

An Overview of Double-Crested Cormorant Management to Protect Natural Resources in Michigan: The First Five Years (2004–2008)

PETER H. BUTCHKO, *USDA, APHIS, Wildlife Services, Okemos, MI, USA*

MARK EBENER, *Chippewa Ottawa Resource Authority, Sault Sainte Marie, MI, USA*

ABSTRACT Michigan, like other Great Lakes states, experienced a tremendous increase of double-crested cormorants (DCCO) in the 1990s that prompted substantial concern about their impacts on natural resources such as sport fish, nesting birds and vegetation. To address these issues, the U.S. Fish and Wildlife Service issued the Public Resource Depredation Order (PRDO) in November 2003 that created a new authority for managing DCCO damage. In this overview, we provide a summary of the collective implementation of the new authority by two agencies, i.e., USDA, Wildlife Services (WS) and five Native American governments for the first five years of PRDO in Michigan. DCCO management under PRDO has been implemented primarily to protect fish species important to both sport and commercial fisheries in many locations but can be categorized in three types of circumstances: 1) during spring migration at locations where DCCOs congregate in large numbers for a period of approximately three weeks; 2) at or near nesting colonies during and shortly after nesting; and 3) in the vicinity of fish stocking sites until the fish disperse. While it is too early to draw definitive conclusions, there is evidence that suggests that as a result of management, in some locations DCCO numbers have been reduced and that the corresponding fisheries have improved.

KEY WORDS double-crested cormorants, fisheries, damage management

Throughout much of the later half of the 20th century, double-crested cormorants (*Phalacrocorax auritus*; hereafter DCCOs) were quite rare in the Great Lakes basin. A census in 1970 indicated only 89 DCCO nests in the Great Lakes (Weseloh et al. 1995). Though not entirely understood, DCCOs underwent a tremendous increase in abundance in the Great Lakes basin with an estimated breeding population in 2000 of 115,000 nests that represents an increase of almost of 130,000% (Weseloh et al. 2002). As this unprecedented increase in abundance was occurring, concerns were raised regarding the effect of large populations of DCCOs on natural resources owned by the public such as vegetation and sport fish. This led the U.S. Fish and Wildlife Service (USFWS) to evaluate a range of alternatives through an Environmental Impact Statement process. In November 2003, the USFWS issued the Public Resource Depredation

Order (PRDO) that extended new authority to manage DCCOs in 24 states where the birds are damaging or threatening natural resources such as fisheries, native vegetation and co-nesting birds.

The authority to manage DCCOs is not unlimited (USFWS 2003). The PRDO is extended only to state wildlife agencies, federally-recognized tribes and USDA, APHIS, Wildlife Services (WS) or individuals acting as their volunteer "agents." Only certain methods are allowed and there are requirements to protect non-target species. There are requirements of the action agency to notify USFWS before acting and to report annually on results of actions taken.

Our objective is to describe DCCO management action under PRDO in Michigan during the first five years (2004–2008). During this time period, actions were independently taken by WS and five Native

American tribes. DCCO management on this scale in Michigan had never been attempted and, as such, presented some unique challenges. Some challenges were operational such as determining the staffing and equipment needs to conduct DCCO management safely. But central to our undertaking was this issue: Can we implement PRDO in a way that reduces the negative impacts of DCCOs to natural resources?

In preparation for the 2006 management season, representatives from Michigan Department of Natural Resources (MDNR) Fishery and Wildlife Divisions, USFWS and WS met to discuss, prioritize and coordinate management actions. In 2007, the tribes were included and the group became the Michigan Cormorant Coordinating Committee. This committee performs an advisory role and no agency surrenders its authority to act by participating.

Actions by WS

With the issuance of the PRDO, WS initiated DCCO management activities in the spring of 2004. In the years of 2004 through 2008, DCCO management has evolved to include three different efforts. They are actions: 1) taken during the nesting season at or near DCCO nesting colonies; 2) taken during DCCO migration in the spring; and 3) to protect stocked fish.

Nesting Season Management

The initial effort was focused at the 5 DCCO colonies adjacent to the Les Cheneaux Islands (LCI), an archipelago of 36 islands in northern Lake Huron. This island complex has supported a very productive and resilient yellow perch (*Perca flavescens*; hereafter perch) fishery for nearly a century (Lucchesi 1998). However, the yellow perch population there suffered an unprecedented collapse during the 1990s that was first documented in 2000 (Fielder 2003, Fielder

2008). MDNR had collected extensive fishery data in this area since 1969. An analysis provided by Fielder of this data set found that there was sufficient recruitment that should have sustained the fishery but that mortality was exceptionally high (Fielder 2003). High mortality is usually an indication of over-fishing but sport fishery harvest was extremely low, suggesting predation as the cause of the excessive mortality. The only new predator of significance was DCCOs that had arrived in significant numbers in the 1990s. This led Fielder to conclude that "it was compelling to conclude that cormorants were at least part of the explanation" for the collapse of the perch population (Fielder 2004).

The overall goal of management in LCI was to reduce DCCO foraging as a means of restoring the yellow perch fishery. Realizing that this would likely require management over several years, the 2004 goal was to oil all the eggs where we had access to the colonies and cull 15% of the adult birds.¹ The combination of these methods was found to be effective by Bedard (1999) in reducing DCCO populations in Quebec. Egg-oiling started in late May and was conducted 4 times at intervals of about 14 to 20 days because the incubation period for DCCO eggs is 25 to 28 days. We had access to 4 of the colonies and the vast majority of the nests were ground nests, making it possible to almost completely eliminate reproduction at those sites. Culling of adult DCCOs was conducted initially in the

¹ It is customary to refer to full-grown DCCOs as "adult" or "breeding birds" which is misleading. In fact, all that can be said is that these birds look like adult breeding birds because of their size or that they can fly. It is impossible to distinguish in the field between breeding birds, immature birds and birds fledged that year with any certainty. For the sake of brevity, we will continue to use the term "adults" or "breeding" but more accurately they should be considered as "assumed to be adult."

colonies with suppressed .22 rifles but DCCOs became very wary of that approach, rendering this method ineffective. More often, DCCOs were shot using 12-gauge shotguns and nontoxic shot at locations somewhat removed from the colonies, i.e., at rocky outcroppings used by DCCOs as loafing sites. Floating and silhouette decoys were found to be very effective for luring DCCOs into shooting range.

The first year served as a “learning curve year” during which we refined our operations of how to safely and effectively apply the methods. In following an adaptive management approach, we increased our percentage of culling in 2005 to 25% and in 2006 to 50%. In 2007, DCCO nesting populations had decreased by about 67% compared to the first year of management (2004) and the beginnings of a recovery were seen in the perch population. These tentative signs of progress prompted a decision by the MI Cormorant Coordinating Committee to set a maximum goal of 1,000 nesting pairs for the LCI DCCO colonies. In 2007 and 2008, WS removed the number of DCCOs that exceeded 1,000 pairs.

After 2004, management actions at nesting colonies were expanded to include other locations prompted by concerns of unacceptable effects on sport fish by DCCOs as identified by MDNR. The additional locations included colonies in Thunder Bay in Lake Huron and Bays de Noc in Lake Michigan, which were added in 2005, and the Beaver Islands and Ludington in 2007, both in Lake Michigan (Fig. 1).

One management action was conducted for the protection of vegetation. South Manitou Island is in northern Lake Michigan and is managed by the National Park Service (NPS) as part of Sleeping Bear Dunes National Lakeshore. A distinctive and valuable feature on the island is a stand of virgin white cedar (*Thuja occidentalis*) on the south end of the island. Not only are the

cedars valuable as natural resource, the trees also have cultural significance for Native Americans (R. Kewaygoshkum, Grand Traverse Band of Ottawa and Chippewa Indians, personal communication). For years, DCCOs have nested on a shipwreck approximately 500 yards from the south shore of South Manitou Island. In early 2005, approximately 245 DCCO pairs were observed nesting on the island itself, in trees very close to the cedars. Because it was thought that DCCOs would have a detrimental effect on the cedars, the NPS requested that 25% of adult DCCOs be removed for the 2006 nesting season. Because the nests were in trees, egg-oiling was impractical, leaving shooting as the only viable control method.

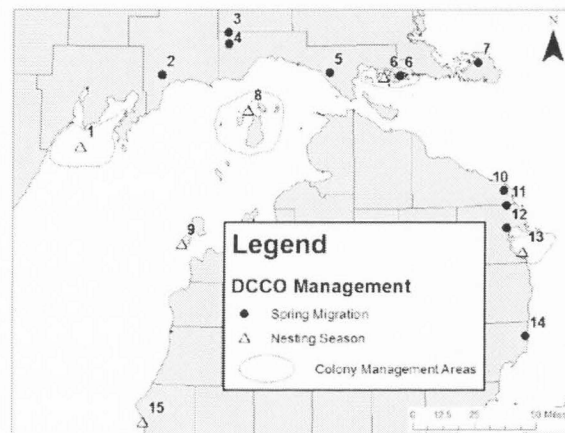


Figure 1. DCCO management locations under PRDO by WS in Michigan, USA 2004–2008. Individual sites are: 1 = Bays de Noc, 2 = Indian Lake, 3 = Manistique Lake, 4 = South Manistique Lake, 5 = Brevoort Lake, 6 = Les Cheneaux Islands, 7 = Drummond Island, 8 = Beaver Islands, 9 = South Manitou Island, 10 = Grand Lake, 11 = Long Lake, 12 = Thunder Bay River, 13 = Thunder Bay, 14 = Au Sable River, 15 = Ludington.

Spring Migration

Early in 2004, WS was presented with a different DCCO scenario at Maxton Bay, part of the larger Potagannissing Bay near Drummond Island in Lake Huron. This is an area of relatively small size (0.25 mi x 0.5

mi) where local residents reported that large numbers (up to 1,000) of DCCOs congregated daily for about 3 weeks from late April to mid-May. This congregation of DCCOs coincides with spawning activity of perch and walleye (*Sander vitreus*), both important sport fish. Fishery assessments by MDNR in 2002 suggested that total annual mortality for perch had increased for the St. Mary's River including Potagannissing Bay (Fielder et al. 2003). While not definitive, the profile is consistent with potentially higher mortality caused by increased predation by DCCOs (Dorr et al. 2010). The relatively brief but intensive nature of the DCCO behavior there called for a different strategy.

The WS staff was not numerous enough to provide the level of effort thought to be necessary to be effective in Maxton Bay; therefore, we elected to use a provision of the PRDO that allowed for volunteers to act as agents on behalf of WS. In doing so, we identified individuals from the community, mostly from the Drummond Island Sportsmen's Club, who would be able and willing to follow our plan for management. Management of DCCOs at Maxton Bay involved mostly harassment measures such as pyrotechnics, shooting to harass, and chasing with boats. The harassment was supplemented with limited amounts of lethal shooting with shotguns.

The number of agents selected at Maxton Bay was quite limited, generally about 16. Of those, only a very few (~4) were authorized to do lethal shooting. A coordinator was selected who was responsible for local coordination. All participants were required to attend a training session at which the guidelines of the project (i.e., when, where and how harassment could take place) were outlined. WS did provide some of the pyrotechnics but volunteers provided their own boats, gasoline and ammunition.

In 2005, the volunteer-based approach was expanded to include other locations that reported similar DCCO springtime congregations. These other locations included Long Lake, Grand Lake and Brevoort Lake and LCI. In 2006, Indian Lake, Manistique and South Manistique Lake were also included (Fig. 1).

Protecting Stocked Fish

It has been observed for several years that DCCOs forage, often in large numbers, at sites where hatchery-reared fish were released, potentially compromising the stocking effort. This was thought to be the case with the brown trout (*Salmo trutta*) in Thunder Bay, Lake Huron. In the 1980s and early 1990s, Thunder Bay was one of Lake Huron's most important put-grow-take brown trout fisheries (J. Johnson et al., Michigan Department of Natural Resources, unpublished report). Brown trout fingerlings were released in the spring and lingered in the shallow, warmer, near-shore water for up to 6 weeks during which time they were very vulnerable to DCCOs. MDNR attempted releasing the trout in deeper water but it did not work because the fingerlings promptly moved to the near-shore areas. Brown trout abundance and harvest declined sharply during the 1990s and the fishery collapsed after 1995; rising predation, principally by DCCOs, on recently stocked brown trout was believed to have been a leading cause of the collapse of this fishery (Johnson and Rakoczy 2004). An alternate release site was tried in Rockport, Michigan about 10 miles north of Thunder Bay that was thought to be less frequented by DCCOs yet close enough for the stocked brown trout to migrate to Thunder Bay where they had previously thrived. In 2005, WS implemented a harassment program using primarily volunteers at Rockport.

MDNR also identified the mouth of the Au Sable and Thunder Bay Rivers as sites

where hatchery-reared steelhead (*Oncorhynchus mykiss*) smolts released in the spring would need protection from DCCOs. Steelhead would linger at these sites for up to a week, again making them very vulnerable to DCCO predation. These stocking efforts, in which 150,000 fingerlings costing about \$1 apiece are released, are significant and valuable (J. Johnson, Michigan Department of Natural Resources, personal communication). In 2006, WS implemented a DCCO harassment program as was done at Rockport at the mouth of the Au Sable and Thunder Bay Rivers, conducted primarily by local agents.

The locations of these stocking sites were in the Au Sable River near Oscoda and in the Thunder Bay River in Alpena. The rivers coursed through populated areas and as such, made lethal shooting largely unsafe. Consequently, management relied primarily on harassment by WS employees and volunteers. Protecting steelhead in the Au Sable and Thunder Bay Rivers was a relatively brief effort, lasting approximately a week. Protection of brown trout at Rockport took much longer because the fish took up to six weeks to disperse.

Actions by the Tribes

Five Michigan tribes have conducted DCCO management actions under PRDO (Fig. 2). In all cases, action was initiated to protect fishery resources important to their members that exercised either commercial or subsistence fishing rights in the 1836 or 1842 treaty-ceded waters of Lakes Superior, Huron and Michigan. The following summarizes the actions by the tribes.

The Bay Mills Indian Community (BMIC) DCCO management was conducted in the Whitefish Bay and Waishkey Bay areas of eastern Lake Superior beginning in 2004 (Bay Mills 2004). BMIC's management action was initiated to protect naturally occurring lake whitefish

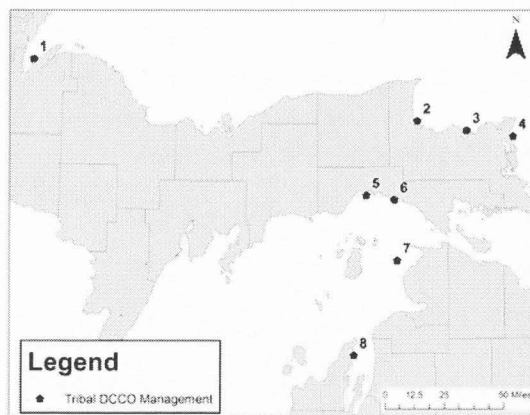


Figure 2. DCCO management locations under PRDO by tribes in Michigan, USA 2004–2008. Individual sites by tribe are: 1 = Keeweenaw Bay Indian Community; 2 and 3 = Bay Mills Indian Community; 4, 5, and 6 = Sault Ste. Marie Tribe of Chippewa Indians; 7 = Little Traverse Bay Bands of Odawa Indians; 8 = Grand Traverse Band of Ottawa and Chippewa Indians.

(*Coregonus clupeaformis*) and stocked walleye fingerlings. A large aggregation of lake whitefish spawns throughout southwest Whitefish Bay and their progeny inhabit the shallow areas from mid April through July. This age-0 fish would be very vulnerable to predation from the DCCO colony on nearby Tahquamenon Island. Approximately 100,000 fingerling walleye of 3.8–5.1 cm (1.5–2.0 inches) total length were stocked annually into Waishkey Bay during 1991–2008 to support both BMIC commercial and sport fisheries. In addition, Waishkey Bay contains an abundant perch population that supports a substantial sport fishery by BMIC members.

The Keweenaw Bay Indian Community conducted DCCO management in 2005 on a small lake within their reservation boundaries in the western Upper Peninsula of Michigan. The lake was stocked for a public fishing event and attracted a small number (10–20) of persistent DCCOs that were unaffected by harassment (Mensch 2005).

The Sault Ste. Marie Tribe of Chippewa Indians (SSM) conducted management actions starting in 2006 to reduce consumption of fish species important to SSM members. The objectives were to: 1) protect fingerling walleye stocked in the St. Marys River and Epoufette Bay, Lake Michigan (Fig. 1); 2) protect naturally reproducing populations of yellow perch in the St. Marys River and northern Lake Michigan; 3) reduce the incidence of cormorant scarring on lake whitefish in northern Lake Michigan; and 4) reduce the incidence of cormorant scarring on round whitefish (*Prosopium cylindraceum*) and protect their populations in northern Lake Michigan (Ebener 2007). SSM annually stocked about 300,000 fingerling walleye of 3.8–5.1 cm (1.5–2.0 inches) total length in the St. Marys River and about 50,000 fingerlings in Epoufette Bay, Lake Michigan during 1991–2008. Lake whitefish are the primary target of the tribal commercial fishery in northern Lake Michigan, while round whitefish have also supported a substantial fishery there. By 2005, round whitefish population abundance was dramatically reduced from levels observed ten years earlier and many commercial fisherman blamed cormorants. Egg-oiling and culling of less than 10% of adult DCCOs was conducted cooperatively with BMIC on Gem and Rock Islands in the Lake George area of the St. Marys River and on Naubinway and Paquin Islands in northern Lake Michigan (Fig. 1).

The Little Traverse Bay Bands of Odawa Indians' (LTBB) primary interests are in northern Lake Michigan in the area of the Beaver Islands that contains approximately 10,000 nesting pairs of DCCOs. The pressure exerted on important fish stocks by such a concentration of DCCOs is of particular concern to tribal commercial and subsistence fishers in the 1836 treaty-ceded waters. LTBB began management activities

in 2007 where they oiled eggs on Ile aux Galets Island (Lenhart 2007).

Grand Traverse Band of Ottawa and Chippewa Indians (GTB) DCCO management took place in northern Grand Traverse Bay near the town of Northport. Annually, GTB participates in the stocking of 80,000 to 100,000 walleye of 3.8–5.1 cm (1.5–2.0 inches) total length in Grand Traverse Bay of which approximately 2/3 are released in Northport Bay. Nearby, on Bellow Island, which is owned by the Leelanau Conservancy, is a colony of DCCOs which in 2006 contained 1,571 nesting pairs. The GTB was concerned that a colony that size plus an unknown number of non-breeders may have a significant negative effect on both forage and game species (Olsen and Winkler 2007).

RESULTS AND DISCUSSION

A summary of the cumulative number of DCCO nests oiled by agency and by year is provided in Table 1. Multiple visits are ordinarily made to every colony and all accessible eggs are oiled, making it possible for a particular nest to be oiled more than once.

A summary of the number of adult DCCOs culled by agency and by year is included in Table 2. This includes all birds taken during spring harassment, during the nesting season and at fish stocking sites.

WS Management Actions

To evaluate DCCO management, the LCI provides the best vantage point because of the depth of fishery data and longevity of management actions. DCCO numbers have been dramatically reduced from approximately 5,500 pairs in 2003 to 1,409 pairs in 2008 by nearly complete egg-oiling and a significant culling of adult birds. However, the DCCO reduction is confounded by the abandonment of one of the biggest colonies presumably caused by

Table 1. Total number of DCCO nests that were oiled in Michigan, USA by agency by year.

Agency*	Year					5-Year Total
	2004	2005	2006	2007	2008	
BM			607	731		
GT				3,329	2,741	
LTB				132	1,207	
SSM			4,177	3,339	4,166	
WS	3,114	2,991	9,205	9,935	10,475	
Total	3,114	2,991	13,989	17,466	18,589	56,149

* BM = Bay Mills Indian Community, GT = Grand Traverse Band of Ottawa and Chippewa Indians, LTB = Little Traverse Bay Bands of Odawa Indians, SSM = Sault Ste. Marie Tribe of Chippewa Indians, WS = USDA, Wildlife Services.

Table 2. Total number of DCCOs culled in Michigan, USA by agency by year.

Agency*	Year					5-Year Total
	2004	2005	2006	2007	2008	
BM	222	176	40	24	20	
GT				265	211	
KB		2				
SSM			280	118	39	
WS	1,197	2,601	5,447	7,360	7,953	
Total	1,419	2,779	5,767	7,767	8,223	25,955

* BM = Bay Mills Indian Community, GT = Grand Traverse Band of Ottawa and Chippewa Indians, KB = Keweenaw Bay Indian Community, SSM = Sault Ste. Marie Tribe of Chippewa Indians, WS = USDA, Wildlife Services.

the introduction of raccoons (*Procyon lotor*), perhaps as early as 2002 (Dorr et al. 2010b).

DCCO management in the LCI appeared to have a beneficial effect on local fisheries. Fielder (2010) found that perch abundance had increased unmistakably in the LCI. He analyzed seven key perch metrics and found that all responded significantly as DCCO abundance declined leading him to conclude "that the yellow perch population and fishery has reacted favorably in a substantial way to the decline of cormorant abundance and that control activities by the USDA's Wildlife Services has been successful." He also cautioned that the long-term forecast for the complete recovery of the perch fishery in the LCI is not clear but will likely depend on a variety of ecological and environmental factors, DCCO abundance being just one.

Dorr et al. (2010a) examined data from spring harassment efforts at Drummond Island and Brevoort Lake. Overall,

harassment prevented 83% of DCCO foraging attempts. In 2008, age-3 walleye at Brevoort Lake increased to record levels. Walleye and perch abundance also increased significantly at the Drummond Island site following management. This led to the conclusion that the "fisheries response in this study supported the underlying hypothesis that cormorant predation was a significant mortality factor and cormorant management reduced sport fish mortality and increased abundance at both locations." At many of the other harassment and shooting sites, anecdotal reports from local anglers also indicated a substantially improved fishery.

To comply with PRDO, management efforts have evolved to lessen the impacts on co-nesting herons, egrets, gulls and terns, which appear to be greatest during egg-oiling. To reduce the disruptive impacts of management, WS takes into consideration:

1) the breeding cycle of the co-nesting birds - DCCOs early in nesting are more likely to abandon; 2) the duration and weather conditions of the visit - visits that are short and that avoid extremely cold or hot temperatures have less negative impact; 3) behavior and sensitivity of the crew - maintain an awareness of the level of agitation of co-nesters and adjust accordingly; 4) consideration of the species composition of the co-nesting birds - potential for disruption increases as the number of co-nesting species increases; and 5) minimizing the frequency of visits - fewer visits means less disruption (USDA 2006).

Management actions at South Manitou were conducted for 2006 and 2007 but discontinued at the request of the NPS in 2008 when it appeared that DCCOs had not expanded into the cedars for nesting. NPS intends on monitoring DCCO nesting there (D. Schultz, National Park Service, personal communication).

Unfortunately, MDNR does not fund a creel census of the Au Sable River that might provide direct feedback on the effects of protecting hatchery-reared steelhead stocked there. However, anglers are reporting more spawning-phase steelhead returning to the Au Sable River than in recent years. The size of the steelhead observed corresponds to sizes that would be expected from fingerlings that were stocked during the years of DCCO management. While it is too early to make definitive conclusions, early signs are in the right direction (J. Johnson, MDNR, personal communication).

From 2005 through 2007, brown trout fingerlings were stocked at Rockport and harassment/shooting efforts appeared to be quite successful in repelling DCCOs. However, very few trout appeared to return to Thunder Bay as hoped and thus stocking at Rockport was abandoned. In 2008, the brown trout were again stocked in Thunder

Bay accompanied with the same DCCO harassment/shooting efforts as conducted at Rockport. There was no appreciable return of brown trout by this approach either. Spring stocking of brown trout in Thunder Bay is now considered to have failed from excessive predation by DCCOs and walleye (J. Johnson, MDNR, personal communication). The next plan is to stock brown trout fingerlings in October after the DCCOs have migrated south. Moreover, brown trout fingerlings in October will be bigger than walleyes can consume. DCCO management is still thought to be necessary to protect fall-stocked brown trout the following spring.

Tribal Management Actions

Management of DCCO by the five tribal governments was generally successful. The number of nesting DCCOs on Bellows Island in Grand Traverse Bay, Lake Michigan declined by 17.6% from 2007 to 2008 after one year to egg-oiling and culling (Table 1 and 2).

The SSM established 5 measurable milestones to evaluate effectiveness of management efforts and 4 have been met at least partially (Ebener 2008). The first milestone to reduce nesting success of DCCOs on islands in the St. Marys River and northern Lake Michigan (Fig. 1 sites 4–6) to less than 10% was achieved for both 2007 and 2008. The second milestone of by 2009, to reduce the incidence of DCCO scarring on lake whitefish and round whitefish by 25% compared to DCCO scarring during 2000–2005 was achieved as no scars were observed on lake whitefish in northern Lake Michigan in 2007 and 2008. The third milestone that by 2009, relative abundance of round whitefish should be at least 2 fish per 1000 feet during gill net surveys was not achieved but relative abundance of round whitefish did increase four-fold to 1.3 fish per 1000 feet of gill net

in 2008 from the average during 2004–2006. The fourth milestone that by 2009, nesting DCCOs on Paquin and on Naubinway islands in northern Lake Michigan would be reduced by 25% from the levels observed in 2006 was achieved as DCCO nests declined 49.8% on Paquin Island and 52.2% on Naubinway Island by 2008. The last milestone was that by 2009 relative abundance of age-0 and age-1+ walleye caught during electrofishing in September in the St. Mary's River should exceed 6 fish per hour could not be evaluated because no electrofishing was conducted in 2008.

The Grand Traverse Band also implemented measures to reduce disruptions during egg-oiling as part of the agreement with the Leelanau Conservancy to access Bellow Island in 2007. It involved the setting of a low-impact access path into the colony and an area of no-control adjacent to a Caspian tern colony on the north end of the island. No Caspian terns were observed to take flight as result of any GTB activities (Olsen and Winkler 2008).

CONCLUSION

In conclusion, there are some conditional successes that we can point to in our first 5 years of implementing PRDO. They are: 1) DCCO numbers have been reduced at the nesting areas with sustained applications of culling and egg-oiling; 2) DCCO foraging pressure can be reduced at spring migration congregation sites with harassment reinforced by limited shooting; 3) Volunteers enrolled as agents have augmented agency efforts in a productive way; 4) Fishery resources have responded in a positive way; and 5) An adaptive management approach has been a useful means with which to move ahead amidst the uncertainty that continues.

There are some unanswered questions. 1) A rebound in the fishery has not been observed in all locations. 2) It is not clear to

what degree the improved fisheries have actually recovered. 3) While it appears that DCCO management can be conducted with minimal impacts to co-nesting birds, this has not been completely verified. 4) It has not yet been determined at what population level are DCCOs compatible with a healthy fishery. These questions, and perhaps others, will be the focus on DCCO management in future PRDO actions in Michigan.

ACKNOWLEDGMENTS

We are deeply indebted to the employees of WS and tribes and to the many volunteers who performed the duties, often in difficult conditions, to achieve results in the field. We are grateful to J. Johnson and D. Fielder, MDNR Fisheries researchers, for providing invaluable insight into the interactions of DCCOs and fish. We thank T. Doyle and S. Lewis, both of the FWS and E. Olsen of the Grand Traverse Band for providing annual PRDO reports. S. Scott (MDNR), B. Dorr, (WS-NWRC) and T. Aderman (WS-MI) provided helpful editorial comments. B. Hughey (WS-MI) created the maps and D. Marks (WS-MI) created Tables 1 and 2. We acknowledge the MI Cormorant Coordinating Committee who has provided guidance and insight in implementing the PRDO. Finally, special recognition is due S. Hanisch, former FWS employee who for many years provided leadership and guidance to make the PRDO work.

LITERATURE CITED

- Bay Mills 2004. Final report, double-crested cormorant control, Bay Mills Indian Community. Bay Mills Indian Community, Biological Services, Brimley, Michigan, USA.
- Bédard, J., A. Nadeau, and M. Lepage. 1999. Double-crested cormorant culling in the St. Lawrence Estuary: results of a 5-year program. Pages 147–154 in M. E. Tobin, Technical Coordinator. Symposium on double-crested cormorants: population status and management issues in the Midwest. USDA, APHIS Technical Bulletin 1879, Washington, D.C., USA.

- Dorr, B. S., A. Moerke, M. Bur, C. Bassett, T. Aderman, D. Traynor, R. Singleton, P. H. Butchko, and J. D. Taylor II. 2010a. Evaluation of harassment of migrating double-crested cormorants to limit depredation on selected sport fisheries in Michigan. *Journal of Great Lakes Research* (In press).
- Dorr, B. S., T. Aderman, P. H. Butchko, and S. C. Barras. 2010b. Management effects on breeding and foraging numbers and movements of double-crested cormorants in the Les Cheneaux Islands, Lake Huron, Michigan. *Journal of Great Lakes Research* (In press).
- Ebener, M. 2007. Sault Ste. Marie Tribe of Chippewa and Bay Mills Indian Community cormorant control activities in 2007. Chippewa Ottawa Resource Authority, Sault Sainte Marie, Michigan, USA.
- Ebener, M. 2008. Sault Ste. Marie Tribe of Chippewa and Bay Mills Indian Community cormorant control activities in 2007. Chippewa Ottawa Resource Authority, Sault Sainte Marie, Michigan, USA.
- Fielder, D. G., D. J. Borgeson, A. K. Bowen, S. R. Koproski, S. J. Greenwood, and G. M. Wright. 2003. Population dynamics of the St. Marys River fish community 1975–2002. Great Lakes Fishery Commission. <<http://www.glfsc.org/lakecom/lhc/SMR2002rpt.pdf>>. Accessed 7 Sept 2009.
- Fielder, D. G. 2004. Collapse of the yellow perch fishery in Les Cheneaux Islands, Lake Huron and possible causes. *Proceedings of PERCIS III, the International Percid Fish Symposium* 3:129–130.
- Fielder, D. G. 2008. Examination of factors contributing to decline of the yellow perch population and fishery in Les Cheneaux, Lake Huron, with emphasis on the role of double-crested Cormorants. *Journal of Great Lakes Research* 34:506–523.
- Fielder, D. G. 2010. Response of yellow perch in Les Cheneaux Islands, Lake Huron to declining numbers of double-crested cormorants stemming from control activities. *Journal of Great Lakes Research* (In press).
- Johnson, J. E., and G.P. Rakoczy. 2004. Investigations into recent declines in survival of brown trout stocked in Lake Charlevoix and Thunder Bay, Lake Huron. Michigan Department of Natural Resources Fisheries Technical Report 2075, Lansing, Michigan, USA.
- Lenhart, S. 2007. Little Traverse Bay Band of Odawa Indians cormorant management summary for 2007. Little Traverse Bay Band of Odawa Indians, Natural Resources Department, Harbor Springs, Michigan, USA.
- Lucchesi, D. O. 1988. A biological analysis of the yellow perch population in the LesCheneaux Islands, Lake Huron. Michigan Department of Natural Resources, Fisheries Research Report No. 1958, Ann Arbor, Michigan, USA.
- Mensch, G. 2005. Summary of efforts to lethally control double-crested cormorants (DCCO) depredation on the Keweenaw Bay Indian Community L'Anse Reservation. Report to S. Wilds, US Fish and Wildlife Service. Keweenaw Bay Indian Community, Natural Resource Department, L'Anse, Michigan, USA.
- Olsen, E., and N. Winkler. 2007. Grand Traverse Band of Ottawa and Chippewa Indians double-crested cormorant control activities on Bellow Island, Northport Bay, 2007. Grand Traverse Band of Ottawa and Chippewa Indians, Natural Resource Department, Suttons Bay, Michigan, USA.
- Olsen, E., and N. Winkler. 2008. Grand Traverse Band of Ottawa and Chippewa Indians double-crested cormorant control activities on Bellow Island, Northport Bay, 2008. Grand Traverse Band of Ottawa and Chippewa Indians, Natural Resource Department, Suttons Bay, Michigan, USA.
- U.S. Fish and Wildlife Service. 2003. Migratory bird permits; regulations for double-crested cormorant management. Final Rule, Federal Register 68:58022–58037. U.S. Fish and Wildlife Service. Washington, D.C., USA.
- Weseloh, D. V., P. J. Ewins, J. Struger, P. Mineau, C. A. Bishop, S. Postupalsky, and J. P. Ludwig. 1995. Double-crested cormorants of the Great Lakes: changes in population size, breeding distribution and reproductive output between 1913 and 1991. *Colonial Waterbirds* 18 (Special Publication 1):48–59.
- Weseloh, D. V., C. Pekarik, T. Havelka, G. Barrett, and J. Reid. 2002. Population trends and colony locations of double-crested cormorants in the Canadian Great Lakes and immediately adjacent areas, 1990–2000: a manager's guide. *Journal of Great Lakes Research*. 28 (20):125–144.
- U.S. Department of Agriculture. 2006. Final amendment to the environmental assessment: reducing double-crested cormorant damage in Michigan. United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Okemos, Michigan, USA.