legal weakfish out of 209 total. The probability of this naturally occurring is < 0.0001 (Graph 2). Panel 2 also allowed for the release of some legal fish. The largest weakfish released was 350 mm, 45 mm greater than the legal limit. Panel 3 allowed 45 illegal fish to escape out of 122 total. The largest weakfish escaping through panel 3 was also 350 mm. The probability of this occurring was 0.0022 (Graph 3). All tested panels significantly discriminated against the release of larger legal weakfish. However, the release of legal fish indicated that culling performance lacked precision.

Flounder:

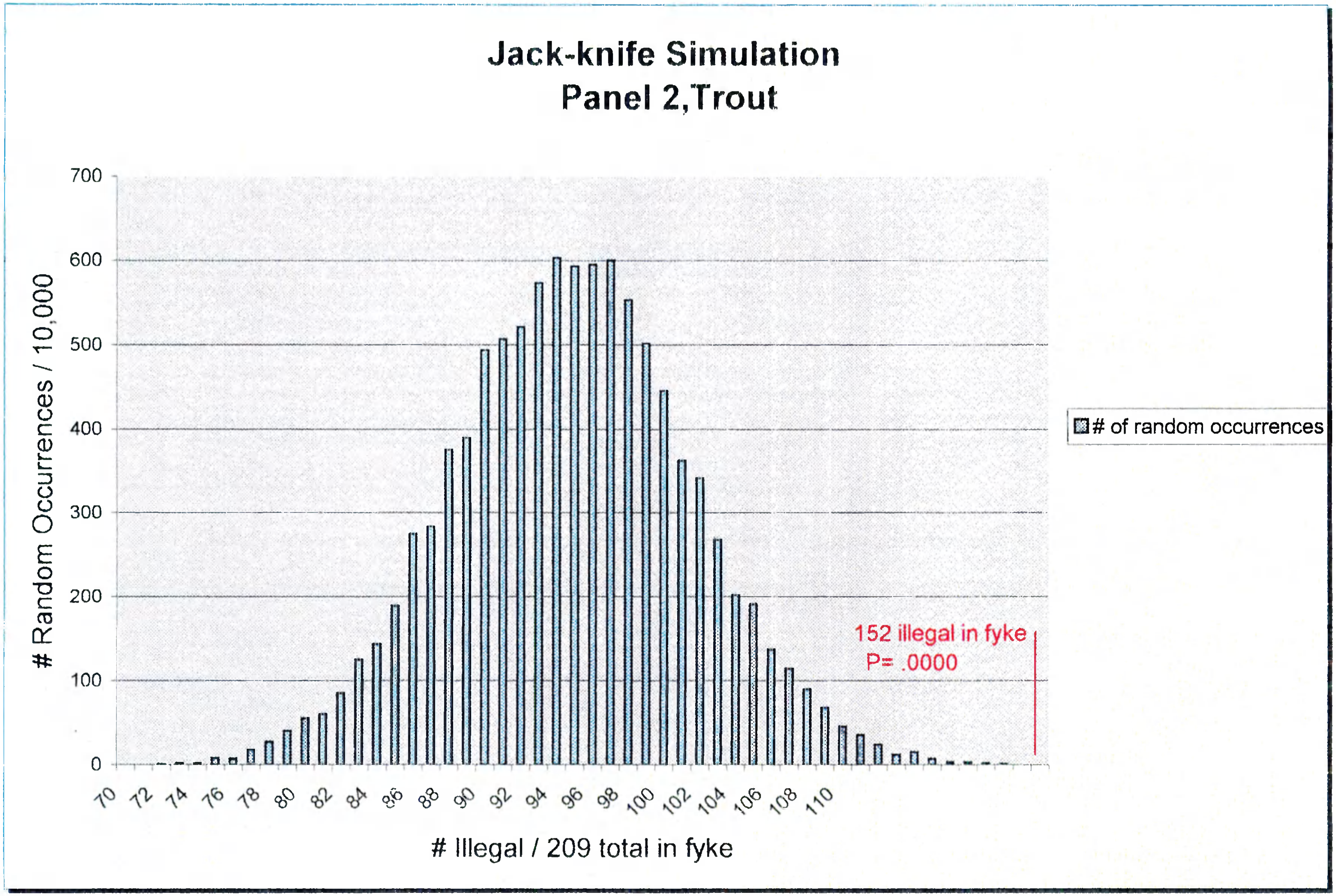
Analysis of flounder data followed the same procedure as applied to weakfish. Panel 1 allowed 77 illegal fish to escape, the largest of which was 205 mm. The probability of this occurring is < 0.0001 (Graph 4). Panel 2's slotted design increased the release of illegal flounder, but it also allowed for the release of some legal fish. The largest flounder released was 385 mm, 35 mm greater than

Graph 1-6. Jack-knife Simulations testing null hypothesis that the panels did not discriminate against legal fishes, presented case by case. Ratio of illegal to legal fish released into fyke and probability of this ratios occurrence given to the nearest 0.0001 illustrate significance.



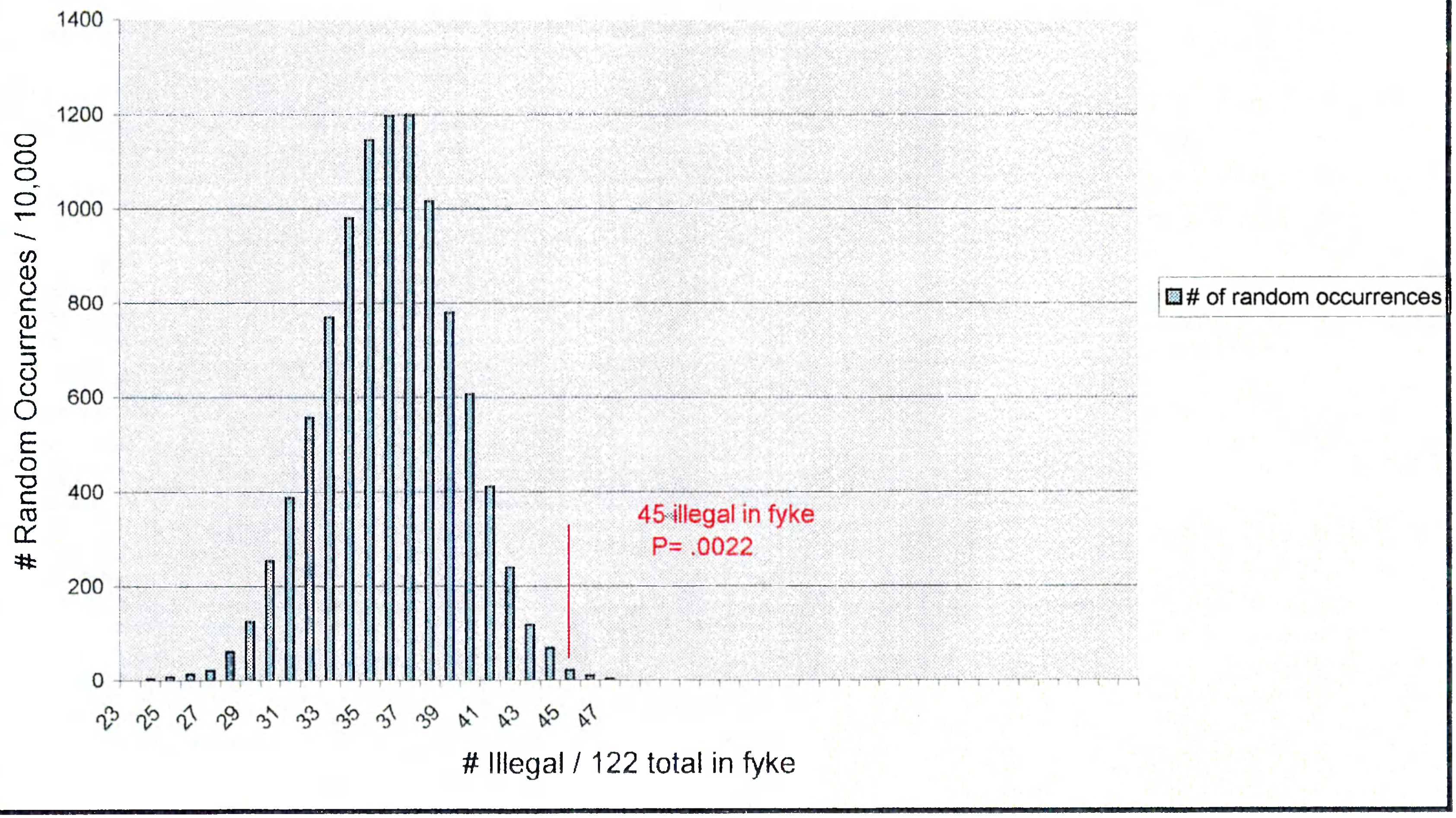
Jack-knife Simulation
Panel 1,Trout

Graph 1

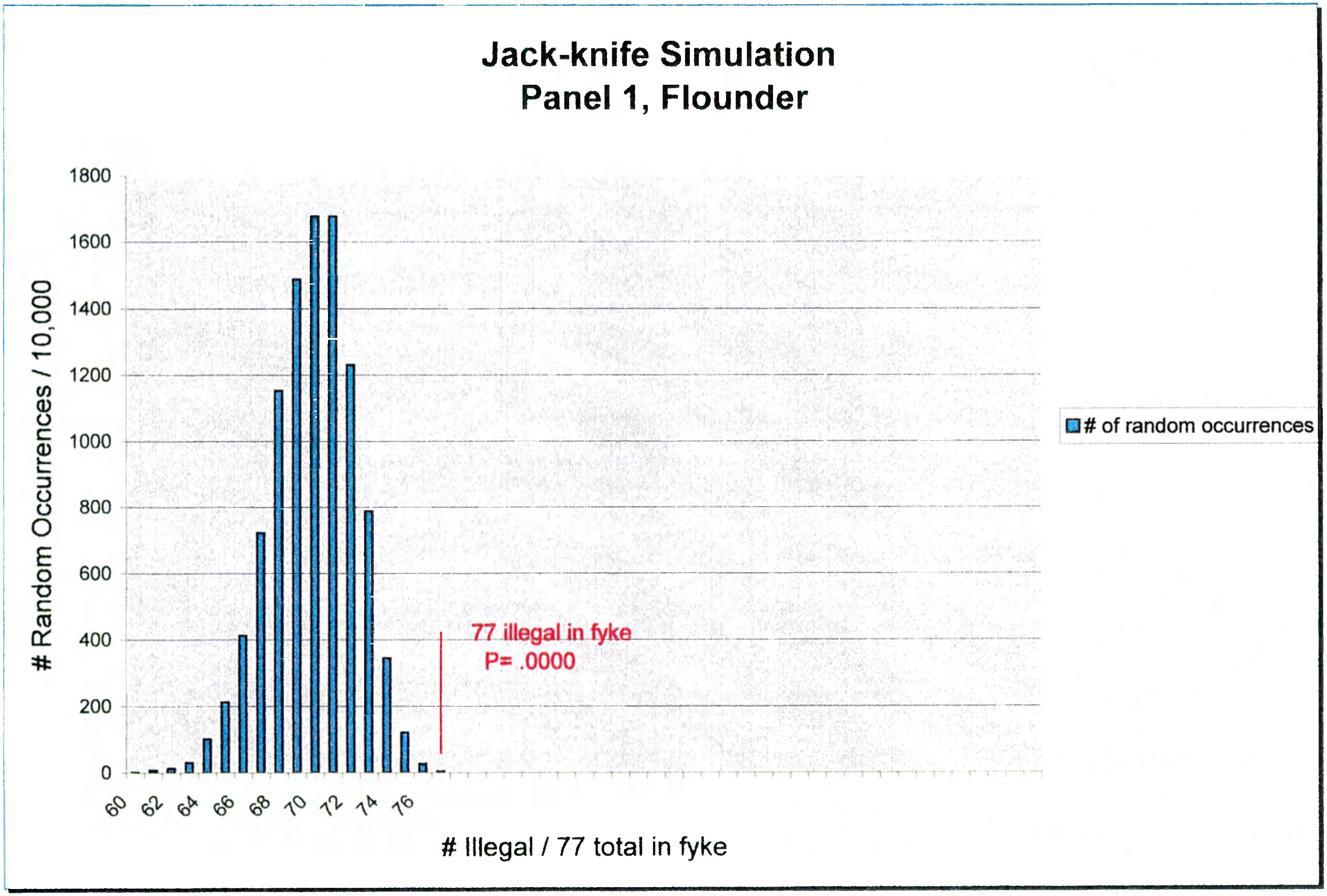

Jack-knife Simulation
Panel 2,Trout
Random Occurrences / 10,000
700
600
500
400
300
200
100
0
70
72
74
76
78
80
82
84
86
88
90
92
94
96
98
100
102
104
106
108
110
Illegal / 209 total in fyke
▨ # of random occurrences
152 illegal in fyke
P= .0000

Graph 2

Jack-knife Simulation
Panel 3,Trout

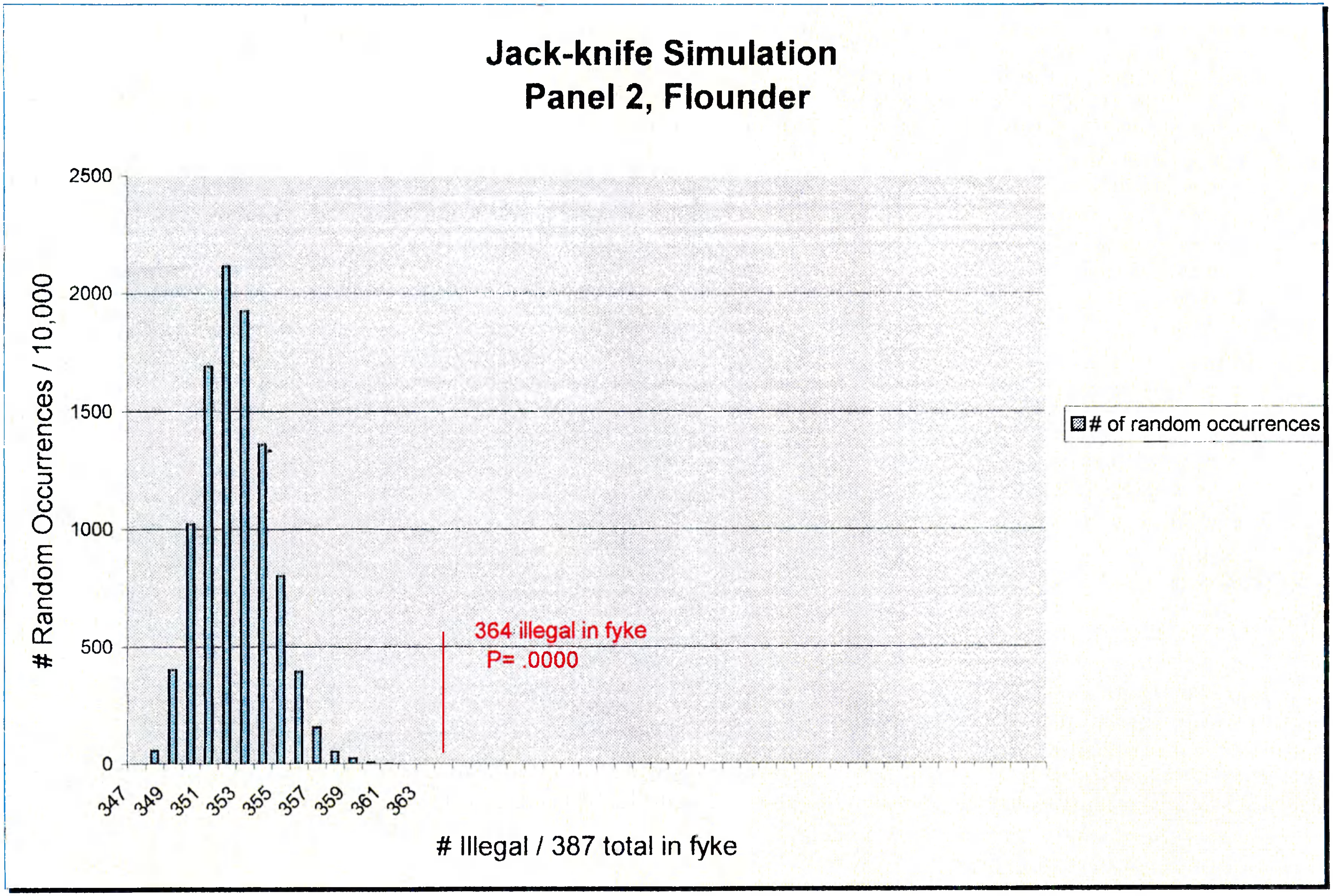


Graph 3

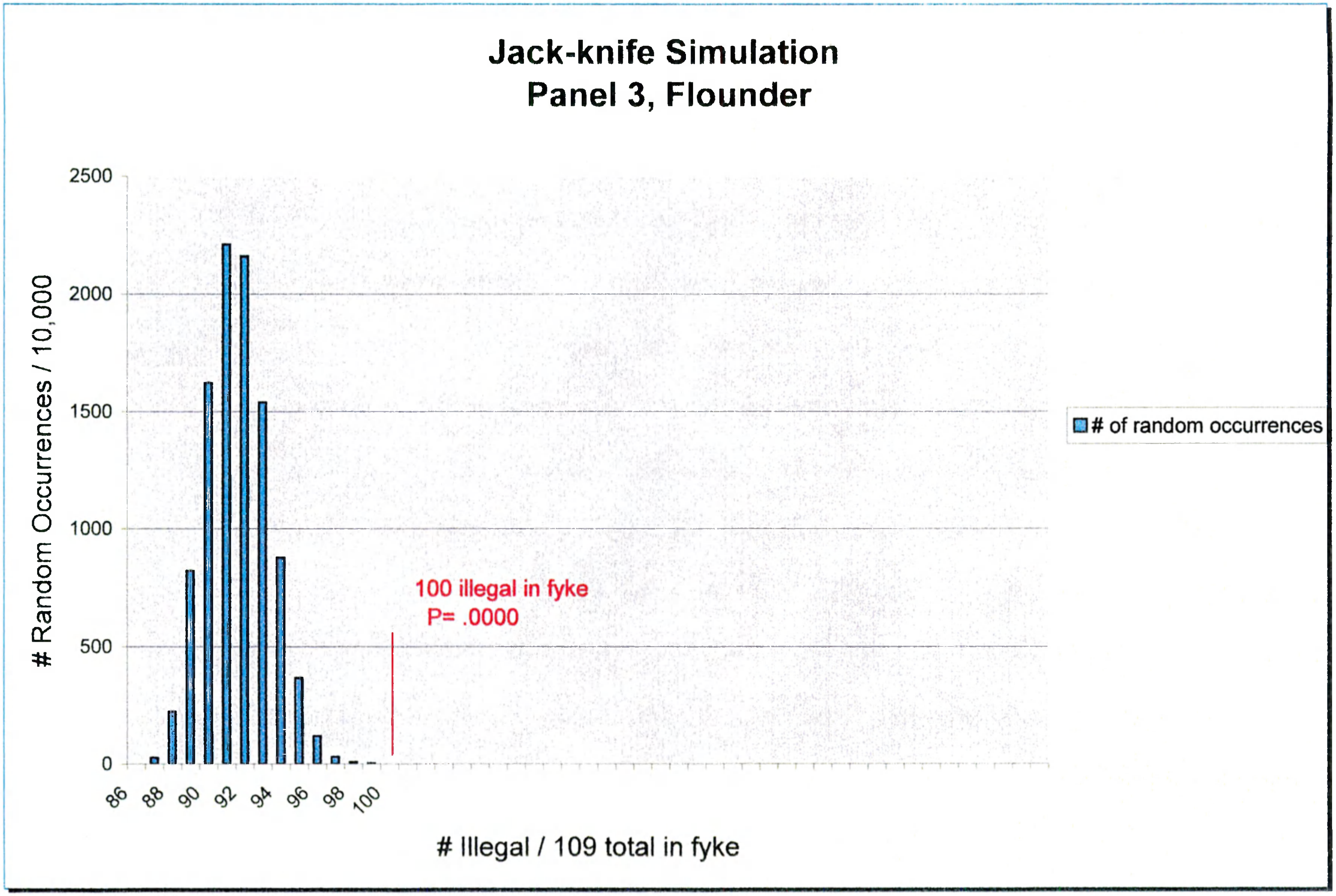


Jack-knife Simulation
Panel 1, Flounder

Graph 4


Jack-knife Simulation
Panel 2, Flounder
Random Occurrences / 10,000
2500
2000
1500
1000
500
0
347
349
351
353
355
357
359
361
363
364 illegal in fyke
P= .0000
# Illegal / 387 total in fyke
▨ # of random occurrences

Graph 5


Jack-knife Simulation
Panel 3, Flounder
Random Occurrences / 10,000
2500
2000
1500
1000
500
0
86
88
90
92
94
96
98
100
Illegal / 109 total in fyke
100 illegal in fyke
P= .0000
# of random occurrences

Graph 6

the minimum retention size. The probability of Panel 2's outcome was also less than 0.0001 (Graph 5). Panel 3 had a similarly low $P < 0.0001$ (Graph 6), but it also allowed for the release of some legal fish. It culled flounder to 407 mm, 52 mm above the minimum size. Again, all three panels significantly discriminated against legal fish but culling accuracy lacked precision.

Panel 4

Panel 4 was a combination of rings and slots like panel three, but its 14 slots measured 152.4 x 38.1 mm (6" x1.5"). These dimensions were determined using dead flounder as models and allowed far too many legal weakfish and flounder to escape. Panel 4's poor culling performance led to the slot size refinements evident in panel's 2 and 3. Panel 4 was discontinued due to its poor culling performance before sufficient data was complied for valid statistically examination. Samples attained while using this panel were not a complete loss, however, because they provided catch data that was used in the two-way loglinear model.

Panel 5

Panel 5's design incorporated rings and slots of reduced dimensions in order to improve the culling performance of both the rings and the slots. The total number of openings was also decreased in order to determine if this would affect release efficiency. Unfortunately, the panel was not tested until late in the season when the number of illegal fishes available in the area was insufficient for conclusive data. Panel 5's raw data also support the hypothesis that the number of openings can be diminished without detrimentally affecting the BRD's release efficiency.

Panel Comparisons

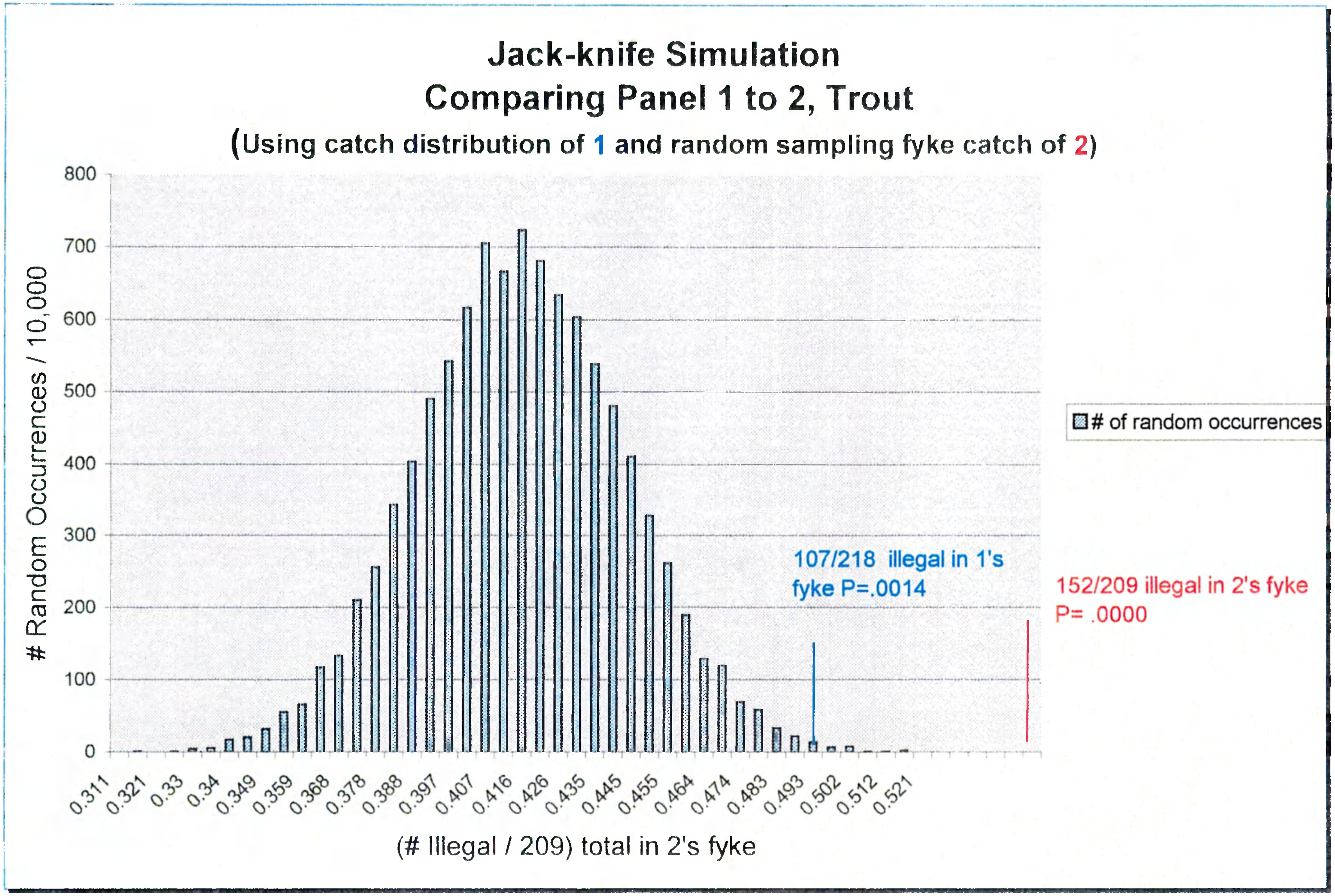
Weakfish

Comparisons between panel 1(all rings) and 2 (all slots) revealed that both panels released a greater number of illegal fish than legal ones. Panel 1's performance had a probability of occurrence of 0.002, an order of magnitude greater than panel 2's of < 0.0001. Both panels significantly selected against larger fish though panel 2 selected more strongly; i.e., it released fewer legal fish. This premise was supported by a comparison of panel 2's release ratio of .73 illegal to legal to panel 1's 0.49 (Graph 7). Panel 1's sub-legal release ratio was greater than panel 3's (0.37). This outcome was unexpected based upon panel designs alone. Both panels enclosed the same 2" rings and panel 3 even contained slots that discriminated aggressively against legal fish (Graph 8). This biased outcome was likely due to the deployment times of each panel and not due to an inherent culling performance difference. Panel 3 was randomly selected for deployment toward the end of the summer when the mean size of weakfish was greater. The Potomac River Pound-net Survey clearly showed these trends in 1996 and 1997 (Austin et al, 1996 and 1997). Temporal changes in mean fish size, combined with the 2" ring's inability to cull correctly, skewed the release ratio for panel 3. Panel 1's probability of occurrence was 0.01 and its release ratio shows its discrimination against legal fishes. Panel 3's performance was so affected by its release of legal fish (355 mm> >305 mm) that its release ratio appears to suggest that it selected against illegal fish with a probability of 0.04. This probability may be insignificant, however, because panel 3's selectivity was no longer significant for or against legal fish (Graph 9) when panel 2 and 3 were compared. Panel 2's .73 release ratio easily outperforms panel 3's (0.37). Panel 2 selected strongly against legal fish and had a probability of occurrence of < 0.0001.

Flounder

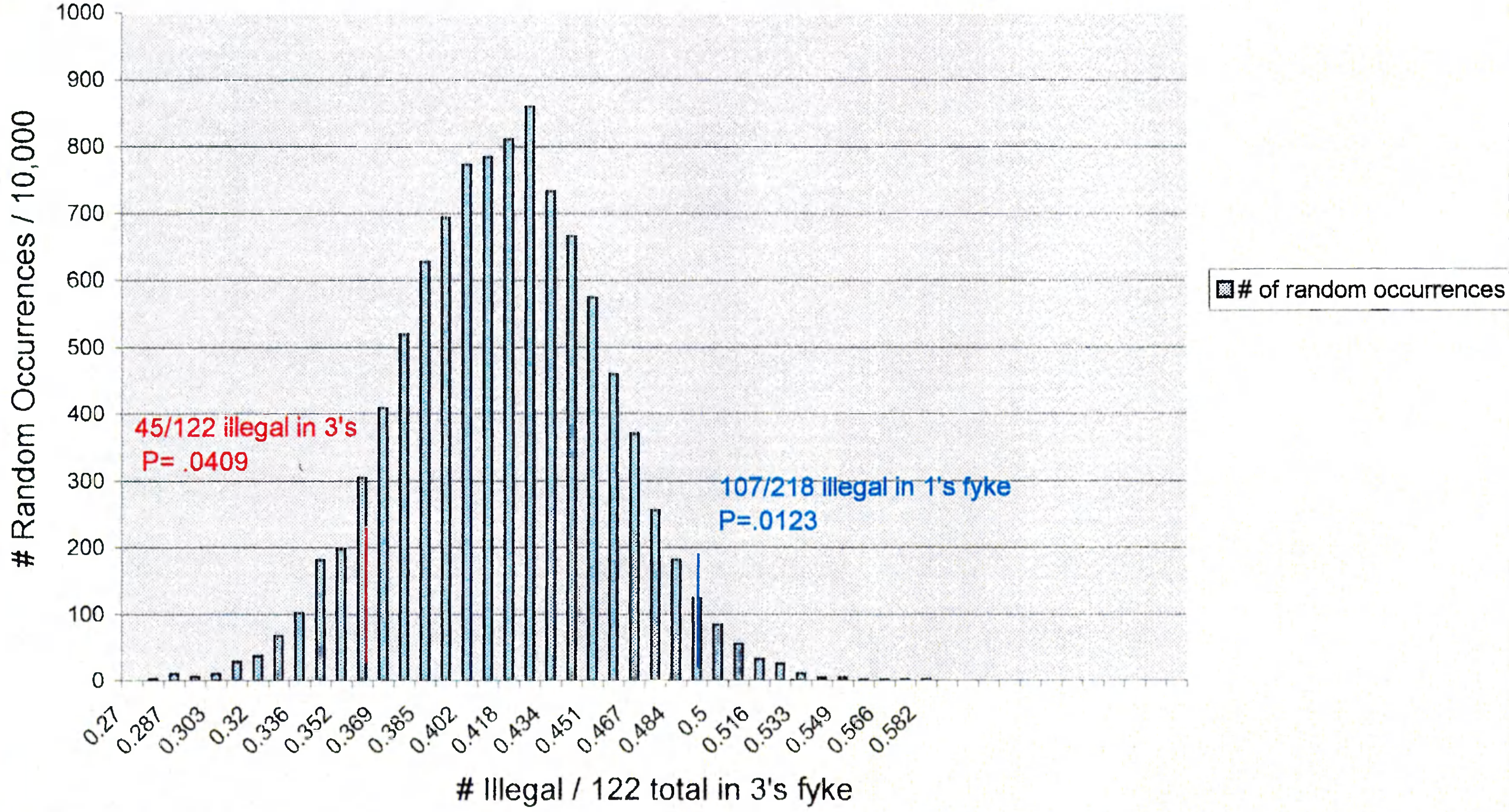
Panel 1 released 17%, panel 2 released 91%, and panel 3 released 86% of the illegal flounder that entered the pocket. Panel 2 and 3 released some legal fish, however, and this negatively influenced their release ratios. Panel 1's release ratio of 1.0 shows that it released no legal fish; the probability of this occurrence was < 0.0001. These figures make panel 1 appear to be more efficient at flounder release than panel 2 which was specifically designed for that purpose. Only when one looks at the size of flounder released, does the picture become clear. Panel 1 released no flounder over 205 mm. Panel 2's released 23 legal flounder out of 387 fish. The release of these legal fish reduced its release ratio to 0.91 but its ability to select against legal fish remained strong. The probability of achieving this ratio of release was < 0.0001(Graph 10). Panel 1 initially appeared to out perform panel 3 due to panel 3's release of 9 legal fish out of the total of 109 (Graph 11). This release ratio approached the pound-net's catch ratio and a probability of occurrence of 0.14 resulted. Panel 2 and panel 3 (Graph 12) performed similarly based solely upon flounder catches. Panel 2's release ratio was 0.86 and panel 3's was 0.91. Neither panel discriminated against legal fish at a significantly different level. This suggests that the number of slots was not as important as the placement of those slots because panel three only contained 18 slots across its bottom compared to panel 2's 210 slots that are evenly distributed.

Graph 7-12. Jack-knife Simulations comparing panel's performance and testing null hypothesis that panels did not differ in their abilities to discriminate against legal fishes, presented case by case. Ratios of illegal to legal fish released into fyke and probability of these ratios occurrence given to the nearest 0.0001 illustrate panel's performances and significant differences.

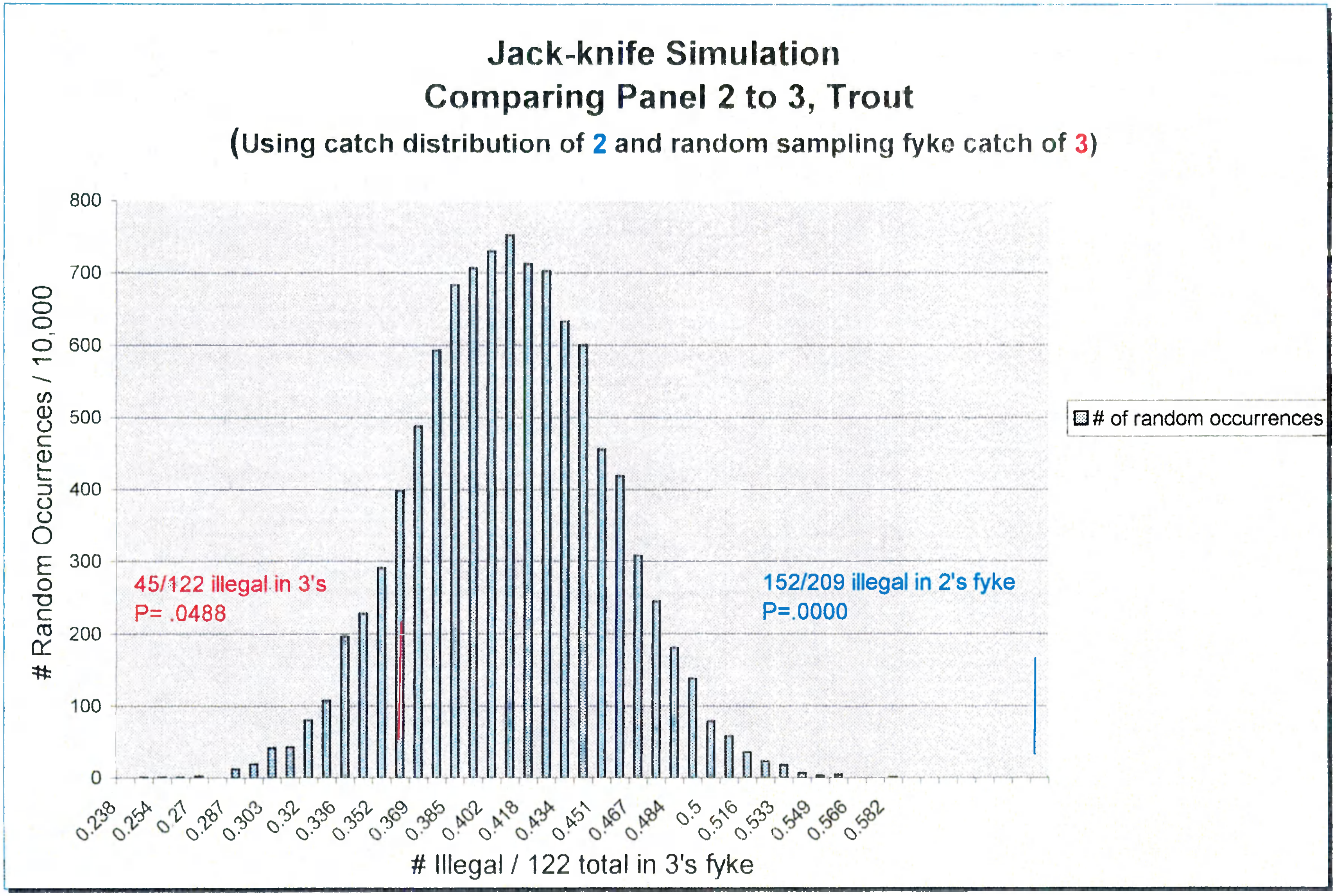

Jack-knife Simulation
Comparing Panel 1 to 2, Trout
(Using catch distribution of 1 and random sampling fyke catch of 2)
Random Occurrences / 10,000
800
700
600
500
400
300
200
100
0
0.311
0.321
0.33
0.34
0.349
0.359
0.368
0.378
0.388
0.397
0.407
0.416
0.426
0.435
0.445
0.455
0.464
0.474
0.483
0.493
0.502
0.512
0.521
(# Illegal / 209) total in 2's fyke
▨ # of random occurrences
107/218 illegal in 1's fyke P=.0014
152/209 illegal in 2's fyke P= .0000

Graph 7

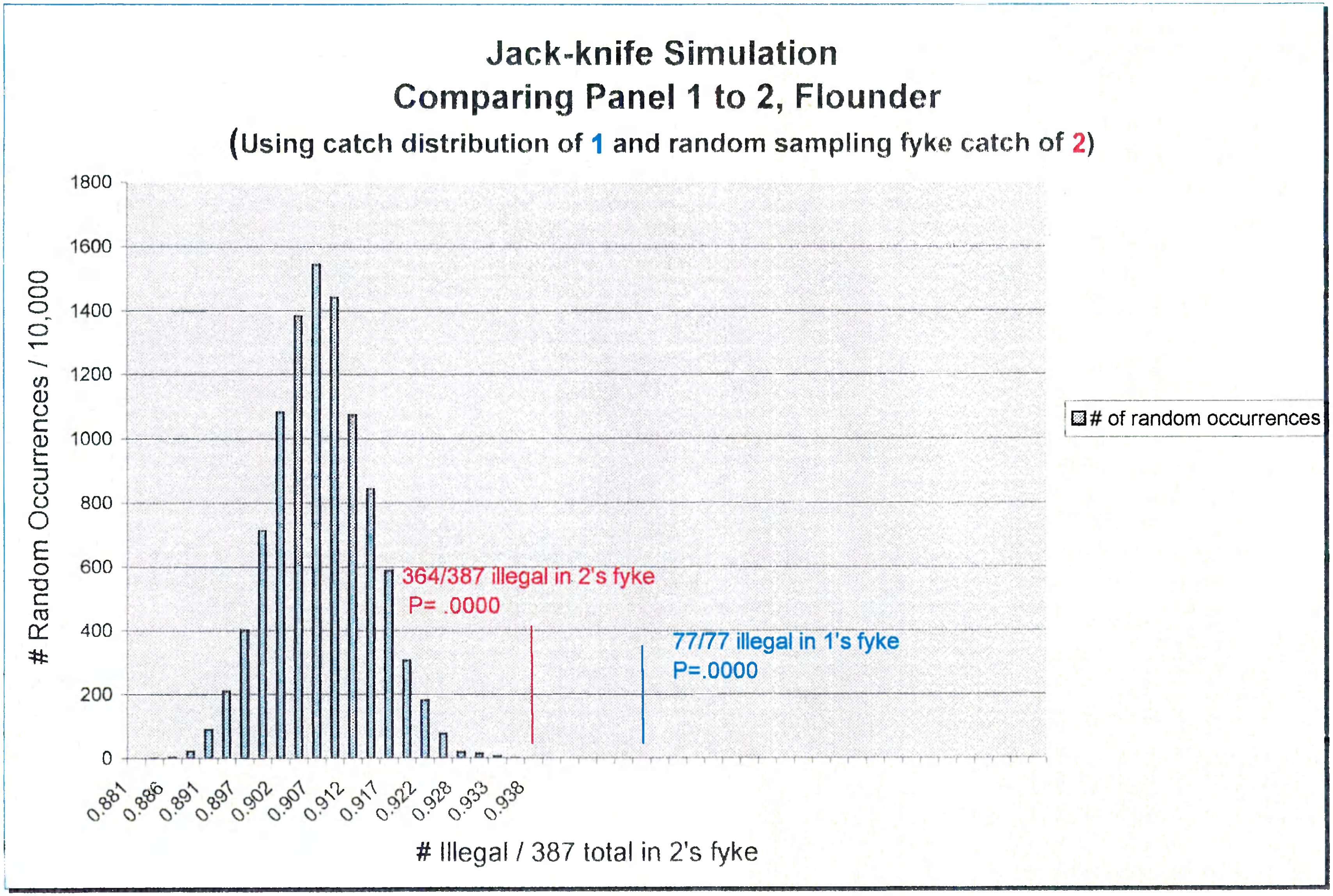
Jack-knife Simulation
Comparing Panel 1 to 3, Trout
(Using catch distribution of 1 and random sampling fyke catch of 3)



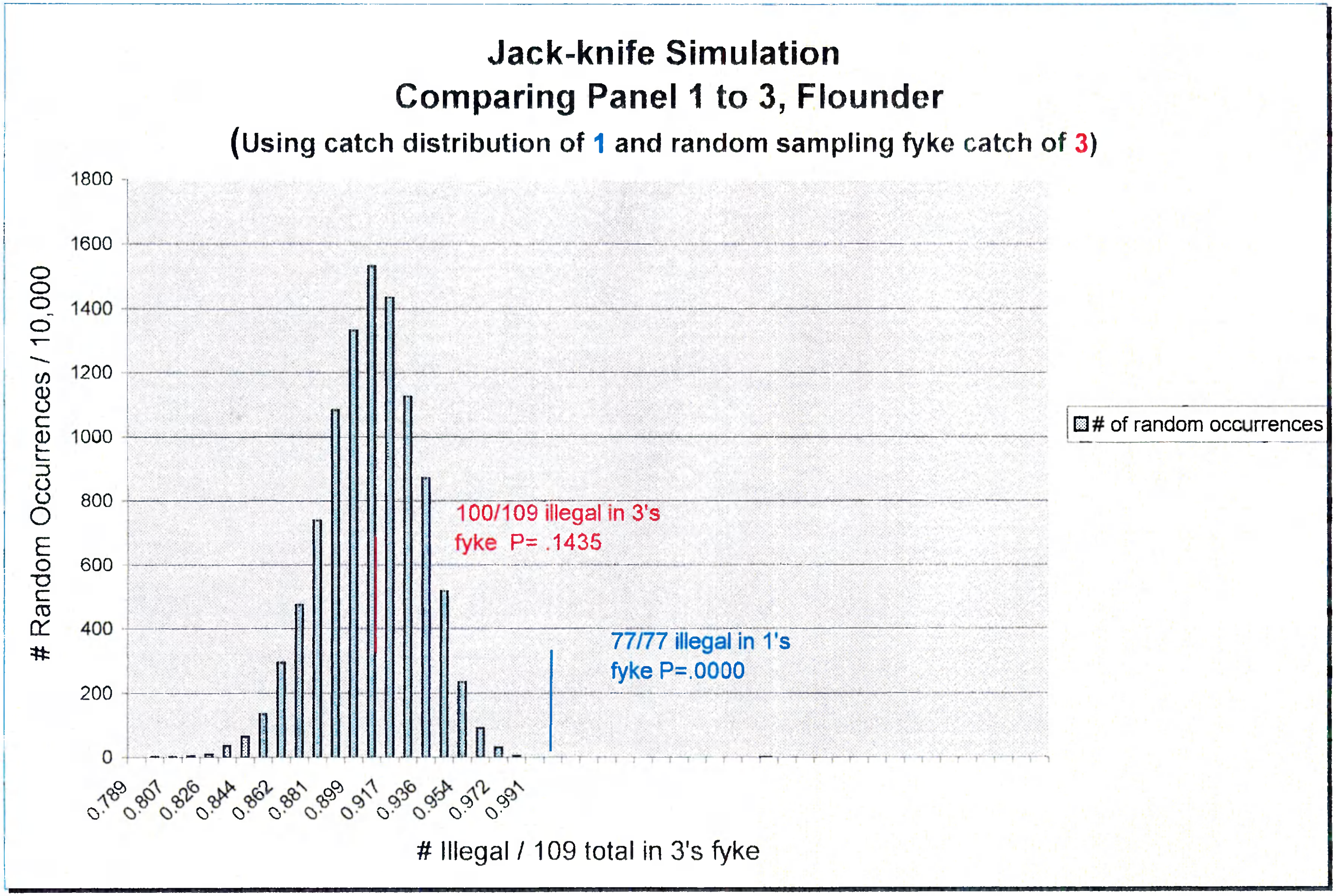
Graph 8


Jack-knife Simulation
Comparing Panel 2 to 3, Trout
(Using catch distribution of 2 and random sampling fyke catch of 3)

Graph 9

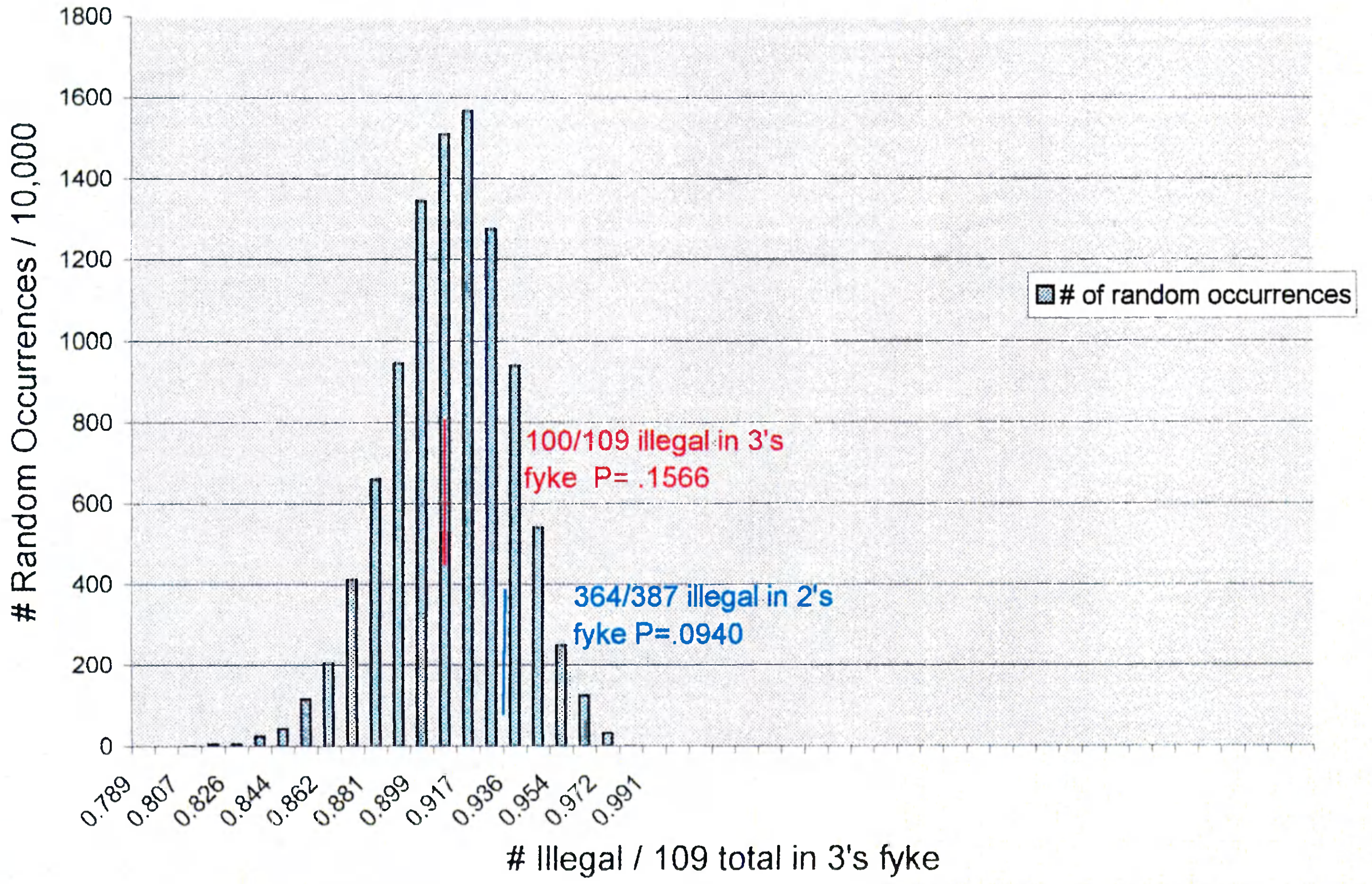

Jack-knife Simulation
Comparing Panel 1 to 2, Flounder
(Using catch distribution of 1 and random sampling fyke catch of 2)

Graph 10


Jack-knife Simulation
Comparing Panel 1 to 3, Flounder
(Using catch distribution of 1 and random sampling fyke catch of 3)
Random Occurrences / 10,000
1800
1600
1400
1200
1000
800
600
400
200
0
0.789
0.807
0.826
0.844
0.862
0.881
0.899
0.917
0.936
0.954
0.972
0.991
Illegal / 109 total in 3's fyke
100/109 illegal in 3's
fyke P= .1435
77/77 illegal in 1's
fyke P=.0000
▨ # of random occurrences

Graph 11

Jack-knifeSimulation
Comparing Panel 2 to 3, Flounder
(Using catch distribution of 2 and random sampling fyke catch of 3)



Graph 12

Discussion

The BRD sponsored by the Potomac River Fisheries Commission (PRFC) in 1998 exhibited rates of passive bycatch release which far exceeded ASMFC's juvenile mortality reduction goals of 33% for weakfish when panel 3 was used. Sub-legal weakfish release greatly surpassed that achieved by VMRC (Boyd 1997) and NCDMF (Gearhart 1998). In addition to the sub-legal weakfish released while using panel 3, an extremely large number of sub-legal flounder were also allowed to escape. Because there is no possession tolerance for undersized flounder this release aids fishermen by reducing culling effort. In a flounder nursery like the Chesapeake Bay pound-net BRD implementation could provide one of the most cost efficient methods of reducing juvenile flounder mortality.

Several reasons may be cited for the lower weakfish release percentages attained using other methods of release. In 1996 Boyd (VMRC) forced dead weakfish through different meshes in order to determine appropriate sizes for his BRD panels. This method is inconsistent with weakfish behavior and may be the first reason for the BRD's poor release performance. Secondly, the release panel was placed in the middle of the pocket's wall, many feet off the bottom. This placement reduced the BRD's availability to the weakfish, which tend to school near the net's bottom, and poor interaction resulted. The low 4.2 % release (< 254 mm) of illegal weakfish illustrated these weaknesses. NCDMF attained a greater release percentage by simply enlarging the reduction device's area and placing the panel at the intersection of the pocket's wall and bottom. In addition to achieving a greater release of sub-legal weakfish, than either of these other methods, the PRFC's combination panel offers multi-species' benefits that can only be achieved if release openings of different shapes are incorporated into the BRD's mechanism. This attribute is of special interest to managers who must reduce the negative impacts of such gears operating in multi-species fisheries or in areas that contain nursery grounds. Greater release percentages may also result if fishes actively seek release during harvest procedures. All active release was prevented due to our harvest methods during this project. Release percentages may also benefit from the removal of the fyke from the BRD because gear saturation would no longer be a concern. The passive nature of the PRFC's BRD enhances the health of released fishes, reduces the fishermen's effort, and may ultimately lead to increases in yield–per-recruit through increased juvenile survival.

The best sub-legal weakfish release ratio occurred using panel 3 (rings and slots). Release efficiency cannot be based on release ratios (illegal: legal fish) alone, however, because these ratios do not convey information on the number of illegal fishes that were not released or the device's culling accuracy or precision. All these pieces of information are necessary in order to understand a mechanism's performance. Species-specific anatomical variability will also prevent the creation of a mechanism that would allow all sub-legal fishes to escape and yet prevent the release of all legal ones.

Though panel 3 achieved the highest percentage of illegal weakfish released, it also allowed for the largest release of legal fish. Comparisons between panel 1 (rings) and panel 2 (slots) show that more legal weakfish escaped through the rings than the slots. These differences in release efficiency may be due in part to weakfish behavior (Higgens and Pearson 1928). Higgins and Pearson (1928) found that a small increase in mesh size was inadequate to allow for increased escapement of undersized weakfish. Although fish up to 152.4 mm (6") could be manually forced through 57.2 mm (2 .25") mesh, live fish chose not to exit a pound constructed of the same mesh in the field. A clear weakfish preference for ring use is evident when all panel performances are compared. Panel 1 (max. size weakfish released =360 mm), 2 (355 mm) and 3 (355 mm) allowed weakfish of roughly the same size to escape but the release efficiency percentages differed. Panel 2 (slots) allowed 24 % of the illegal fish to escape and only 6% of the legal fish. Panel 1 (rings) released 47 % of the sub-legal fish and 35 % of the legal fish and panel 3 (combination) released 73% of the sub-legal fish and 52% of the legal ones. Large numbers of weakfish that were small enough to use the slots elected not to. Slots were not as efficient as rings at affecting the release of weakfish and the controlling factor was not due to the slot's restrictive size but, instead, due too the fish's behavior.

Panel 1 appeared to be the most efficient panel for flounder release based solely on the release ratios; but this was a function of the fact panel 1 only released flounder less than 205 mm, a full 155 mm less than the legal limit. The effect this severe restriction had on sub-legal flounder release is clearly evidenced by the percent of illegal fishes that used each panel. Though panel 1 released only 17% of all the illegal flounder it encountered this release represented 49% of all the flounder below 205 mm. The slots tested in panel 2 increased the efficiency of flat fish release without increasing the escape of legal weakfish. The slots increased the release percentages of sub-legal and legal flounder. The mouth of the Potomac River at times contains large numbers of sub-legal flounder and relatively few legal fish. Therefore, large augmentations in the percentage of legal flounder released may actually only represent a few fish. Release of legal flounder occurred through the slots in panel 3 as well. Panel 5's catches contained 62 flounder. The panel released 50% of the illegal fish it encountered with the largest being 330 mm, well under the legal limit of 355 mm. These results suggest that legal flounder release may be curtailed without reducing the percentage of illegal flounder released below the 33%.

It is expected that if the BRD tested by PRFC in 1998 is applied to the Chesapeake Bay's pound-net fisheries, it could reduce bycatch mortality of undersized weakfish and flounder by greater than 33%. Such reductions would bring the Potomac's and the Chesapeake's pound-net fisheries into full compliance with ASMFC's weakfish mortality reduction goal as set forth in

Amendment #2 to the Fishery Management Plan for Weakfish and greatly reduce the mortality of immature flounder, a management objective set forth in Amendment #12 to the Summer Flounder Fishery Management Plan. Already, this experiment has enhanced cooperation and mutual respect between the Potomac River's pound-netters and the Potomac River Fisheries Commission. Reductions in juvenile weakfish mortality may be sufficient to allow for the reopening of a year round harvest season, a step that would provide positive reinforcement and encourage future cooperative conservation efforts. Funds have been made available in 1999 to further develop an easily applicable inexpensive pound-net BRD based upon 1998's design. If applied Bay-wide the resulting reductions in juvenile flounder and weakfish mortality could significantly increase the populations of both species and advance the likelihood of both stocks' sustainability.

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