Tangle Nets and Gill Nets as a Live Capture Selective Method to Collect Fall Chinook Salmon Broodstock in the Okanogan River: 2004

Annual Report, Pilot Study

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May 2005

Acknowledgements

We thank the Bonneville Power Administration (project #200302200) for their financial support. Lincoln Feddersen, Chris Fisher, and Sydrine Sam from the Colville Tribes and Chuck Clayson from the Washington Department of Fish and Wildlife assisted in the fieldwork. Editorial suggestions were provided by Chris Fisher of the Colville Tribes and John Skalski of the University of Washington.

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Abstract

Selective fishing methods often rely on modified fishing gears and methods to capture and release non-target species or stocks in a manner that minimizes mortality. Consequently, these methods are expected to also provide a way to capture live salmon as broodstock for hatchery programs. Tangle nets have been shown to improve the long-term survival of released salmon when compared to the conventional gill nets during commercial fisheries. To evaluate the feasibility of using commercial selective fishing methods for broodstock collection and harvest opportunities, a pilot study was conducted in the Okanogan River in an area where tribal gill net fishing typically occurs. The goal of the study was to compare tangle nets to gill nets for collecting fall chinook salmon (*Oncorhynchus tshawytscha*) and to evaluate their impacts on non-target species. Researchers fished 4.5” tangle and 6” gill nets for eight nights and collected data on the species captured and all salmonids’ condition at capture and release. Salmonids also were tagged at release for recovery information from sport fisheries, tribal fisheries, and during spawning ground surveys. In addition to chinook, steelhead salmon (*Oncorhynchus mykiss*), and sockeye salmon (*Oncorhynchus nerka*) were captured. Regardless of net type or species, salmonids were typically captured in lethargic condition and released in lively condition. The tangle net captured much more bycatch than the gill net and pulling the tangle net in required significantly more time because of bycatch and river debris. The expected late portion of the fall chinook run did not occur, and only two target fish were captured, one per net type. Recommendations are provided to conduct further evaluation.

Introduction

The second largest river in North America, the Columbia River is also well known for its hydropower generation. The completion of the Grand Coulee Dam in the upper portion of the Columbia River in 1942 made the corresponding section of river impassable to fish, prompting the Federal Government to authorize mitigation actions to offset losses in anadromous fish production. These actions were delayed because of the onset of World War II. However, recent mitigation actions have been renewed and one consequence is the plan to build the Chief Joseph Dam Hatchery. Once the hatchery is built, the next key requirement will be the collection of locally adapted fall chinook salmon (*Oncorhynchus tshawytscha*) for broodstock. To collect broodstock in a genetically responsible manner, adult fish should be captured from the same locations where their progeny will later be stocked. To ensure that target fish and any released non-target fish (bycatch) have high survival, selective harvest methods are being evaluated. The environments on the Okanogan River, a tributary to the mainstem Columbia River and just below the Chief Joseph Dam, will include the testing of capture methods such as fish wheels, beach seining, and tangle nets to evaluate which is most appropriate.

Selective harvest methods can be described as the use of technologies and practices that allow a continued harvest, while protecting weak stocks. Currently the most promising commercial selective harvest methods are those that capture salmon live so that target fish may be harvested and bycatch released with minimal mortality (Buchanan et al., 2002, Farrell et al., 2001b, Farrell et al., 2000.) Traditional gill net fisheries can be modified by using shorter nets, shorter soak times, careful removal methods for disengaging fish from the net, using a revival box (Farrell et al. 2001a.), and by switching to tangle nets (Vander Haegen et al. 2004). Tangle nets are visually similar to gill nets but have smaller mesh sizes (typically 3.5”-4.5”) and are made from multifilament rather than monofilament web (Figure 1). Both gears are fished in the same manner and locations, but unlike a gill net, which captures fish around the gills or body, the mesh size of the tangle net prevents large fish from entering the net beyond the opercle. Gill nets often kill fish from gill damage or asphyxiation. In contrast, tangle nets catch fish by the maxillary or teeth, allowing them to continue respiring in the net, and reducing gill damage and scale loss (Vander Haegen et al. 2004). Modifications in fishing practices, including the use of fish revival boxes, short soak times, and careful fish handling, are as important as the gear in ensuring that fish are released live and unharmed.

Tangle nets have been used successfully for the lower Columbia River spring chinook salmon commercial fishery, and so they may be a reasonable alternative to gill net fishing for collecting fall chinook broodstock in the upper Columbia River system. The purpose of this pilot study was to evaluate whether tangle nets could be used to capture fall chinook salmon broodstock in areas where gill net fishing typically occurs. A secondary purpose was to evaluate if tangle nets could be used to enhance subsistence fishing opportunities in the Okanogan River. Tangle and gill nets were fished for eight nights in similar areas in the lower Okanogan River. Researchers fished both net types, using shorter than standard nets, shorter than standard soak times, and a water filled bin to revive lethargic salmonids. We estimated the immediate mortality, catch efficiency of the two net types, and evaluated the characteristics of fish caught in each gear. Net type may result in encounters with different bycatch. This is expected with the tangle net as many small fish species that dwell in the Columbia River can pass through the large mesh gill nets without incident, but would be captured in the smaller-meshed tangle net. We also compared the capture of species other than chinook salmon in each net type because it is undesirable to shift the impacts from one species to another.

Figure 1. Gill net (left) beside tangle net (right).

Methods

The Okanogan River was chosen as the study site because gill nets have been a traditional harvest method for the Colville Tribes and broodstock for the planned Chief Joseph Hatchery will be collected from this river. The Okanogan River is an upper Columbia River tributary that spans Canada and Washington State within the United States and drains a total area of 8200 square miles. The section of this river within Washington State drains 2500 square miles and flows 65 miles. The Okanogan River is located between the confluence of the Methow River and the base of Chief Joseph Dam and meets the Columbia River at river mile 533.5 (Figure 2). The largest tributary, the Similkameen River, provides three quarters of the water and sediment in the Okanogan River. The Okanogan River is a lake-dominated system, while the Similkameen tributary is snow dominated. Four lakes, all within Canada, form the Okanogan River. Of these four lakes, the Okanogan Lake is the headwaters, followed by Skaha Lake, Vaseaux Lake, and Osoyoos Lake.

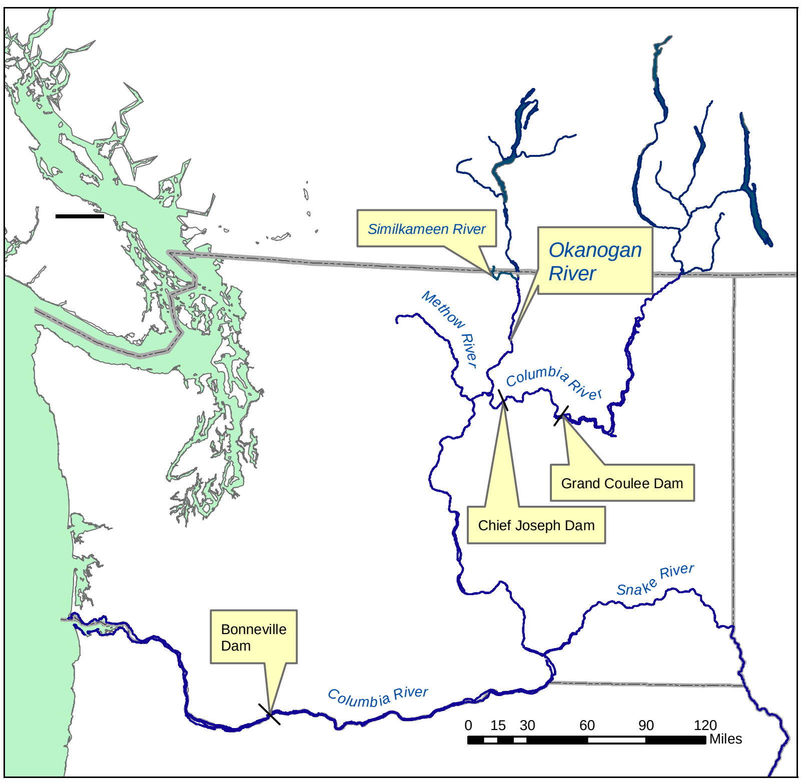

Figure 2. Map of Columbia River, Bonneville, Chief Joseph, and Grand Coulee Dams, and Okanogan River.

Adult fall chinook migrating up the Columbia River first encounter Bonneville Dam at river mile (RM) 146, and ultimately encounter eight more mainstem hydroelectric dams before reaching Chief Joseph Dam at RM 545. Two or more populations comprise the stock component of fall chinook that return to spawning grounds above Wells Dam. The spawning habitat for these populations extends to include the mainstem Columbia, Methow, Okanogan, and Similkameen

Rivers. Harvest of fall chinook consists of subsistence and sport fisheries. The tribal gill net fishery for the Okanogan River is regulated by mesh size and net length.

We fished for returning adult chinook from September 20 through October 1, 2004, in the area shown (Figure 3). We used a 16-foot jon boat that was modified for fishing by removing the surrounding rails and installing PVC pipes over all corners, edges, and screws that might catch and damage the nets. We fished with a 75-foot long tangle net (1.5 mm x 5 strands, hung at a ratio of 2:1) and a 100-foot long gill net. The hang ratio describes the number of fathoms of mesh per fathom of cork line. Both gear types were light green and hung to the same depth that was the suitable to the areas fished, approximately six feet below the float line. Because the tangle net was originally 35 feet in depth, it was rolled up and parachute cord was woven in and out of the meshes and tied off so the net would fish at a six feet deep. Fishing began at dusk and continued into the night.

Field personnel from the Colville Tribe's Fish and Wildlife Department are familiar with the Okanogan River and gill net fishing. They chose sites based on where fall chinook were likely to migrate or hold. Each day four areas where two nets (both a tangle net and a gill net) could be deployed were chosen for a total of eight nets. After three days, the four areas that were expected to capture the most fish were finalized, and these areas were fished for a total of six days (Figure 3). The tangle net was placed near the gill net for each of the four areas. In some cases, this required that the tangle net be placed across the river near the opposite bank from the gill net. The first day, a coin was tossed for each of the four areas to determine which net (tangle or gill) would be placed at each location or site within the area. On subsequent fishing days, the nets were alternated. For example, within a given area the net type fished site 1 the first night, then fished site 2 the second night. This strategy ensured that the fishing effort of each net was similar for each area fished. Nets were deployed and retrieved by hand. The nets were set across the river (typically in a straight line) and one end was attached to the shoreline while the other was weighted by a lead weight attached to a buoy. Observers selected the soak time for each set. The soak time was defined as the time from when the buoy went into the water until the buoy was removed from the water. The fishing vessel was equipped with a 90-quart Sterlite plastic bin that measured about 33" long, 13" high, and 15" wide. The space within the container was large enough for the entire fish to fit inside but narrow enough to prevent a chinook from turning around.

Three or four workers were on board the vessel each day. One person operated the boat and primarily recorded data, while the other two people deployed and retrieved the nets and primarily handled fish. For times when there was a fourth worker, this person recorded the data and assisted in applying tags.

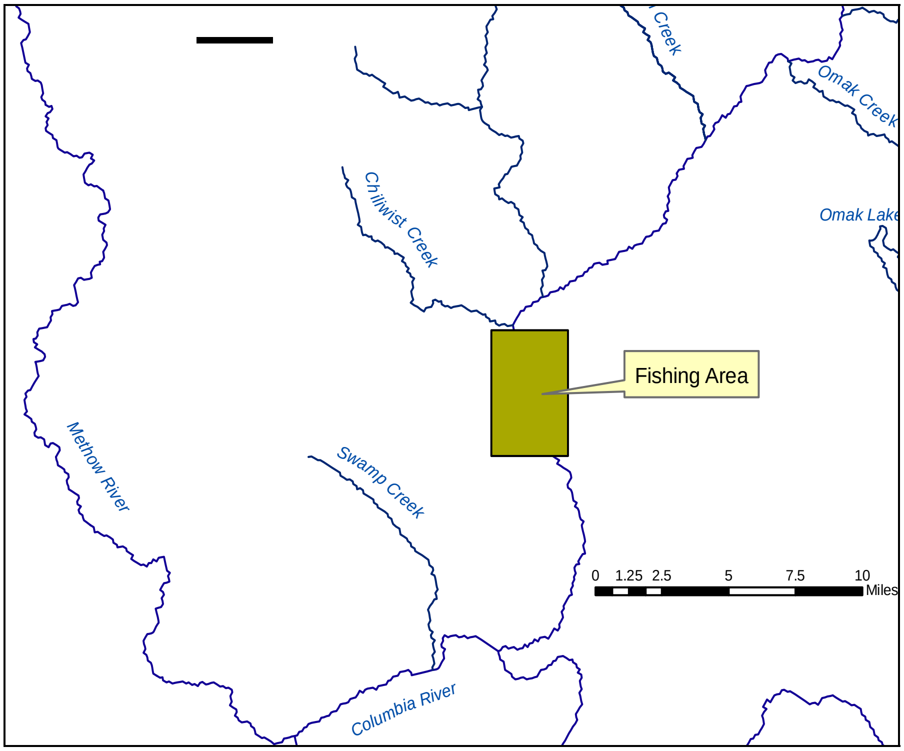

Figure 3. Fishing site locations for Okanogan test fishing study using tangle nets and gill nets.

For each set, the following information was collected:

1) time when the first part of the net was secured to the shoreline;
2) time when the end of the net and its connecting buoy and weight were placed in the water;
3) each time the net was pulled in to check for fish; and
4) time when the end of the net and its connecting buoy were removed from the water.

For each site, the net type used was documented and the latitude and longitude were collected with a Garmin handheld GPS unit. Observers also recorded the date, observer names, weather conditions, water and surface temperatures, and any other observations pertaining to each particular set.

The nets were picked up after about an hour and a half to ensure short soak times. As fish were removed from the net, we used proper fish handling techniques. These included holding fish with two hands, avoiding touching the gill area, and not lifting the fish by the caudal peduncle. Fish were placed immediately into the bin of freshwater. For each salmonid caught, the observer noted the net type it was captured in, the type of capture, whether the adipose fin was missing, and the condition of fish at capture. The observer then measured the fork length and tagged the fish with a jaw tag covered with a plastic sheath and printed with a number. Fish were given a jaw tag to obtain information about where they spawn and if they spawned successfully.

Because of conservation concerns, we documented the condition of all salmon that arrived to the boat in lethargic condition and held them in a bin until they revived to lively condition. We characterized the type of capture as tangled by teeth or mouth, gilled (net around the gills), wedged (web around body further than gills), or mouth clamped (net wrapped around mouth, clamping it closed). A fish was initially ranked as condition 1 if it was lively and not bleeding, condition 2 if it was lively but bleeding, condition 3 if it was lethargic but not bleeding, condition 4 if it was lethargic and bleeding, condition 5 if it showed no visible movement or ventilation, or condition 6 if the fish was clearly dead on arrival to the boat. Fish ranked condition 1 or 2 were tagged and released overboard immediately. Fish in conditions 3 to 5 were held in the bin until they recovered to condition 1 or 2, and could be released, or died. Fish in condition 6 were either donated to the Colville Tribes or returned to the water. We recorded the condition of all salmon and those that arrived to the boat in lethargic condition were held in the bin until they revived to lively condition. Loss of scales, damaged fins and other visible injuries were recorded. Bycatch species were counted by net type.

The fishing time included only the time the nets were actually fishing and not time spent preparing for the next set. Total soak time and time to retrieve each net were analyzed for the final four locations fished using t tests ($P=0.05$). We calculated the total number of fall chinook salmon adults, the total number of non-target salmon, and the total number of non-salmon bycatch for the gill and tangle net.

Results

Immediate Survival and Condition

Test fishing for fall chinook began September 20, 2004, and we fished eight days between that day and October 1, 2004. We captured a male adult chinook salmon in the tangle net and a female adult chinook salmon in the gill net. The male was captured by tangling whereas the female was captured around the gills. No external visible injuries were observed for the tangle net captured male. The gill net captured female had net marks on the head and body. Both fish were captured in lethargic condition, revived to lively condition, tagged, and released overboard with minimal holding. Holding time in the plastic bin was not calculated, but the fish showed a quick improvement in condition.

The total soak time for tangle net sets varied from 33 minutes to 127 minutes with an average of 103.2 minutes (N=70 sets). The total soak time for gill net sets varied from 40 minutes to 148 minutes with an average of 104.1 minutes (N=72 sets). The total soak time for the nets was not significantly different (t=0.22,P=0.82). The time required to pull the tangle nets in ranged from about 1 minute to 44 minutes with a mean of 5.86 minutes (N=96). The time required retrieving the gill nets ranged from about 1 minute to 47 minutes with a mean of 3.64 minutes (N=97). The retrieval time for the nets was significantly different (t=2.39, P=0.02). The surface temperatures during test fishing ranged from 58.6ºF to 64.7ºF. The mean surface temperature for sets was 61.2ºF (N=7).

Bycatch

Because it is undesirable to shift the impact from one species to another, we collected information on bycatch captured in the tangle and gill nets. For this study, bycatch species included carp, northern pike minnow, sockeye salmon, steelhead, sucker, whitefish and a turtle. The tangle net did capture more non-target species than the gill net (Table 1; paired t test, t=3.6,d.f. = 8, P=0.003). A chi-square test of homogeneous species compositions (Table 2) also showed that the tangle net captured significantly more bycatch than the gill net (Table 2; chi square=43.0, d.f.=4, P=0.00000001; Zar, 1999). The release condition of all the species was generally good.

Table 1. Count of bycatch captured in tangle nets and gill nets during the Okanogan River test fishery. The unknown fish escaped before it could be identified.

Species	Tangle net	Gill net
Carp	0	6
Northern Pike Minnow	5	0
Sockeye Salmon	7	3
Steelhead	2	1
Sucker	35	0
Turtle	1	0
Unknown	1	0
Whitefish	3	0
Total	54	11

Table 2. Count of bycatch captured in tangle nets and gill nets during the Okanogan River test fishery and grouped by species composition. The other category consists of three whitefish, an unknown fish that escaped before it could be identified, and a turtle.

Species	Tangle net	Gill net
Carp	0	6
Northern Pike Minnow	5	0
Salmonids	9	4
Sucker	35	0
Other	5	0
Total	54	11

Salmonids

Both sockeye and steelhead were captured by the tangle and gill nets. The tangle net captured more salmonids than the gill net. This may be of special concern for wild steelhead, which is a listed species under the Endangered Species Act.

Sockeye

We captured ten sockeye salmon during the test fishery. Of those, seven were caught in the 4.5" tangle net and three were caught in the 6" gill net. Capture type in the tangle net consisted of tangled (2), gilled (3), mouth clamped (1), and wedged (1). All sockeye salmon captured in the 6" gill net were tangled in the net. All sockeye were captured in condition 3 (lethargic), 5 (unmoving), or 6 (dead). Table 3 shows these results broken down by net type. Each net yielded a dead sockeye. However, the sockeye in the gill net appeared to have been dead for a while and likely floated into the net.

Despite the poor condition at capture, no fish died during handling and all but the two that arrived in the boat dead were released in condition 1 (vigorous). The most common injury for sockeye captured in the 4.5" tangle net was net marks on the head (7), followed by net marks on the body (4), and one sockeye had a seal wound. One sockeye salmon captured in the 6" gill net had net marks on the head. The mean fork length of fish captured in the 4.5" tangle net was 50.0 cm and the mean fork length for sockeye captured in the 6" gill net was 49.3 cm. All sockeye captured in the tangle nets were male (N=8) while the gill net captured one female and one male (which appeared to float into the net).

Table 3. Count and condition of bycatch salmon captured in tangle nets and gill nets during the test fishery on the Okanogan River.

Condition at capture	Net type	Number	Condition at release
1, lively	4.5” Tangle	5	1, lively
3, lethargic	4.5” Tangle	1	1, lively
5, unmoving	4.5” Tangle	0	1, lively
6, dead	4.5” Tangle	1	6, dead
1, lively	6” Gill	0	1, lively
3, lethargic	6” Gill	1	1, lively
5, unmoving	6” Gill	1	1, lively
6, dead	6” Gill	1	6, dead
Total		10	

Steelhead

We captured three steelhead during the test fishery. Of those, two were caught in the 4.5” tangle net and one was caught in the 6” gill net. Capture type in the tangle net consisted of tangled (1 male) and wedged (1 unknown sex). The steelhead captured in the 6” gill net was a female that was gilled. All these fish were captured and released in condition 1 (lively). The male captured in the 4.5” tangle net had net marks on the head and the other fish had a torn pectoral fin. The female captured in the 6” gill net had no visible injuries resulting from capture, but did have a Peterson disk tag, indicating that it had been captured at Wells Dam and anesthetized. The mean fork length of fish captured in the 4.5” tangle net was 49.8 cm and the fork length for the fish captured in the 6” gill net was 61 cm.

Non-Salmon and Unknown Bycatch

The tangle net captured many more non-salmon bycatch than the gill net. The non-salmon species were generally released in good condition. Common carp, an exotic species, were exclusively captured in the gill nets. These fish were killed and their bodies returned to the water. Suckers and whitefish were exclusively captured in the tangle nets. One unknown fish escaped from the tangle net before being identified.

Post Release Tag Recovery

We tagged and released two fall chinook with uniquely numbered yellow jaw tags. Tags from these fish were not recovered.

Catch Efficiency and Size of Adults Captured

Because too few fall chinook were captured, catch efficiency between the two net types cannot be evaluated. The tangle net captured male measured 75 cm in length, and the gill net captured female measured 64 cm in length.

Discussion

Vander Haegen et al. (2004) found that tangle nets can be as efficient at capturing adult spring chinook salmon as gill nets and that they have an acceptably low immediate mortality for fish brought on board. Consequently, tangle nets are also expected to be an appropriate method for collecting salmon broodstock in areas where gill net fishing traditionally occurs (Ashbrook et al, in press b).

This experiment is the first year we used tangle nets and gill nets to capture fall chinook in the Okanogan River. Funding for the study became available suddenly and because most of the chinook run was complete, we viewed this as a pilot study. A late run of fall chinook was expected, but did not materialize. Our results indicate that tangle nets and gill nets with modified selective fishing techniques such as short soak times may be suitable for broodstock collection of Chief Joseph Dam Hatchery chinook. However, too few fish were captured for the planned statistical analysis (Ashbrook et al. in press a). From this study we located fishing sites, learned about working with tangle nets, and discovered what types of bycatch issues will likely result if tangle nets are used to capture chinook in the Okanogan River.

At a minimum, we recommend two further years of this study that encompasses the entire run for summer and fall chinook salmon. Future studies should use a randomized complete block design to establish which net fishes each site for each night fished. This approach will further ensure that systematic biases do not occur. We expect that capture and release from these nets may have an effect on reproductive success (Schreck et al., 2001) and recommend spawning success evaluation for future studies. In addition to evaluating chinook, it will be important to consider the post-release survival of listed steelhead salmon.

Further work should evaluate potential sex ratio differences of salmon captured by tangle net. One shortcoming of tangle nets is that they capture many more bycatch species than conventional gill nets. Both of these factors will be important to consider when deciding between tangle and gill nets for broodstock collection. Regardless of which net is used to capture broodstock, careful handling techniques and methods must be used to maximize fish survival.

One method we recommend is the use of a revival box. The boat used during this study was too small to hold the two-chambered revival box that Farrell et al. (2001a) have found effective for recovering coho salmon. These boxes have also been used with success for spring chinook salmon in the lower Columbia River (Vander Haegen et al., 2002; Ashbrook et al., 2004) and are now a standard requirement for commercial selective tangle net and gill net fisheries in Washington State. However, it may not be practical to navigate a larger boat into the Okanogan River during the low flow season.

Pull time for tangle nets was significantly longer than for gill nets. As we fished, we observed that tangle nets retained more sticks and leaf debris and this was difficult to remove. For future studies, both nets should be the same length and depth. When more fall chinook are present in the river, the soak times for the nets may need to be reduced.

We hoped to learn about post release survival, spawning location, and spawning success for chinook salmon released from tangle nets and gill nets. However, since only two fish were captured it was not surprising that neither fish was reported by anglers or observed on the spawning ground.

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This program receives Federal financial assistance from the U.S. Fish and Wildlife Service Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972. The U.S. Department of the Interior and its bureaus prohibit discrimination on the bases of race, color, national origin, age, disability and sex (in educational programs). If you believe that you have been discriminated against in any program, activity or facility, please write to:

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