Results of a Bibliographic Search Comparing the Effects of Circle and "J" Hooks

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Falterman, Brett and John Graves. 2002. A Preliminary Comparison of the Relative Mortality and Hooking Efficiency of Circle and Straight Shank ("J") Hooks Used in the Pelagic Longline Industry. Pages 80–87 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ The fishing characteristics of circle books and straight shank or "J" hooks were investigated in the pelagic longline fishery during two successive trips, In one trip, circle hooks and J-hooks of comparable size were alternated along the length of the longline on six sets of approximately 400 live-baited hooks each, allowing a preliminary comparison of catch per unit effort (CPUE), hooking location, and mortality between the two hook types. On a previous trip, records of hooking location and mortality were obtained for J-hooks on nine additional longline sets. Yellowfin tuna *Thunnus albacores* accounted for 60% of the catch; the remainder was composed of 15 other species, none of which was represented by more than eight individuals. There was higher CPUE for all species combined, using circle hooks (5.05 fish/ 100 hooks) as compared with using "J" hooks (2.28 fish/100 hooks). Similar results were observed with the catch of the target species (yellowfin tuna), for which CPUE was approximately 2.5 times higher with circle hooks (3.33 tuna/ 100 hooks) as compared with J-hooks. Circle hooks also resulted in a lower mortality for all species (31 % versus 42%) and for the target species (21 % versus 39%). For all species, 95% of the fish taken on circle hooks were hooked in the jaw. Hooking location varied by species, but for all species combined, circle hooks consistently had a higher frequency of jaw hooking and a lower frequency of gut hooking than J-hooks. These preliminary results suggest that use of circle hooks in the pelagic longline fishery targeting yellowfin tuna may not only increase CPUE and survival of this species but also improve the survival of incidental catch and bycatch.

Falterman and Graves. 2002.

- There was higher CPUE for all species combined, using circle hooks (5.05 fish/100 hooks) as compared with using 'J' hooks (2.28 fish/100 hooks). Similar results were observed with the catch of the target species (yellowfin tuna), for which CPUE was approximately 2.5 times higher with circle hooks (3.33 tuna/100 hooks) as compared with J-hooks.
- Circle hooks also resulted in a lower mortality for all species (3.1% versus 42%) and for the target species (21% versus 39%).
- For all species, 95% of the fish taken on circle hooks were hooked in the jaw.
- These preliminary results suggests that use of circle hooks in the pelagic longline fishery targeting yellowfin tuna may not only increase CPUE and survival of the species but also improve the survival of incidental catch and bycatch.

Grover, Allen M., M. S. Mohr, and M. L. Palmer-Zwahlen. 2002. Hook-and-Release Mortality of Chinook Salmon from Drift Mooching with Circle Hooks: Management Implications for California's Ocean Sport Fishery. Pages 39–56 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ A total of 276 chinook salmon *Oncorhynchus tshawytscha*, less than 660-mm total length, were drift mooch-caught using barbless circle books and held for four days in 8,700 L, onboard holding tanks for wound location-specific, mortality rate evaluation. Only gut-hooked fish died in the first 24 hours of holding, and only lower-jaw hooked and gut-hooked fish died within

the first 48 hours of holding. Gut-hooked fish that survived the four-day holding period but whose internal organs were severely damaged were considered mortalities. The four-day mortality rate attributable to the effects of handling and holding alone was estimated to be 0.048, based on a surrogate control group consisting of tank-held fish having no wounds or superficial wounds. The control-adjusted, four-day mortality rates depended strongly on hook wound location. The distribution of wound locations in the California recreational drift mooch salmon fishery was estimated based on a sample of 522 fish, less than 660-mm total length; the relative frequency of gut-hooked fish (0.406) was twice that of any other location. The fishery overall hook-and-release mortality rate was estimated to be 0.422 (95% confidence interval of 0.342–0.502), obtained by weighting the wound location-specific, four day mortality rates by the relative frequency of those wound locations in the fishery. The distribution of wound locations was found to depend on both hook size and fish-size class, but the effects of these factors were not additive on the log-odds scale. Blood plasma cortisol concentration, a measure of stress, was significantly higher in fish held for four days than in ocean-caught (presumably stress-free) fish, but there was considerable variation among individuals and the results were not useful in evaluating the effects of wound-induced stress. The requirement that (only) barbless circle hooks be used in the California drift mooch fishery substantially reduced the hook-and-release mortality rate in this fishery; however, the rate is still high. Hook-and-release mortality might be reduced further by educating anglers on the use of drift mooch methods that lessen the probability of gut hooking. If such education is effective in changing the fishery's wound location profile, our estimate of the hook-and-release mortality rate can be easily updated using the methods described in this paper.

Grover et al. 2002.

- The requirement that (only) barbless circle hooks be used in the California drift mooch fishery substantially reduced the hook-and-release mortality rate in this fishery, however, the rate is still high.

Halliday, R. G. 2002. A comparison of size selection of Atlantic cod (*Gadus morhua*) and haddock *(Melanogrammus aeglefinus*) by bottom longlines and otter trawls. Fisheries Research 57 (1): p 63–73. Amsterdam July, 2002.

Abstract ~ The size selection of Atlantic cod and haddock by bottom longlines was described in an experiment conducted off Nova Scotia, Canada, by comparing their catches at length with those from an otter trawl with a small mesh codend fished concurrently. Three longline configurations were tested that differed primarily in the size of circle hooks and baits used. Bait size was increased with increasing hook size. Size selection of diamond and square mesh otter trawl codends of 130-mm mesh size were tested in the same experiment. The size selection curves obtained for cod taken on longlines were asymptotic and selection parameters were calculated by fitting logistic curves to the data. For haddock, only the lower end of the selection curves could be described.

Larger hooks /bait were less efficient at catching smaller cod, but more efficient at catching larger cod, than were smaller hooks /baits. The smallest hook/bait combination had a length at 50% selection for cod below that of the 130-mm diamond mesh trawl codend, the minimum mesh size allowed at the time of the experiment. This result was counter to expectations based on the observed length compositions of commercial landings. The largest hook/bait combination had a 50% selection above that of the 130 mm square mesh. Although cod up to 126 cm were caught during this experiment, few were larger than 90 cm, leaving unresolved the question of whether the selection curves described are applicable to the largest cod.

Halliday. 2002.

- Larger circle hooks/bait were less efficient at catching smaller cod, but more efficient at catching larger cod, than were smaller circle hooks/bait.

Lukacovic, Rudolph and James H. Uphoff, Jr. 2002. Hook Location, Fish Size, and Season as Factors Influencing Catch-and-Release Mortality of Striped Bass Caught with Bait in Chesapeake Bay. Pages 97–100 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ Striped bass *Morone saxatilis* catch-and-release mortality is influenced by hook location, bait and hook type, angler experience, and season (Diodoti and Richards 1996). Anatomical location of hook wounds is the most important factor in hooking mortality (Muoneke and Childress 1994). In comparison with artificial lures, natural baits generally cause higher mortalities because they tend to be swallowed more often (Muoneke and Childress 1994). Temperature, salinity, and fish size were cited as risk factors when Maryland's striped bass catch-and-release policy was formulated. We conducted two catch-and-release mortality experiments on striped bass using natural bait, one each during October 1996 and June 1997, to measure mortality associated with fish size, hook location, and season. We also appraised the potential of nonoffset circle hooks to reduce deep hooking of released fish. To assess mortality associated with catch-and-release angling, striped bass were caught by volunteer anglers aboard contracted charter boats in Maryland's Chesapeake Bay. Standard 3/0 offset J-style bait hooks were used in October; 6/0 offset J-style or 11/0 nonoffset circle hooks were used in June (the latter two hooks were similarly sized). Ground Atlantic menhaden *Brevoortia tyrannus* were used as chum. If a fish was shallow hooked (lip, mouth or gills), a hole was punched in the lower lobe of the caudal fin and the hook was removed. If a fish was deep hooked (hooked past the gills), the hook was left in place, the line cut, and a hole was punched in the dorsal lobe of the caudal fin. Fish were taken to 4.6 m x 4.6 m x 3.7-m (15 ft x 15 ft x 12 ft) holding pens. Pens were checked every day for five days and dead fish removed and measured. All dead, deep-hooked fish were necropsied. Overlap of 95% confidence intervals (CI) was used to determine whether October or June percent mortality or deep-hooking percentages were significantly different from zero and from each other (Ott 1977). Confidence intervals for October or June were estimated from the normal distribution approximation of the binomial distribution (proportions converted to percentages). We considered fish size (legal or sublegal), season (October or June), and hook location (deep or shallow) explanatory factors and coded them as binary (O or 1) variables. A three-way, log-linear model tested mortality as a combination of season, hook location, and fish size using the Statistical Analysis System's (SAS) Proc Catmod (SAS 1998).

Finally, to examine the potential of nonoffset circle hooks to offset deep hooking we compared the 95% CI of the percentage of deeply-hooked striped bass caught on standard chumming hooks or on nonoffset circle hooks during trials conducted on 23 and 24 June 1997. On these dates, our anglers also fished with circle hooks, and we recorded the number of deeply and shallow-hooked striped bass.

Seasonal differences were documented in both deep-hooking rates and overall mortality. During October, eleven of ninety striped bass died (12.2%, SD = 3.5). Seventeen fish (I 8.8%, SD = 4. 1) were deeply hooked, and seven of these died. Approximately 69% of striped bass were above the fall season's legal size of 457 nun (I 8 in). During June 1997, 47 of 131 striped bass died (35.9%, SD = 4.2). Based on 95% CI overlap, striped bass hooking mortality was greater in June than in October. Seventy-one striped bass (54.2%, SD = 4.4) were deeply hooked. Twenty-five fish (19%) were above the spring season's minimum size of 660 mm (26 in).

Size, season, and hook location were not independent influences on hook-and-release mortality; main effects and their three-way interaction were significant ($P < 0.05$) in the saturated log-linear model and were kept in the reduced model. Two-way interactions were not significant and were dropped.

Deeply hooked, legal-sized striped bass were predicted to be most likely to die after release (50–60%), regardless of season. In June, more than 30% of shallow-hooked, legal-sized striped bass died. High mortality of shallow-hooked, large striped bass in June suggests a broader catch-and-release problem not confined to chumming. Low mortality (7–9% dead) was predicted after release for shallow-hooked legal or sublegal fish in October or shallow-hooked sublegal fish in June. High release mortality (> 50%) was predicted when fish were deeply hooked and legal or sublegal size in June or deeply hooked and legal size

in October. Fewer fish were deeply hooked on circle hooks, 10.6% (SD = 2.9%, N II 3), than on standard hooks, 45.6% (SD = 5.6%, N = 79). Mean lengths were not significantly different (Wilcoxson Rank Sum test, P = 0.62) between fish caught on circle hooks (542 mm, N = 63) and standard hooks (561 mm, N =40). Deeply hooked fish of any species generally suffer higher mortality than shallow-hooked fish (Muoneke and Childress 1994), and the differential mortality that we observed appears typical. Deep-hooking percentage decreased approximately four-fold in June when circle hooks were used instead of standard chumming hooks.

Circle hooks provide anglers with an option that lowers deep hooking, and their use should be promoted. Lowering the size limit in June 1998 to that of October 1996 (457 mm) allowed quicker filling of the creel. If a 457-mm size limit were substituted for the 660-mm minimum length in our June experiment, potentially harvestable fish would have increased from 19% to 88%.

Lukacovic and Uphoff. 2002.

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- Deep-hooking percentage decreased approximately four-fold in June when circle hooks were used instead of standard chumming hooks.
- Circle hooks provide anglers with an option that lowers deep hooking, and their use should be promoted.

Malchoff, Mark H., J. Gearhart, Jon Lucy, and Patrick J. Sullivan. 2002. The Influence of Hook Type, Hook Wound Location, and Other Variables Associated with Post Catch-and-Release Mortality in the U.S. Summer Flounder Recreational Fishery. Pages 97–100 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ Major recreational and commercial fisheries in the mid-Atlantic region of the United States are dependent upon summer flounder or fluke *Paralichthys dentatus*, currently managed under the Summer Flounder Fishery Management Plan (MAFMC 1995). The number of flounder caught by recreational anglers and subsequently released alive has grown from less than 6 million fish in 1990 to over 16 million fish in 2000, and now regularly exceeds 60% of the total recreational catch (National Marine Fisheries Service, Fisheries Statistics and Economics Division, personal communication). Only limited data, however, exist on post-release mortality rates in the fishery and the most important factors, which contribute to this mortality (Lucy and Holton 1998).

In 1997, a field study on flounder release mortality was begun in New York (NY), with similar work planned in 1998 for Virginia (VA) and North Carolina (NC) where researchers coordinated data collection during that year. From July 1997 to December 1998, using conventional angling gear, researchers and volunteer anglers conducted 17 fishing trials catching 623 summer flounder (200–650 mm total length).

In the New York trials, fish were primarily caught aboard party/charter vessels (Great South Bay area) with small open research vessels used in Virginia's lower Chesapeake Bay, and along beaches and sounds in the Cape Lookout, North Carolina area. Fish were typically caught by drifting or slow trolling using medium action spinning and bait casting rods (5.5–7.7 kg test line) and natural baits (live and dead). Barbed sproat (J-shaped hook, used only in New York), wide gap, and offset circle hooks (sizes #1–4/0) were used without spinners or skirts on conventional bottom rigs.

Capture event data included hook type and size, hook wound location (anterior to pharynx; posterior to pharynx), presence-absence of severe bleeding, and fish length. In the Virginia and North Carolina trials, fish hooked posterior to the pharynx (i.e., deep or "gut-hooked") had the leaders cut, leaving hooks in the fish. In New York, party boat mates removed all hooks regardless of hook wound location as per local custom in the Capture fleet.

Following capture, individual fish were tagged with T-Bar anchor tags (Floy and Hallprint) then placed in onboard tanks/live-wells. Aerator pumps (New York) and water exchanges maintained adequate oxygen levels. Onboard fish holding densities were less than or equal to 48 g/L, and holding times ranged from one to four hours. In Virginia and North Carolina, fish were transferred to holding cages directly from sampling boats. In New York, logistical constraints necessitated the additional transport (< 3.2 km) of live fish via aerated tank equipped trucks.

Cages were constructed of 13–25 mrn bar plastic mesh (NY), plastic-coated wire (NC), and galvanized wire (VA), and placed either under piers (NY), on the bottom (NC, about 3 m depth), or moored from docks using flotation collars (VA). Mesh size was sufficient to enable prey to enter, though the extent of such prey entry during the trials is unknown. Cage shape was rectangular (NY and VA) or cylindrical (NC); cage volumes were $3.5M^3$ (NY) and $0.4\ M^3$ (VA/NC). In Virginia and North Carolina, cage bottoms were covered with material to reduce fish chaffing, and in Virginia alone the floating cages were shaded on top. Maximum fish densities were 9, 10, and 20 fish/m^2 (NY, VA, and NC, respectively). Fish were held for 72 hours without food (Malchoff and Heins 1997). All fish were recovered, dead fish identified by tag number, and surviving fish either released (NY, VA) or some kept for aging (NC). Water temperature and salinity were 17–28C and 17–26 ppt at holding sites. During trials, mean water temperatures were: NY (21'C in 1997; 17'C in 1998), VA (25C, September–October 1998), NC (18'C, October–December 1998). Post release mortality rates for the 72-hour holding period were determined for New York trials, and Virginia/North Carolina trials combined, since fish in New York were subject to different hook recovery methods. Bootstrapping (1000 samples, N = 247 for NY, and 376 for NC and VA) was used to calculate mean mortality and 95% confidence interval from a cumulative binomial distribution. Calculated P values were ordered (lowest to highest), enabling selection of those corresponding to P less than or equal to 0.25 and P greater than or equal to 0.975 (SYSTAT 1997)'. Fitted logistic regression models were compared using likelihood ratio tests to develop a parsimonious model from which to identify significant predictors of mortality and interaction relationships among variables (S-Plus 1998) 2.

Mean mortality estimates, 14.6% (7.9–21.2% CI) for New York trials compared to 6.1% (3.2–9.5% CI) for Virginia/North Carolina trials, were not significantly different (Table 1). Overall mean mortality for all trials combined was 9.5% (7.4–11.9% CI)

Working through the logistic regression model, hook type-size variables were reduced from nine to three (sproat, wide gap, and offset circle). While “state" was available as a predictor variable, "leader status," which varied by state, better represented the physical differences between treatments. Furthermore, "state" provided no additional statistically significant information (at the alpha = 0.05 level) after "leader status" had been included in the model. Therefore, selected model variables were: leader status, hook type, hook wound location, and bleeding (discrete), along with temperature and fish length (continuous). Regressions were conducted and F-tests were used to examine significance of inclusion of interaction terms. While main factors of hook type and length appeared to be not statistically significant with main effects alone, a more complex model that included these terms as interactions with bleeding, significantly improved the fit ($p < 0.0001$). All factors but hook type and fish length were significant predictors of release mortality (Table 2).

Our interest was the elucidation of those factors (some controllable by anglers) most closely associated with hooking mortality. Significant predictors of mortality included leader status, wound location, bleeding, and water temperature. These results largely support similar research on striped bass *Morone saxatilis* where deep hooking and higher water temperatures were found to contribute significantly to release mortality (Diodati and Richards 1996; Lukacovic and Uphoff, this volume). Hook type (as a main effect) was not a significant predictor of mortality. These results are in general agreement with an earlier analysis on part of these data where hook type was not a significant predictor of deep hooking (Gearhart 2000). However, these results remain unexpected given the popular thinking about circle hooks and their demonstrated utility in the striped bass and billfish fisheries (Lukacovic and Uphoff, this volume; Prince et al., this volume). We speculate that the degree of offset (15^0 in the Eagle Claw 197 hooks used here) may have negated the normal "jaw hooking only" pattern normally seen with circle hooks. This is corroborated in the sailfish fishery where highly offset circle hooks were associated with significantly more deep hooking than were minor offset (4) and nonoffset hooks (Prince et al., this

volume). As importantly, these hooks were found to be particularly difficult to extract by mates in the New York flounder samples. This probably explains the strong interaction between bleeding and hook type, and the importance of "leader status" in deeply hooked fish (Table 2). Taken together these observations underscore the importance of proper techniques when preparing to release fish alive. Also noted is the strong interaction between bleeding and fish length, despite the fact that length alone was not a significant predictor of mortality. Additional research on summer flounder post release mortality is warranted regarding nonoffset circle hooks across a larger fish length range as well as quantifying catch rates using circle and noncircle hooks.

Malchoff et al. 2002

- Hook type (as a main effect) was not a significant predictor of mortality. These results are in general agreement with an earlier analysis on part of these data where hook type (sproat J hooks vs. circle hooks) was not a significant predictor of deep hooking (Gearhart 2000).
- However, these results remain unexpected given the popular thinking about circle hooks and their demonstrated utility in the striped bass and billfish fisheries.
- We speculate that the degree of offset (15^0 in the Eagle Claw 197 hooks used here) may have negated the normal “jaw hooking only” pattern normally seen with circle hooks.
- Taken together these observations underscore the importance of proper techniques when preparing to re release fish alive.

Orsi, Joseph A., Alex C. Wertheimer, and Herbert W. Jaenicke. 1993. Influence of selected hook and lure type on catch, size, and mortality of commercially troll-caught chinook salmon. North American Journal of Fisheries Management 13 (4): 709–722.

Abstract ~ Circle and J hooks of two sizes, plugs of two sizes, hootchies, and painted spoons were tested to determine their relationship to hook-and-release mortality of chinook salmon Oncorhynchus tshawytscha. Fewer chinook salmon and adult coho salmon *O. kisutch* were caught with circle hooks than with J hooks. Large J hooks caught more large chinook salmon than did small J hooks , but the difference was not significant (P = 0.10). Large plugs caught significantly (P < 0.05) larger chinook salmon and fewer coho salmon and sublegal (66 cm fork length) chinook salmon than other lures tested. Wound distribution on chinook salmon varied (P < 0.05) with hook type; circle hooks lodged in the periphery of the mouth more frequently than did J hooks . Results indicate that, in a directed coho salmon troll fishery, the use of circle hooks could reduce incidental mortality of chinook salmon but would substantially reduce coho salmon catch rate. In a quota-limited chinook salmon fishery, large plugs could be used to harvest larger fish selectively, thereby reducing encounters with sublegal fish.

Orsi et al. 1993.

- Fewer chinook and adult coho salmon were caught with circle hooks than with J hooks. Large J hooks caught more large chinook than did small J hooks but the difference was not significant (P=0.10).
- “… the use of circle hooks could reduce incidental mortality of chinook salmon but would substantially reduce coho salmon catch rate.”

Prince, Eric D., M. Ortiz, and A. Venizelos. 2002. A Comparison of Circle Hook and "J" Hook Performance in Recreational Catch-and-Release Fisheries for Billfish. Pages 66–79 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999

Abstract ~ This study evaluates the performance of circle and comparable-size "J" hooks on Atlantic and Pacific sailfish *Istiophorus platypterus* and, to a lesser extent, on Pacific blue marlin *Makaira nigricans*. Terminal gear performances were assessed in terms of fishing success, hook

location, and bleeding associated with physical hook damage and trauma. Evaluations of trolling with dead bait took place off Iztapa, Guatemala, during the spring and summer of 1999, and assessment of drifting/kite fishing with live bait took place off South Florida during the summer of 1999. Three hundred and sixty Pacific sailfish were caught in Iztapa, Guatemala, to assess terminal gear performance; 235 sailfish were on circle hooks, and 125 were on "J" hooks. Circle hooks used on sailfish had hooking percentages (i.e., fish hooked/fish bite) that were 1.83 times higher compared with "J" hooks. Once the fish were hooked, no difference in catch percentage (i.e., fish caught/fish hooked) between hook types was detected. Significantly more sailfish were hooked in the comer of the mouth using circle hooks (85%), as compared with "J" hooks (27%). In contrast, significantly more sailfish were deep hooked in the throat and stomach with "J" hooks (46%), as compared with circle hooks (2%). Only one sailfish (1%) was foul hooked using circle books, while 11 (9%) sailfish caught on "J" hooks were foul hooked. Sailfish caught on "J" hooks are 21 times more likely to suffer hook-related bleeding than those caught on circle hooks. Seventy-five Atlantic sailfish were caught using circle hooks in the South Florida live bait recreational fishery to assess possible differences in hook performance between circle hooks with and without an offset point. No difference in catch percentage or bleeding was found between circle hooks with no offset, minor offset (about 4 degrees), or severe offset points (about 15 degrees). However, the percentage of deep hooking in the throat and stomach for circle hooks with a severe offset (44%) was comparable to the deep hooking percentage for "J" hooks (46%) used in the Guatemala study. A comparison of circle and "J" hook catch rates of Pacific sailfish and blue marlin, using logbook catch statistics from recreational fishing off Iztapa, Guatemala, was also conducted. In general, use of circle hooks resulted in measures of fishing success that were comparable to or higher than "J" hooks. Circle hooks also minimized deep hooking, foul hooking, and bleeding.

Prince et al. 2002

- Circle hooks used on sailfish had hooking percentages (i.e., fish hooked/fish bite) that were 1.83 times higher compared with ‘J’ hooks.
- Significantly more sailfish were hooked in the corner of the mouth using circle hooks (85%), as compared with ‘J’ hooks (27%).
- In contrast, significantly more sailfish were deep hooked in the throat and stomach with ‘J’ hooks (46%0, as compared with circle hooks (2%).
- Only one sailfish (1%) was foul hooked using circle hooks, while 11 (9%) sailfish caught on ‘J’ hooks were foul hooked.
- Sailfish caught on ‘J’ hooks are 21 times more likely to suffer hook-related bleeding than those caught on circle hooks.
- The percentage of deep hooking in the throat and stomach for circle hooks with a severe offset (44%) was comparable to the deep hooking percentage for ‘J’ hooks (46%) used in the Guatemala study.
- Circle hooks minimized deep hooking, foul hooking, and bleeding.

Skomal, Gregory B., Bradford C. Chase, and Eric D. Prince. 2002. A Comparison of Circle Hook and Straight Hook Performance in Recreational Fisheries for Juvenile Atlantic Bluefin Tuna. Pages 66–79 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ Catch quotas, bag limits, and minimum sizes have been the primary management tools to limit mortality in U.S. Atlantic bluefin tuna *Thunnus thynnus* fisheries. As a result of these regulations, increasing numbers of bluefin tuna are released annually by recreational and commercial fishermen. Post-release survival is highly dependent on the degree of physiological stress and physical trauma experienced by the fish. The type of terminal fishing tackle strongly influences hook location in the fish, as well as the degree of hook damage. This study compared the performance of circle hooks to straight hooks, relative to hooking location, damage, and

catching success in natural bait fisheries for bluefin tuna that are practiced on the U.S. Atlantic coast. During the summers of 1997–1999, fishing trips were made offshore of Virginia and Massachusetts to catch juvenile bluefin tuna with comparable size circle hooks (sizes 10/0–12/0) and straight hooks (sizes 5/0–8/0), while drifting with natural bait. A total of 101 bluefin tuna was caught and dissected to quantify hooking location and to assess the extent of hooking damage. There was a significant association between hook type and hook location ($p < 0.05$). Ninety-four percent of the bluefin tuna caught on circle hooks were hooked in the jaw, and four percent were hooked in the pharynx or esophagus. Fifty-two percent of the bluefin tuna caught on straight hooks were hooked in the jaw, and thirty-four percent were hooked in the pharynx or esophagus. Based on the observed hook damage, we estimated that release mortality would have occurred in four percent of the bluefin tuna caught on circle hooks and twenty-eight percent caught on straight hooks. The ability of each hook type to hook and hold tuna was significantly different; however, overall catching success was similar. This comparison indicates that circle hooks cause less physical damage than straight hooks, while catching juvenile bluefin tuna, using natural baits and can be a valuable conservation tool in these recreational fisheries.

Skomal et al. 2002

- There was a significant association between hook type and hook location (p,0.05). Ninety-four percent of the bluefin tuna caught on circle hooks were hooked in the jaw, and four percent were hooked in the pharynx or esophagus.
- Fifty-two percent of the bluefin tuna caught on straight ('J') were hooked in the jaw, and thirty-four percent were hooked in the pharynx or esophagus.
- Based on the observed hook damage, we estimated that release mortality would have occurred in four percent of the bluefin tuna caught on circle hooks and twenty eight percent caught on straight hooks.
- The ability of each hook type to hook and hold tuna was significantly different, however, overall catching success was similar.
- This study indicates that circle hooks cause less physical damage than straight hooks.

Trumble, Robert J., Stephen M. Kaimmer, and Gregg H. Williams. 2000. Estimation of discard mortality rates for Pacific halibut bycatch in groundfish longline fisheries. North American Journal of Fisheries Management 20 (4): 931–939.

Abstract ~ Mandatory release to the sea of Pacific halibut, *Hippoglossus stenolepis,* incidentally harvested in Alaskan and Canadian groundfish fisheries has the potential to close fisheries or to close fishing to individual fishermen or vessels that reach Pacific halibut bycatch mortality limits. Tagging experiments of Pacific halibut from longline gear demonstrated that Pacific halibut with similar types of injuries experienced lower mortality following release from small (13/0) circle autoline hooks than from large (16/0) circle hooks. As a result, the current viability criteria for individual Pacific halibut overestimate discard mortality rates. Proposed, simplified four-category viability criteria based on injury codes increased accuracy of bycatch mortality calculations over the present three-category criteria. The new criteria may reduce calculated discard mortality of Pacific halibut released from longlines by 20%. Use of the new criteria would result in more accurate estimates, which in turn could lower the probability of bycatch-induced fishery closures, increase the Pacific halibut available for a directed fishery, or both.

Trumble et al. 2000.

- Tagging experiments of Pacific halibut from longline gear demonstrated that Pacific halibut with similar types of injuries experienced lower mortality following release from small (13/0) circle autoline hooks than from large (16/0) circle hooks.

Trumble, Robert J., Stephen M. Kaimmer and Gregg H. Williams. 2002. A Review of the Methods Used to Estimate, Reduce, and Manage Bycatch Mortality of Pacific Halibut in the Commercial Longline Groundfish Fisheries of the Northeast Pacific. Pages 88–96 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society

Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ Management of the hook-and-line-only fishery for Pacific halibut *Hippoglossus* steps in waters off the United States and Canada requires discard to the sea of Pacific halibut bycatch (out of season, undersized, or by fishermen without individual quotas or licenses). Depending on hook type and release methods, survival from longline discards can vary from nearly 100% to none. Conversion in the early 1980s from J-hooks, used by foreign fleets and the domestic halibut fleet, to circle hooks, now used by most domestic longline fishermen, increased survival potential through less damaging hooking locations. Bycatch mortality caused by a fishery was estimated by applying a discard mortality rate to the total halibut discarded. Onboard observers collected viability data used to calculate annual fishery-specific Pacific halibut discard mortality rates and collected fishery-specific bycatch rate data used to estimate total bycatch. Limits on bycatch mortality, which closed fisheries when exceeded, provided an incentive for the longline fleet to practice careful release. Estimated halibut bycatch mortality dropped following careful release regulations. Results of tagging studies on halibut released using careful release demonstrated that the distribution of hook injuries shifted to minor and moderate injuries compared with moderate and severe injuries when careful release did not occur. Tag return rates used to quantify survival by injury type led to criteria describing the injuries.

Trumble et al. 2002

- Conversion in the early 1980s from J-hooks, used by the foreign fleets and the domestic halibut fleet, to circle hooks, now used by most domestic longline fishermen, increased survival potential through less damaging hooking locations,

Woll, Astrid K., J. Boje, R. Holst, and A. C. Gundersen. 2001. Catch rates and hook and bait selectivity in longline fishery for Greenland halibut (*Reinhardtius hippoglossoides*, Walbaum) at East Greenland. Fisheries Research 51 (2–3): p 237–246 (Amsterdam).

Abstract ~ A joint Norwegian-Greenland longline survey was conducted at East Greenland in August 1997, using different hook and bait types. Most Norwegian longliners use hooks of the type EZ 12/0. This hook was compared to three versions of a new circle 14/0 hook. A total catch of 2899 Greenland halibut from 45,760 hooks baited with squid were used in the hook selectivity analyses. In average, CPUE was 281kg/1000 hook for the EZ hook. CPUE for the circular hook was 36% higher making an overall significant difference in CPUE between the EZ hook and the circle hooks . On 6630 hooks squid and grenadier were used alternately. The CPUE of Greenland halibut was 25% higher for grenadier bait. The grenadier bait resulted in a reduction in bycatch compared to the squid bait (1.1 and 20.7% by numbers, respectively). Catches by EZ 12/0 hook and one of the circle 14/0 hooks were compared in order to examine size selectivity.

Using the SELECT approach, expected proportions were fitted to the observed proportions for five different models of selectivity. All models resulted in almost identical fits. The absence of non-selective data requires the choice of selectivity curve to be based on knowledge about the capture process. Since the selectivity curves cannot be determined unambiguously in this study, none of the estimated curves are preferred for the other.

Woll et al. 2001.

- In average, CPUE was 281kg/1000 hook for the EZ hook. CPUE for the circular hook was 36% higher making an overall significant difference between the EZ hook and the circle hooks.

Zimmerman, Steven R. and Eleanor A. Bochenek. 2002. Evaluation of the Effectiveness of Circle Hooks in New Jersey's Recreational Summer Flounder Fishery. Pages 106–109 *in:* Jon A. Lucy, Editor. Catch and Release in Marine Recreational Fisheries. American Fisheries Society

Symposium 30. National Symposium on Catch and Release in Marine Recreational Fisheries. Virginia Beach, VA. 5–8 December 1999.

Abstract ~ Summer flounder *Paralichthys dentatus* support an important commercial and recreational fishery in the Mid-Atlantic Bight and are currently under a rebuilding plan. As a result, size and bag limits have been imposed upon recreational anglers to reduce fishing mortality. An important factor that affects the success of implemented minimum size limits is the survival of undersized fish. Minimum size limits have little success if there is high mortality occurring in released undersized fish (Waters and Huntsman 1986). Therefore, information on recreational catch-and-release mortality is crucial for effective management of summer flounder (Diodati 1996).

Many studies have examined the effects of hook-and-release mortality on recreational fishes (Bugley and Shepherd 1991; Matchoff 1995, 1997; Williams 1995; Diodati 1996; Bettoli and Osborne 1998; Lucy and Holton 1998), but few have studied the effectiveness of hook types and how these particular gear relate to hook sets. Lucy and Holton (I 998) found the average hook-and-release mortality of summer flounder to be 11%, with 95 % of the mortality the result of being hooked in the esophagus (76%), gills (16%), and tongue area (8%). Other studies (Bugley and Shepherd 1991; Diodati 1996) have also found that hooking fish in the esophagus/gill area contributed to high release mortality. The use of gear that will reduce the number of cases in which summer flounder are hooked in the esophagus, gill, and tongue area could greatly reduce hook-and-release mortality, in turn making management practices such as the implementation of minimum size limits more effective at conserving the resource (Waters and Huntsman 1986).

Some managers believe that the use of circle hooks will reduce the amount of hook sets occurring in the esophagus, gills, and tongue area and keep hook sets confined to the jaw of the fish. The objectives of this study were to determine the location of circle hook sets on recreationally caught summer flounder and to compare circle hook sets with standard hook sets.

A survey form was developed to collect information on hook type used, hook size, rig type, length of time that the rig was fished, number of fish caught and released on each rig, hook set location, unhooked condition, fish length, and difficulty unhooking fish in New Jersey's recreational summer flounder fishery. Survey forms were distributed to summer flounder anglers with various levels of experience (anglers in their first year of fishing to those with more than 20 years of fishing experience) at the beginning of each season (May 1998, 1999) and collected at the end of each season. Eagle Claw circle hooks, sizes 4/0 (#LI97BM) and 510 (#LI97Fs), were also given to these anglers. Fishing was conducted from shore and party and private boats. Summer flounder rigs were either drifted from a boat or fished stationary from shore. Data were analyzed using a Mann-Whitney rank sum test to test the null hypothesis that the results of the two hook types (circle and standard) were not different. "Standard" hook types were long shank J hook, short shank J hook, and English bend flounder hooks.

Seventeen anglers participated in the study and hooked 160 summer flounder (circle hooks N = 64, standard hooks N = 96). Anglers used hook sizes ranging from 2/0 to 510. The majority (69%) of anglers using circle hooks fished with size4/0.Anglers fishing with standard hooks fished with hook sizes of 4/0 (55%) and 510 (36%).

Most (> 80%) of the hook sets on circle hooks occurred in the upper and lower jaws (Figure IA), and the summer flounder were easily unhooked with no damage. Only 1.6% of summer flounder experienced gill damage, 4.7% experienced gut damage, and 12.5% experienced bleeding as a result of the hook set.

In the standard hook treatment, hook set location was observed to be primarily in the upper and lower jaws with some sets located in the tongue, throat, and gut (Figure I B). Release condition of summer flounder caught with standard hooks was 77. 1 % easily unhooked with no damage, 2. 1 % gill damaged, 11.5% gut damaged, and 9.4% exhibited bleeding as a result of being hooked.

There was no statistical difference between circle hook and standard hook sets for both hook set location and release condition ($p = 0.05$). This study found that in the recreational summer flounder fishery, circle hooks were not more effective than standard hooks at keeping hook sets confined to the jaw area.

However, the instances of gut hooked summer flounder were lower (4.7%) in fish caught with circle hooks than in fish caught with standard hooks (15.6%).

Angler comments concerning deep-hooked fish indicated that summer flounder were more prone to experience deep hooking from circle hooks when the rig was slowly drifted. Angler experience, particularly the ability to detect a strike, may have had an effect on the amount of time the fish was allowed to manipulate and ingest the hook.

In this study, hook size did not seem to affect hook set location. Further studies should be conducted to look more closely at the effects of hook size on circle hook set location or how drift speed affects the location of circle hook sets. In addition, recreational release mortality could be reduced once future studies are conducted to determine the best terminal tackle to use in reducing hook sets in the gills, esophagus, and tongue area of summer flounder.

Zimmerman and Bochenek. 2002.

- Most (80%) of the hook sets on circle hooks occurred in the upper and lower jaws and were easily unhooked with no damage. Only 1.6% experienced gill damage, 4.7% experienced gut damage, and 12.5% experienced bleeding.
- With standard hooks, 77.1% were easily unhooked with no damage. 2.1% had gill damage, 11.5% gut damage, and 9.4% exhibited bleeding.
- There was no statistical difference between circle hook and standard hook sets for both hookset location and release condition ($p=0.05$).
- This study found that in the recreational summer flounder fishery, circle hooks were not more effective than standard hooks at keeping hook sets confined to the jaw area.
- However, the instances of gut hooked summer flounder were lower (4.7%) in fish caught with circle hooks than in fish caught with standard hooks (15.6%).
- In this study, hook size did not seem to affect hook set location. Further studies should be conducted to look more closely at the effects of hook size on circle hook set location or how drift speed affects the location of circle hook sets.

Summary

Although circle hooks have only recently begun to be used in some of the inshore recreational fisheries, they have been used in the commercial longline industry since the 1970s. However, in many cases, the “hooks” used by Native Americans most resembled the circle hook configuration rather than the “J” style hook. The use of circle hooks is currently being touted as a more conservative gear because they are believed to be less injurious and more effective in hooking and catching the targeted quarry. Conservation groups believe that replacing “J” hooks with circle hooks will significantly reduce release mortality and therefore positively impact exploited fish stocks.

A literature search documented a limited number of research reports that addressed the comparative effects of circle and “J” hooks. More than half of the studies found significant positive advantages to using circle hooks while the rest found no significant differences between the two hook types, however, four of these studies dealt with flat fishes, summer flounder, and halibut. The remaining study looked only at using circle hooks of different sizes. If we consider the effects and advantages of using circle hooks in the fisheries that target fishes of the Order Perciformes, (the typical torpedo shaped, dorso-ventrally oriented fishes) then all of the pertinent studies found positive significant improvements when using circle hooks.

Studies that compared the effects of the two hook types in the commercial longline and recreational fisheries for tunas found higher rates of “hook and hold,” higher frequency of hooking locations in the jaw, less physical damage and consequential lower release mortality, and an overall significant increase in CPUE (catch-per-unit-effort). Similar studies conducted in the billfish fisheries reported that circle hooks achieved the following advantages over “J” hooks: there were about twice as many hook ups, 85% of the hook ups occurred in the jaw, fish caught on “J” hooks were 21 times more likely to bleed, and that circle hooks minimized deep hooking, foul hooking and injury. Researchers found that circle hooks used in the salmon fisheries reduced release mortality by hooking the fish in the mouth. A study conducted on striped bass found that circle hooks reduced deep hooking fourfold and that the mean lengths of fishes caught on either type hook was not significantly different.

In studies conducted on summer flounder, there were no differences in the numbers of fishes caught on either of the hook types. Hook type was not found to be a significant predictor of mortality nor were there statistical differences for both hookset location and release condition. Additionally, offsetting the points of circle hooks greater than 15° resulted in increased gut hooking.

A single study on salmon found that circle hooks caught fewer sub-legal chinook and adult coho salmon but resulted in decreased incidental mortality.

Overall, past research supports the hypothesis that release mortality can be reduced by replacing “J” hooks with circle hooks and that this may result in positive impacts on the exploited fish stocks in Florida.

Additional Reading (Gray Literature)

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