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Trends in Agency Use of Propagated Fishes as a Management Tool in Inland Fisheries

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Abstract.—The use of cultured fishes by fisheries agencies is a long-standing management technique. In recent decades, however, potential negative impacts of fish stocking programs have received increased attention, particularly as they affect native fish communities and the genetic integrity of wild fish populations. In 1994, a facilitated workshop was organized to develop recommended procedures for the use of cultured fishes that would be compatible with these broader environmental concerns. We administered a survey to state and provincial fisheries management agencies in the United States and Canada to determine the current status of fish culture and stocking programs and assess progress toward adoption of these procedures. With 54 of 62 agencies reporting, our results indicated that stocking programs continue to be an integral part of management programs, but that substantial progress has been made toward addressing concerns about potential negative effects of cultured fishes. The percentage of responding agencies reporting use of management plans in which stocking was considered as part of a larger management program more than doubled in the years since 1980. Consistent with this finding, agency emphasis on alternative management approaches was evidenced by a twofold greater increase in expenditures on habitat management programs relative to culture programs in six agencies that provided budget figures. The percentage of responding agencies evaluating appropriateness of stocking through the use of formal criteria on at least half the waters where cultured fish were used tripled since 1980, and decisions not to stock due to potential impacts on biodiversity or the genetic integrity of recipient fish communities were reported to be four times more likely today than in 1980. Emphasis on the use of native fishes in stocking programs since 1980 was reported to have increased for more than half the agencies responding to our survey, and the number of agencies reporting development of broodstock plans for at least some of the species they cultured also doubled since 1980. Agency perceptions of angler attitudes concerning the importance of stocking indicated that the percentage of anglers who believed that stocking was the primary or only solution to low fish abundance remained high, at 61%, a decline of only 27% from reported attitudes in 1980. While positive strides have been made by agencies toward more careful evaluation of the appropriateness of stocking for achieving management objectives and in the institution of programs to minimize impacts of cultured fishes, these policies have not been adopted by all agencies, nor are they routinely used on all stocked waters by the agencies that have them. To make continued progress, agencies may be required to make difficult decisions regarding allocation of funding, and a more concerted effort to educate anglers and reduce

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public pressure for stockings will be needed to create an atmosphere where reduced emphasis on stocking is possible. The American Fisheries Society should play a continuing role in providing opportunities for scientists and policy makers to interact and discuss prevailing and emerging issues relative to the use of propagated fishes in resource management.

Introduction

The use of hatchery-produced fishes to sustain, restore or create fisheries dates back to the very origins of agency efforts to manage fisheries. Bowen (1970) cited the Massachusetts Fish Commission as the first governmental fisheries management agency in North America to include propagation and stocking as part of a larger management plan, recommending it for restoration of anadromous fish runs in 1856. By 1871, six state fish commissions had been formed in New England, all of which participated in efforts to restore American shad *Alosa sapidissima* and Atlantic salmon *Salmo salar* runs through hatchery programs (Bowen 1970). In 1870, a group of influential private fish culturists met in New York City and formed The American Fish Culturists' Association (AFCA), an organization that adopted today's name of The American Fisheries Society (AFS) in 1884 (Thompson 1970). Largely due to the influence of the AFCA, propagated fishes were viewed as a panacea for declining or unproductive fisheries. As a result of a strong AFCA-led lobbying effort, development of hatcheries and stocking programs was added to the mission of the U.S. Commission of Fish and Fisheries in 1872, only 1 year after its original congressional authorization as an investigative agency (Baird 1877).

Livingston Stone, on behalf of the Commission of Fish and Fisheries, toured Pacific Coast salmon fisheries in 1872 to locate potential sites for a federal hatchery and set the stage for transcontinental transfer and introduction of commercially valuable fish species (Taylor 1999; Leonard, no date). Stocking had become the dominant fisheries management activity by the turn of the century, and programs were established for inland as well as coastal fisheries and included widespread introductions as well as restoration projects (Bowen 1970). The continuing faith with which hatcheries were viewed as the solution to sustaining productive fisheries without compromising natural resource development is evident in the 1910 president's address at the AFS Annual Meeting (Bower 1910): "'Conservation of resources' is a misleading and deceptive phrase if it means that such of the natural resources of the earth as may be reproduced, as are subject to cultivation, are to be tied up and locked up and withdrawn from use."

The modern era of fisheries management reflects substantial changes from early philosophies promoting the use of fish stocking as a way to avoid the necessity of restricting fisheries or limiting the exploitation of other natural resources in order to protect aquatic habitats (Nielsen 1999). Sustainable fisheries development is now recognized to require integrated approaches that include consideration of habitats and management of user groups as well as direct management or manipulation of fish populations. Even within the context of this more holistic approach, stocking of hatchery-produced fishes remains a common and valuable tool for managers. As of 1996, Heidinger (1999) estimated some 2.5 billion sport fishes were being stocked annually in the United States and Canada.

According to Heidinger (1999), fisheries managers had accumulated enough negative experiences by the 1960s to realize that stocking, like any other management practice, had limits in the range of problems it could effectively be used to solve. In the decades that have ensued, the use of hatchery-produced fishes in fisheries management has come under increasing scrutiny and the issues surrounding what, where, and even if to stock have become increasingly complex as concerns over biodiversity and genetics have been brought into the sometimes heated debates over the use of cultured fishes. At the same time that the science of fisheries management has allowed more detailed assessments of the effects of cultured fish in natural systems, an increasingly informed public has demanded a greater voice in environmental management, adding an arguably more diverse and complex layer of societal priorities to the debate over the biological issues surrounding fish stocking (Radonski and Loftus 1995).

The current volume represents the third such effort organized under the aegis of AFS, and the contents of the previous volumes provide a convenient capsule history of how the issues surrounding the use of cultured fishes have evolved in recent decades (Stroud 1986; Schramm and Piper 1995). The proceedings from the 1985 symposium "Fish Culture in Fisheries Management" contained 43 papers, excluding keynote and summary papers (Stroud 1986). The contents of this volume reflect an emphasis on enhancing the effectiveness of stocking as a management

tool, with 35 (81%) of the papers broadly directed at establishing improved criteria for stocking programs, improved culture techniques and better poststocking assessments. Only 8 papers (19%) can be broadly categorized as cautionary, representing a roughly equal mix of genetic and biodiversity concerns. The shift in emphasis by the time of the second symposium in 1994 is immediately evidenced by its title: "Uses and Effects of Cultured Fishes in Aquatic Ecosystems" (Schramm and Piper 1995). Of the 59 technical papers published in the proceedings of the second symposium, 30 (51%) can be characterized as reporting success in the use of cultured fishes or recommending techniques for improvement of hatchery contributions to natural systems. A noticeable increase in the emphasis on cautionary themes is reflected by the 22 papers (37%) that fell into the broad category of characterizing negative impacts of hatchery fish or were directed at methods for minimizing these impacts, with a strong emphasis on genetic considerations. Finally, a new area of emphasis emerged in the 1995 symposium—that of using hatcheries to restore threatened and endangered species or stocks, represented in 7 papers (12%).

As a follow up to the 1994 symposium, a workshop was organized, including representatives from a variety of fisheries management agencies, in an effort to develop a blueprint for the future of cultured fish as a management tool. The resulting document reflected many of the concerns that had emerged over stocking in the two symposia and organized under six broad categories recommended guidelines for making decisions regarding future uses of cultured fishes (Anonymous 1995). The guidelines included specific recommendations under the category "Biological Feasibility" for prestocking assessments directed at determining the appropriateness of stocking relative to defined management objectives, including assessments of existing fish populations, availability of adequate forage, and opportunities for alternate management approaches. Under the title "Effects Analysis," the guidelines recommended careful prestocking evaluations of potential negative effects of stocked fish, including impacts on biodiversity, genetic composition of wild populations, introduction of diseases, and escapement into nontarget systems. This section also included the recommendation of careful poststocking evaluations to monitor the impact of cultured fishes and facilitate change or termination of stocking programs where negative impacts are detected or objectives are not being met. Additional sections of the document included "Economic Evaluation," calling for more detailed cost–benefit analyses of stocking programs; "Public Involvement," encouraging development of mechanisms for soliciting public input into stocking decisions; "Interagency Cooperation," which encouraged more codified recognition of the interjurisdictional impacts of stocking programs; and "Administrative Considerations," which addressed the application of the earlier recommendations within an administrative framework.

In this paper, we report the results of a survey of fisheries management agencies in the United States and Canada concerning the present state of and recent trends in hatchery programs and the use of cultured fishes. The survey was designed to allow assessment of how agencies have adapted their hatchery and stocking programs in the face of recent concerns and the extent to which recommendations from the 1994 workshop have been incorporated in agency policies. Additionally, respondents were asked to forecast those issues surrounding the use of cultured fishes that they felt would likely shape the future of this long-standing management technique in their agencies.

Methods

Survey Development and Administration

We developed a survey to assess trends in agency use of and policies concerning cultured fishes in fisheries management since 1980. The survey was designed so that it could be completed in approximately 45 min. Prior to finalization of the survey, reviews of an early draft were solicited from five agency fishery chiefs to ensure that questions were realistic and consistent with our objectives. The final version of the survey was sent electronically to fisheries management agency chiefs in all 50 states in the United States and the 12 provinces and territories of Canada using the mailing list of the AFS Fisheries Administrators Section and accompanied by a letter requesting cooperation from the president of the section. A follow-up reminder was sent to all nonrespondents a month after the initial mailing, and a second reminder 2 weeks later.

The Survey

The final survey was 17 pages long and included 38 questions. The survey was organized into five sections (four sections with specific questions followed by an opportunity for general comments; one section with a single open-ended question). Two questions concerning familiarity with and influence of the previous AFS

publications on cultured fishes preceded the survey proper. With the exception of open-ended questions intended to provide opportunities for additional comments, most questions were designed to be answered by selection of the most appropriate from a range of possible answers (i.e., a range of levels of increase or decrease in a practice or a range in percent of water bodies where a practice was employed). In general, we provided a range of five possible answers for each question to gain sufficient separation of answers to detect trends through time. Most questions were designed to track changes over the course of three time periods: before 1980, 1980–1990, and 1990 to the present.

The first section of the survey, "General Trends in Use of Propagated Fishes," asked respondents for general impressions on changes in the importance of stocking, trends in the level of required prestocking justification, and trends in poststocking assessments in their agencies. Section 2, "Trends in Hatchery Practices and Resources," included questions on trends in the number of species cultured for management purposes, hatchery production potential (both extensive and intensive), number of water bodies stocked, fish culture expenditures relative to habitat restoration programs, changes in culture practices to improve stocking success, utilization of nonnative species/nonnative genetic strains and hybrids, emphasis on use of native species, introduction of new species, and development of broodstock plans. Section 3, "Trends in Procedural Practices," included questions on trends in the extent of participation by other government agencies (i.e., federal agencies and tribal governments), requirements for formal management plans in which stocking is part of broader programs, establishment of measurable objectives for stocking programs, written policies requiring meeting of specific criteria before stocking, policies regarding potential genetic impacts on recipient populations, consideration of biodiversity issues, and level of poststocking assessments. Section 4, "Stocking and Public Relations," included questions intended to determine trends in angler attitudes about the importance of stocking as a management tool (or at least agency perspectives on these attitudes), concerns about stocking from the nonangling public, the importance of public pressure in stocking decisions, existence of privately conducted stocking programs, and outreach programs designed to educate the public about stocking. The final section provided an open-ended opportunity for respondents to speculate about emerging issues and future directions in their agency's use of cultured fishes in fisheries management.

Results

We received responses from 44 out of 50 United States agencies, and 10 of 12 Canadian agencies, for a total response rate of 87%. While some agency chiefs completed the survey themselves, responsibility was often delegated. As a result, responses came from a cross section of agency personnel, including both management and culture specialists.

Influence of Previous Symposia

Of the 54 respondents, 81% indicated at least some familiarity with the previous two AFS symposia on use of cultured fishes in fisheries management, although only 22% indicated that they were "very" familiar with the publications. Despite the high level of familiarity with the two symposia, 33% of respondents reported that the publications had no influence on their agency's polices, with 63% indicating some level of influence and only 4% responding that the symposia had substantial influence.

General Trends in Use of Propagated Fishes

Survey responses did not indicate a strong trend toward de-emphasis of stocking relative to other management practices (Figure 1A). Nineteen of the 54 respondents reported that there was no change in their agency's emphasis on stocking during the period 1980–1990, as compared to before 1980, while 33% indicated that stocking was relatively more important, and 31% said it was less so. In the period since 1990, 30% of responding agencies indicated that stocking was more important than in the period 1980–1990, while 37% said the relative importance of stocking had decreased.

Responses to the survey did reveal a strong trend toward increased agency requirements for justification prior to decisions to stock (Figure 1B). For the 1980s, 63% of respondents indicated that requirements for stocking justifications had increased relative the period before that, with 91% of responding agencies indicating further increases in the years since 1990. No agency reported reduced justification requirements in the years since 1990.

As with prestocking justification, survey respondents also indicated that poststocking assessments were becoming more common than in the past (Figure 1C). Half of the 54 respondents indicated that poststocking assessments increased during the years 1980–1990,

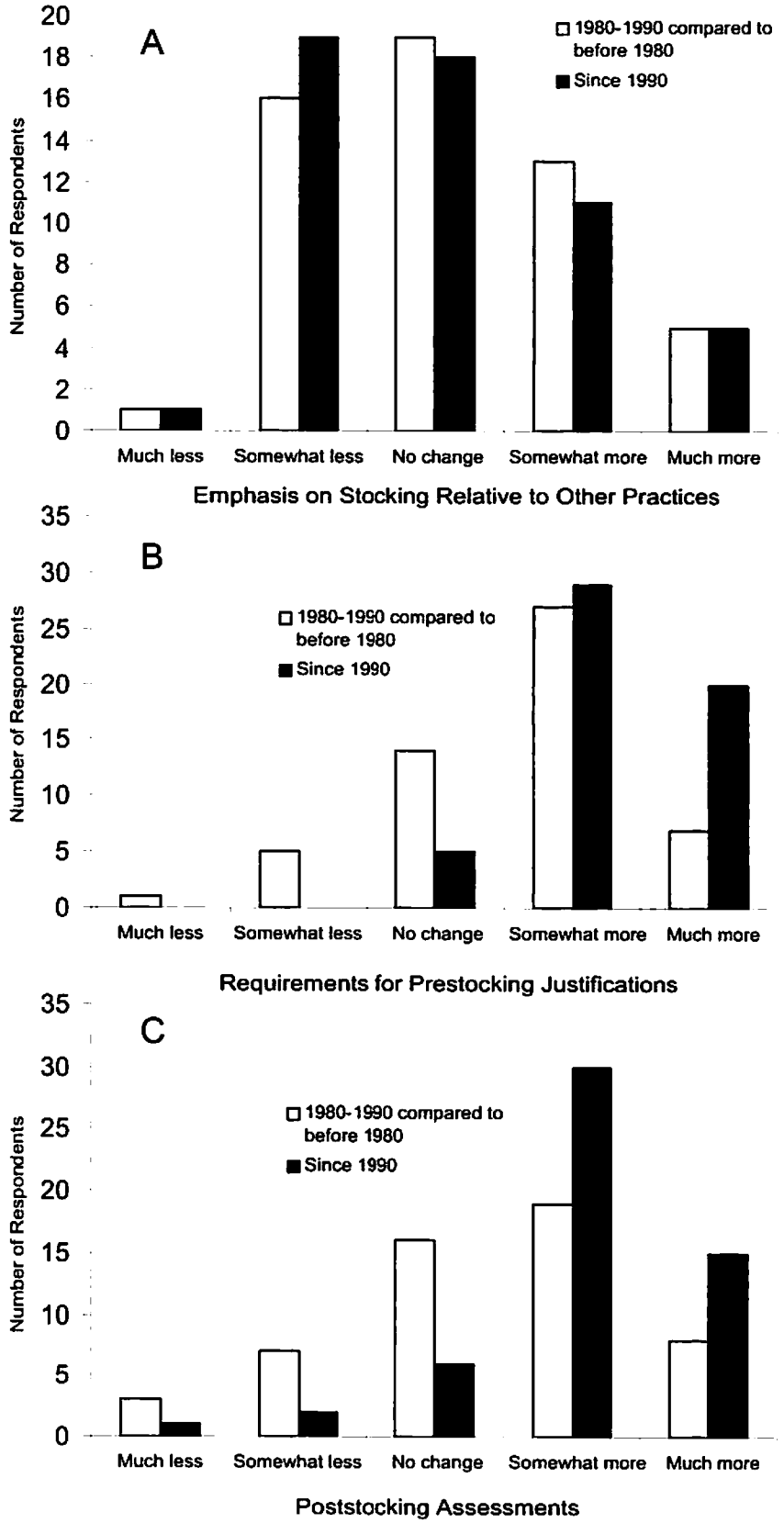

Figure 1. Trends in agency emphasis on stocking relative to other management practices (A); requirements for prestocking justifications (B); and detailed poststocking assessments (C).

with 83% of agencies further increasing poststocking assessments since 1990. Only 6% of respondents indicated that their agencies had reduced poststocking assessments since 1990.

Trends in Hatchery Practices and Resources

Trends in the number of species (including hybrids) cultured by agencies for management purposes did not exhibit a consistent pattern, but there was some indication that the addition of new species to stocking programs has slowed in recent years. Of the 53 respondents (one responding agency did not have a hatchery program), 58% reported that their agencies cultured more species during the years 1980–1990 than were cultured prior to that, with 15% reporting reductions in the number of species cultured during the same period. Since 1990, 42% of responding agencies have added new species to their culture programs, while 25% reported reductions. Hybrid and sterile fishes accounted for the majority of new species reported in culture and stocking programs (61% of new species during the period 1980–1990; 59% since 1990). Exotics and nonnative species were added to the stocking programs of seven agencies between 1980 and 1990, and to six agency programs since 1990. Five agencies added new native species to their stocking programs between 1980 and 1990, while 10 agencies have done so since 1990.

Salmonid species were the most commonly cultured group according to survey responses, with 91% of agencies reporting culture programs for at least one species (Figure 2). Percid species were the second most commonly cultured group (60% of responding agencies), followed by centrarchids (58%). No clear time trends in agency use of species groups were evident, and the reductions in the number of species cultured were not conspicuously focused in specific groups. Esocid culture programs had been dropped by 19% of responding agencies, and centrarchid programs by 13%, but no pronounced movement by agencies away from specific species was evident in survey responses.

Survey responses indicated a clear increase in the incorporation of broodstock management plans in agency culture programs (the survey indicated that plans should address fish origins, estimates of effective population size, maintenance methods, breeding plans and production schedules). Thirty-nine of 54 respondents (72%) reported that broodstock plans were in place for at least some of the species their agency cultured, up from 52% reported for the period 1980–1990, and 33% prior to 1980 (Figure 3). Broodstock plans were most common for salmonid species, with 63% of the

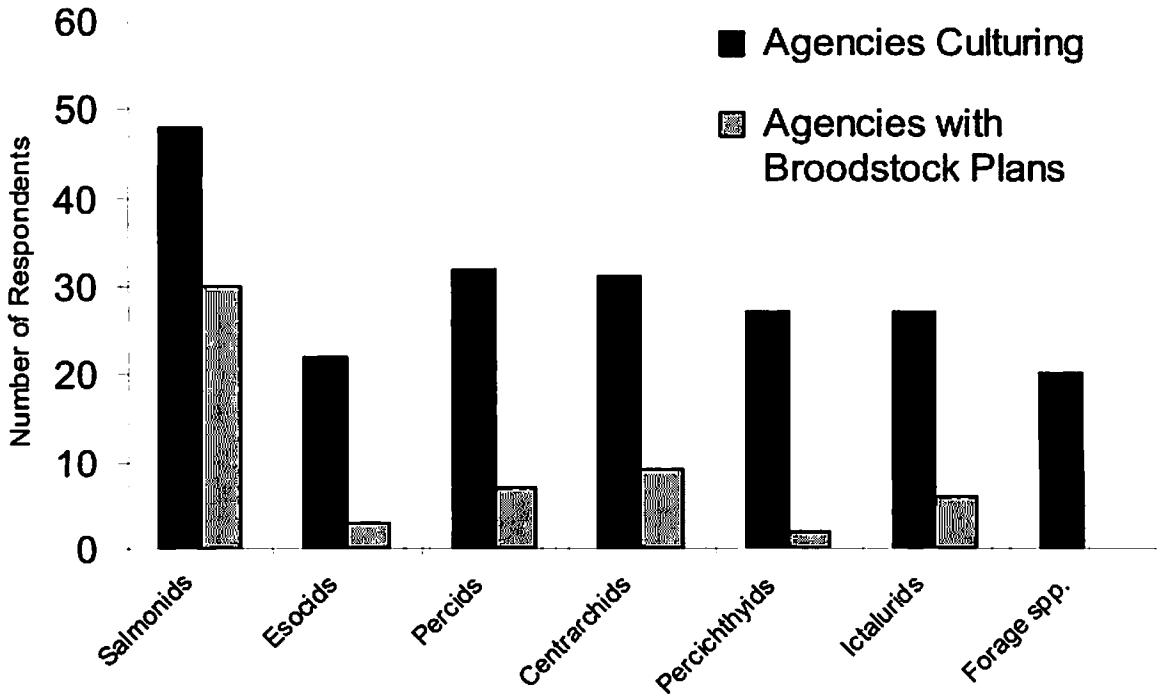

Figure 2. Number of responding agencies currently culturing major fish species groups and number of agencies with broodstock plans for species within species groups.

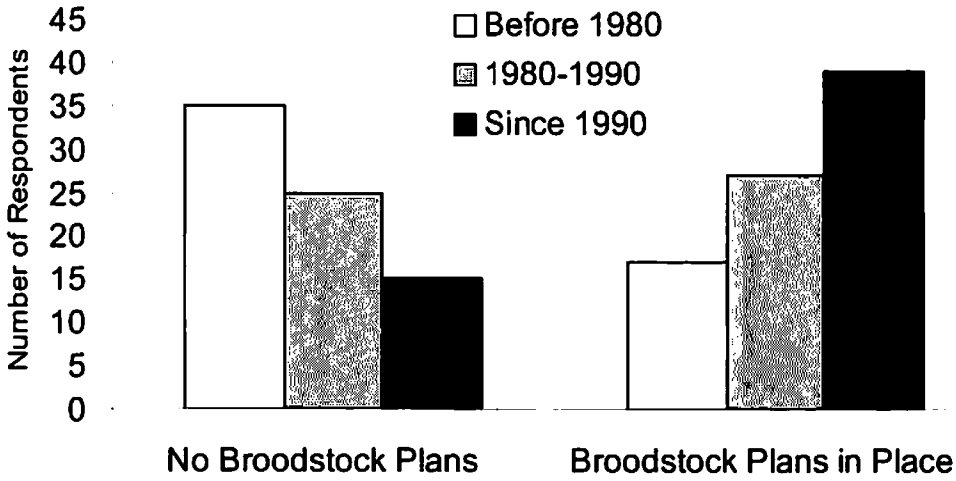

Figure 3. Trends in the use of broodstock management plans in agency culture programs.

agencies culturing salmonids reporting the use of broodstock plans (Figure 2). Broodstock management plans were in place in 29% of reported centrarchid culture programs and 22% of percid programs.

Respondents reported increases in agency potential for extensive (pond) culture throughout the period from 1980 through the present. Pond production potential increased for 51% of reporting agencies between 1980 and 1990, and 53% since 1990. Only 15% of respondents reported decreases in extensive culture potential between 1980 and 1990, and 11% in the years since 1990. Similar trends were evident in agency potential for intensive culture with 57% of agencies increasing potential between 1980 and 1990 and 56% indicating increases since 1990. Decreases in intensive culture capabilities were reported by 9% of respondents for the period 1980–1990, and 15% for the years since 1990.

Survey responses indicated that the number of water bodies stocked by management agencies has increased over time, but the rate has slowed since 1980. Thirty-four of 54 respondents (63%) reported that the number of water bodies their agency stocked increased between 1980 and 1990, with 17% reporting decreases. Since 1990, increases in water bodies stocked were reported by 54% of respondents and decreases by 24%.

In an effort to determine if agencies were placing relatively more emphasis on management strategies other than stocking of cultured fishes, we asked for estimates of expenditures on stocking programs and habitat management programs in 1980, 1990, and 2002. If financial figures were not available, we asked for the respondent's impression of relative expenditures over the last 20 years. Only six respondents were able to provide estimates of expenditures for all 3 years, but their numbers indicate that expenditures on habitat are increasing at a faster rate than those on stocking programs. For the year 1980, expenditures for stocking programs averaged 6.6× those for habitat programs in the six reporting agencies. By 1990, the difference had declined to 4.2×, and by 2002–2.7×. These trends were consistent with the impressions of relative expenditures provided by other respondents. Respondents reported that over the last 20 years expenditures on habitat had increased more than those for stocking programs in 52% of agencies responding to the survey, while stocking programs had received greater relative increases in expenditures in 38% of agencies.

Survey respondents reported that agency utilization of nonnative species and genetic strains had declined over the last decade (Figure 4A). While 31% of the 54 respondents reported that use of nonnative fishes had increased during the years 1980—1990 (13% reported decreased use during the same period), only 15% indicated that additional increases in use of nonnative fishes had occurred since 1990, with 33% of agencies reporting decreased use of nonnative fishes. The use of interspecific hybrids has shown an increase in recent decades (Figure 4B). Of the 54 respondents, 41% reported their agencies had increased use of hybrids during the period 1980–1990, with only 7% of agencies reporting decreased utilization of hybrids during the same period. Since 1990, 22% of reporting agencies have further increased use of hybrids, while 19% reported decreased use.

The most dramatic shift in agency emphasis on

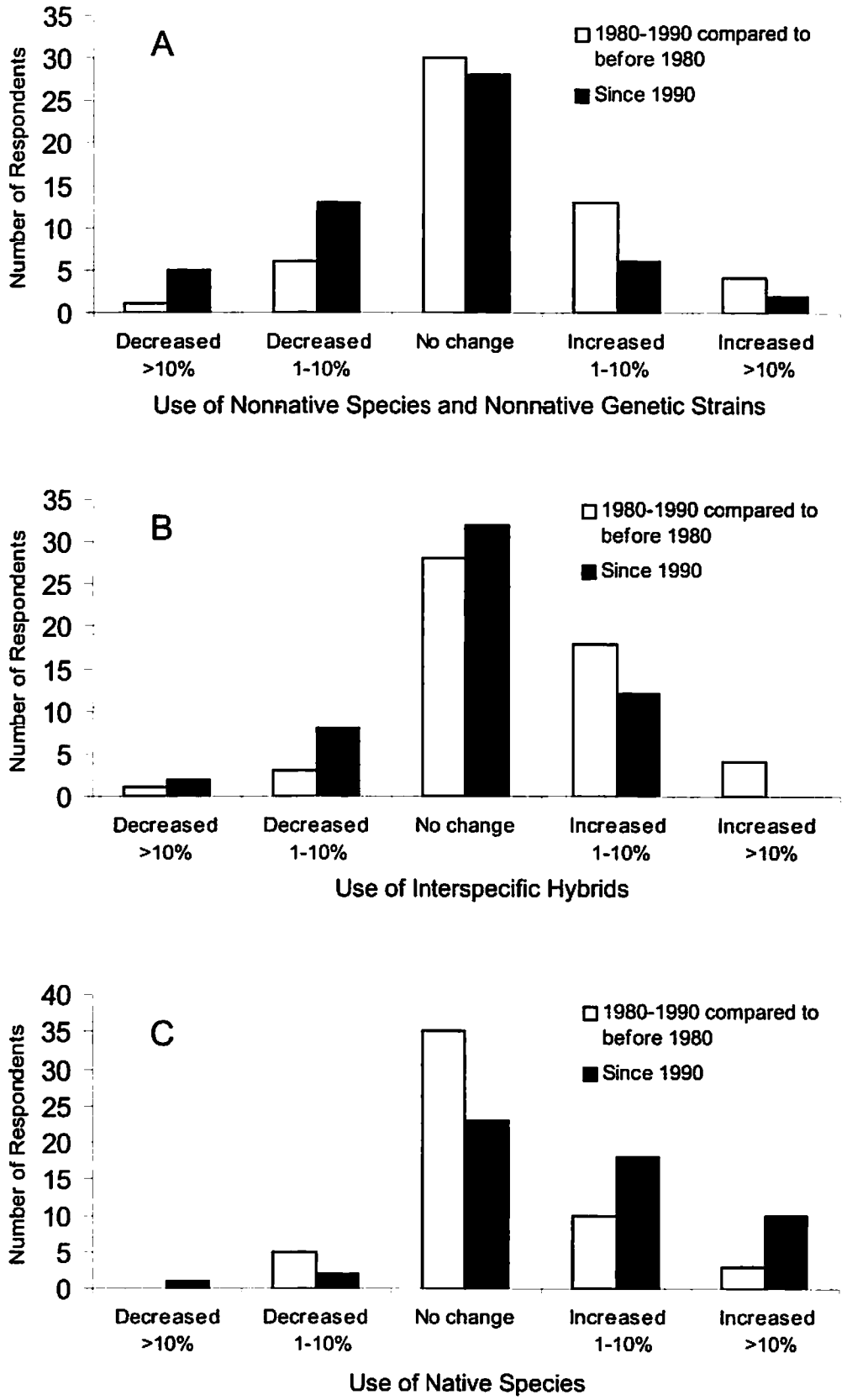

Figure 4. Trends in utilization of nonnative species/nonnative genetic strains (A); interspecific hybrid strains (B); and native species (C); in stocking programs.

types of fishes used in culture-based management programs was an increase in the use of native species (Figure 4C). The 54 respondents reported that 24% of agency stocking programs increased their emphasis on use of native fishes between 1980 and 1990, and 52% of agencies have increased use of native fish since 1990. Only 9% of respondents reported that native fish use in stocking programs had decreased between 1980 and 1990, with only 6% reporting declined use since 1990. Some of the increase in emphasis on native fishes is likely accounted for by the growing number of culture programs directed at restoration of threatened and endangered species, which are being conducted by 42% of the agencies responding to our survey.

In addition to the changing emphases in the types of fish being cultured by agencies for management purposes, respondents also indicated that substantive changes had taken place in the last 20 years directed at improving survival of stocked fish. Responses indicated that 85% of agencies have instituted changes in culture practices to improve stocking success. The most common practice in the past 20 years has been to increase the sizes of fish being stocked, with 75% of the 44 respondents who provided descriptions of new culture techniques reporting implementation of this practice. Six (14%) of the 44 respondents reported that their agencies had implemented changes in environmental or feeding conditions in which fish were raised, 7% have changed techniques to reduce disease, and 5% have modified transport practices.

Trends in Procedural Practices

Respondents reported a sharp increase in the percentage of waters where stocking of cultured fishes was only part of a more comprehensive management plan (Figure 5A). Prior to 1980, only 21% of responding agencies had such plans for more than 50% of the waters where they used cultured fishes. Between 1980 and 1990, this number rose to 35%, and since 1990 has increased further to 51%. Whereas 42% of responding agencies had no such plans in place prior to 1980, only 23% of agencies were currently without formal management plans where cultured fishes were used.

Similarly, survey responses indicated that the establishment of finite (measurable) objectives had become more common in recent years (Figure 5B). As of 1980, 44% of responding agencies did not require measurable objectives as part of any of their stocking programs, with this number subsequently declining to 25% over the last 20 years. In 1980, only 13% of agencies responding to our survey used measurable objectives for more than half of the waters where cultured fishes were used. Between 1980 and 1990, this number rose to 31%, and currently 44% of the responding agencies require measurable objectives for the use of cultured fishes in at least half of the waters they stock. Of those agencies requiring measurable objectives as part of stocking programs, 63% of the respondents reported that failure to meet objectives led to discontinuation or modification of stocking programs "most of the time," and 35% "some of the time." No respondents indicated that achievement or nonachievement of objectives was unimportant in making decisions regarding the future of stocking programs.

Consistent with the trends in usage of management plans and measurable stocking objectives, written policies requiring that specific criteria and/or conditions be met prior to decisions to stock cultured fishes increased dramatically over the time period covered by the survey (Figure 6A). Twenty-one (41%) of the respondents reported that their agencies had no such required policies in place prior to 1980, and only 18% of agencies were using them on more than 50% of the waters they stocked in 1980. During the period 1980–1990, the number of responding agencies using formalized stocking criteria on at least half of the waters they stocked increased to 45%, with 64% of the reporting agencies currently having formal criteria in place for at least 50% of the waters being stocked. Despite the overall increased use of formal stocking criteria, 26% of responding agencies reported that they did not currently have such requirements. Of the 41 respondents providing details about the nature of criteria used by their agencies, potential impacts on existing fish communities was the most commonly used criteria, reported by 30 agencies (Figure 6B). Potential escapement of cultured fish was part of prestocking assessment criteria for 29 agencies, adequate forage for 28, and potential for genetic contamination of recipient populations for 27.

Poststocking assessments of cultured fishes have also become a more common feature of agency policies over the past 20 years (Figure 7A). While only 19% of responding agencies reported that such assessments were conducted on 50% or more of the waters they stocked prior to 1980, this percentage rose to 26% between 1980 and 1990, and currently 42% of the agencies responding to our survey conduct poststocking assessments on at least half the waters where cultured fishes are used. In addition to routine (standardized) surveys of stocked waters, 90% of the

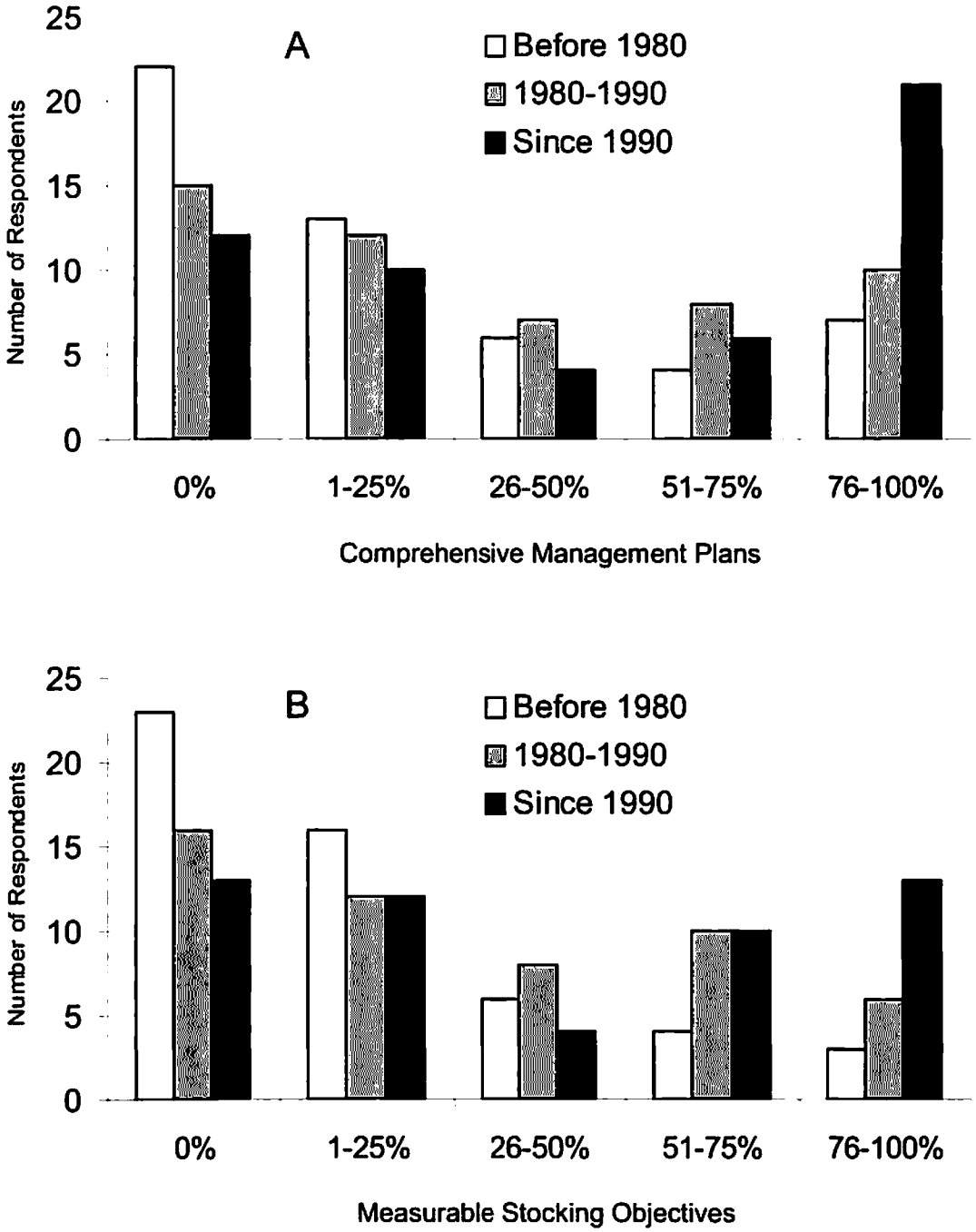

Figure 5. Trends in percent of stocked waters where agencies require comprehensive management plans where cultured fish are used (A); and agency requirements for finite (measurable) objectives in stocking programs (B).

50 agencies reporting poststocking assessment methods used marked fish, 84% implemented creel surveys to assess stocking success, and 72% conducted intensified or directed sampling to assess stocking success (Figure 7B). Cost–benefit analyses of stocking programs were conducted by 30% of reporting agencies.

Decisions not to use cultured fishes due to concerns of genetic contamination of recipient populations have increased sharply in the last 20 years for agencies responding to our survey (Figure 8A). Prior to 1980, only 21% of respondents indicated that genetic concerns led to decisions not to stock in their agencies. This percentage rose to 51% between 1980 and 1990, and 96% of the agency respondents reported that their agencies have made decisions not to stock based on concerns about genetic contamination

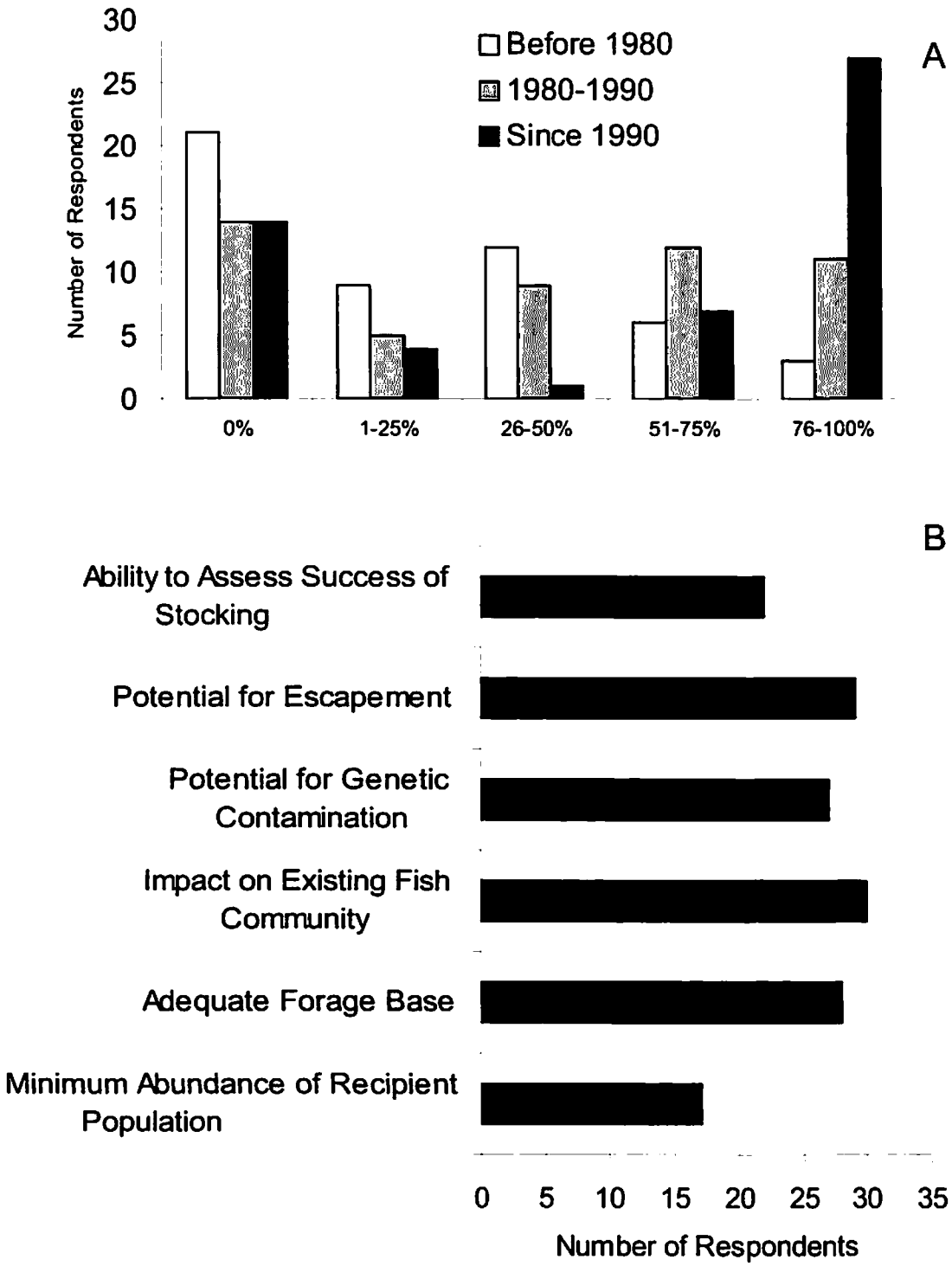

Figure 6. Trends in percent of stocked waters where agencies have written policies requiring specific criteria be met prior to stocking (A); and frequency of use of selected criteria (B).

of fishes in receiving waters in the years since 1990. There has also been an increase in the frequency with which agencies conduct genetic analyses on existing fish populations prior to stocking cultured fishes. Of 53 responding agencies, 81% reported that genetic analyses were rarely or never conducted prior to 1980, with only 6% of reporting agencies conducting genetic analyses "always" or "usually." The percentage of respondents indicating that genetic analyses were usually or always conducted rose to 21% between 1980

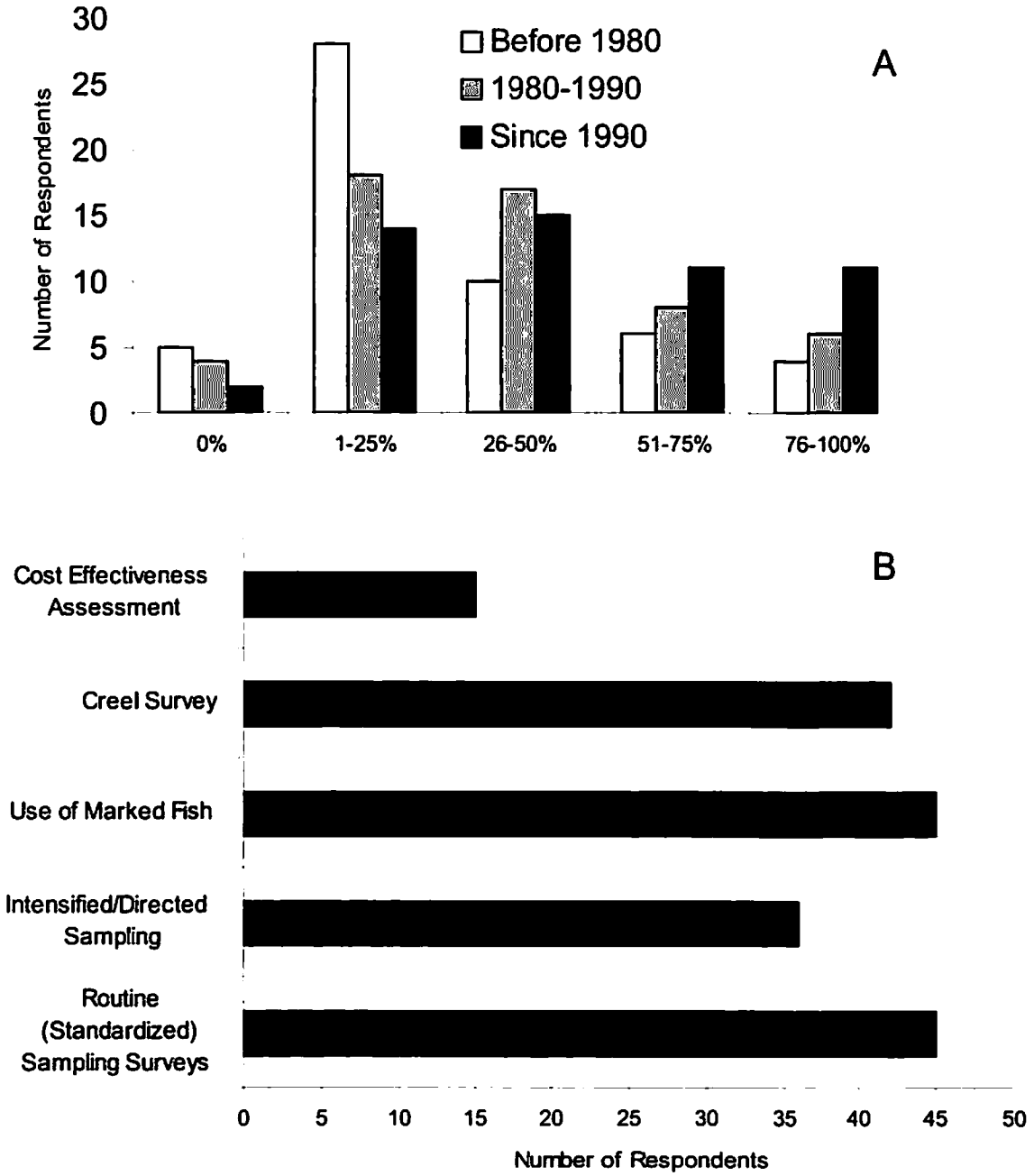

Figure 7. Trends in percent of stocked waters where agencies conduct poststocking assessments (A); and frequency of use of selected assessment methods (B).

and 1990, and currently stands at 40%. Forty-nine respondents reported that their agencies currently had procedures in place to address genetic concerns (up from 24 in 1990 and 13 in 1980). Discontinuation of stocking was the most commonly reported procedure (65%), followed by use of broodstock only from recipient waters (63%), and use of only sterile fishes in areas of concern (41%).

As with responses to genetic concerns, trends in agency policies also exhibit increased attention to biodiversity issues when considering the use of cultured fishes (Figure 8B). Only 8 of 52 respondents reported that their agencies had made decisions not to stock due to biodiversity concerns prior to 1980. Between 1980 and 1990, such decisions were made by 37% of responding agencies, and since 1990 biodiversity concerns have resulted in decisions not to stock by 71% of the agencies responding to our sur-

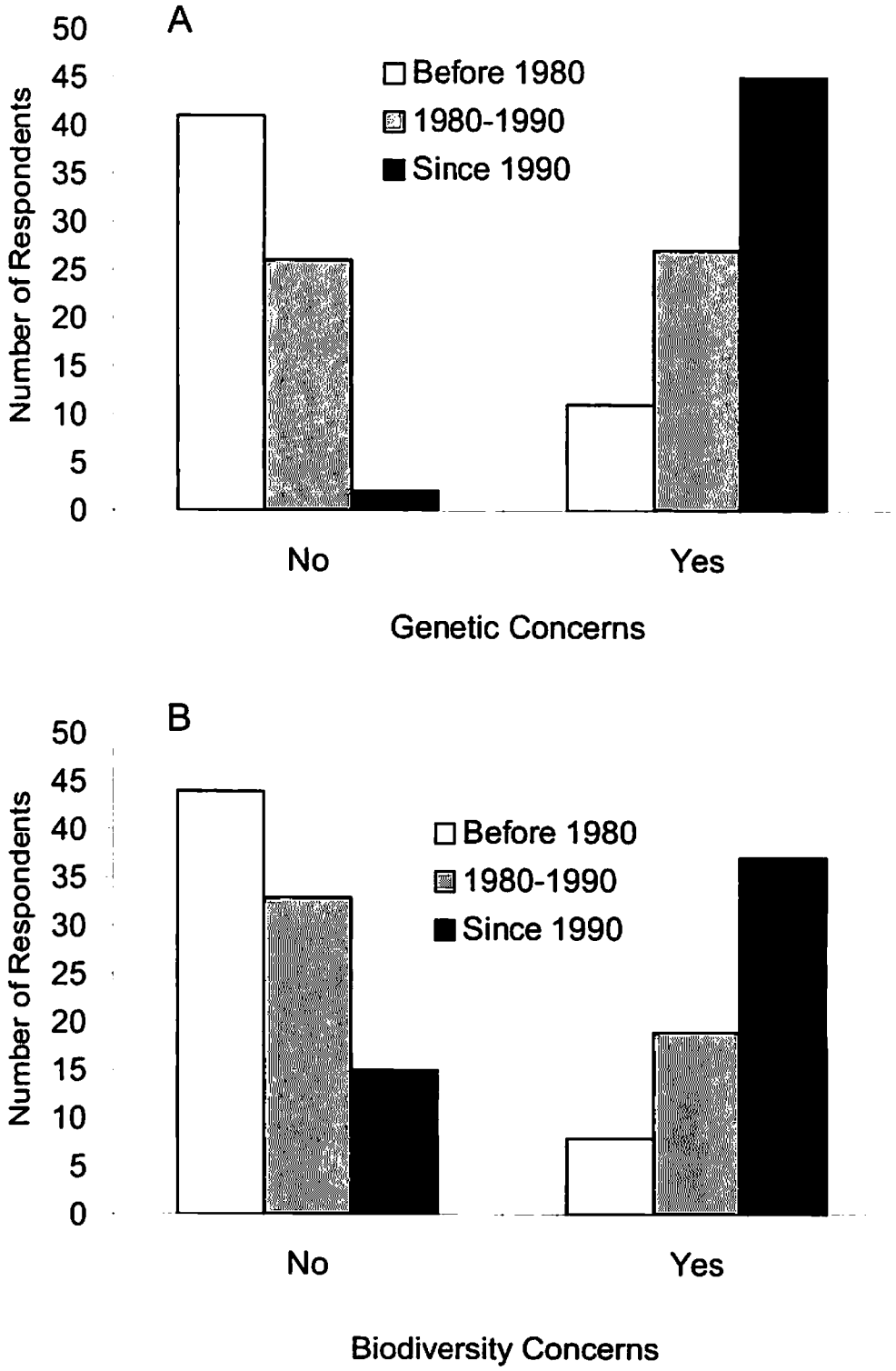

Figure 8. Trends in agency decisions not to stock cultured fishes due to concerns about genetic contamination of recipient populations (A); and in agency decisions not to stock cultured fishes due to concerns about biodiversity (B).

vey. Overall impressions of respondents about the importance their agencies place on genetic and biodiversity considerations in stocking programs agreed with the more detailed survey responses. During the period 1980–1990, only 13% of the respondents reported that such concerns increased in importance,

but 52% of agencies have increased the level of importance placed on genetics and biodiversity in their consideration of using cultured fishes in the last decade. No agency reported that genetic and biodiversity concerns had been de-emphasized in the years since 1990.

Survey responses indicated a slight rise in the level of participation by other government entities (i.e., federal agencies, tribal governments) in agency stocking programs. Of the 53 responding agencies, 15% reported involvement of other entities in stocking programs in at least half of the waters they stocked as of 1980, with 19% reporting no such involvement. As of 1990, 19% of reporting agencies involved other government entities in more than half of their stockings while 13% had no such involvement in any stocking waters. Since 1990, agencies reporting no involvement of other entities fell to 8%, and 23% of respondents reported involvement of other government entities in more than half the waters their agencies stocked.

Stocking and Public Relations

Opinions of the respondents regarding perceptions of anglers about the importance of stocking relative to other management practices indicate that a high percentage of the angling public regards stocking as the primary or only solution to low fish abundance (Figure 9). While some shift in angler attitudes toward prioritizing nonstocking practices was reported, only 12% of anglers were classified as currently feeling stocking should be avoided or receive lower priority than other practices (up from 5% prior to 1980). Prior to 1980, respondents thought that 84% of anglers in their states viewed stocking as the primary or only solution to low fish abundance, and thought that 61% of anglers continued to hold these opinions at the time of our survey.

Similarly, public pressure to stock cultured fishes is an important influence on agency decisions to use cultured fishes (Figure 10; we did not ask respondents to specify sources of public pressure, so responses presumably reflect pressure from both organized groups and individuals). Public pressure played a role in more than 40% of stocking decisions in 41% of the agencies responding to our survey as of 1980. By 1990, the percentage of agencies that conducted 40% or more of their stockings as a result of public pressure had fallen to 31%, and to 25% currently. However, only one responding agency reported that public pressure did not affect any of their agency's stocking decisions, indicating that public pressure is an important factor in decisions to stock throughout the United States and Canada.

Further evidence of the public interest in stocking was provided by respondents' reports of trends in inquiries from nongovernment organizations (i.e., angler organizations) concerning desires to conduct privately sponsored stockings of public waters. Respondents estimated that before 1980, agencies received an average of 18 calls annually (SE = 5.8) concerning private stockings. The average number of calls to agen-

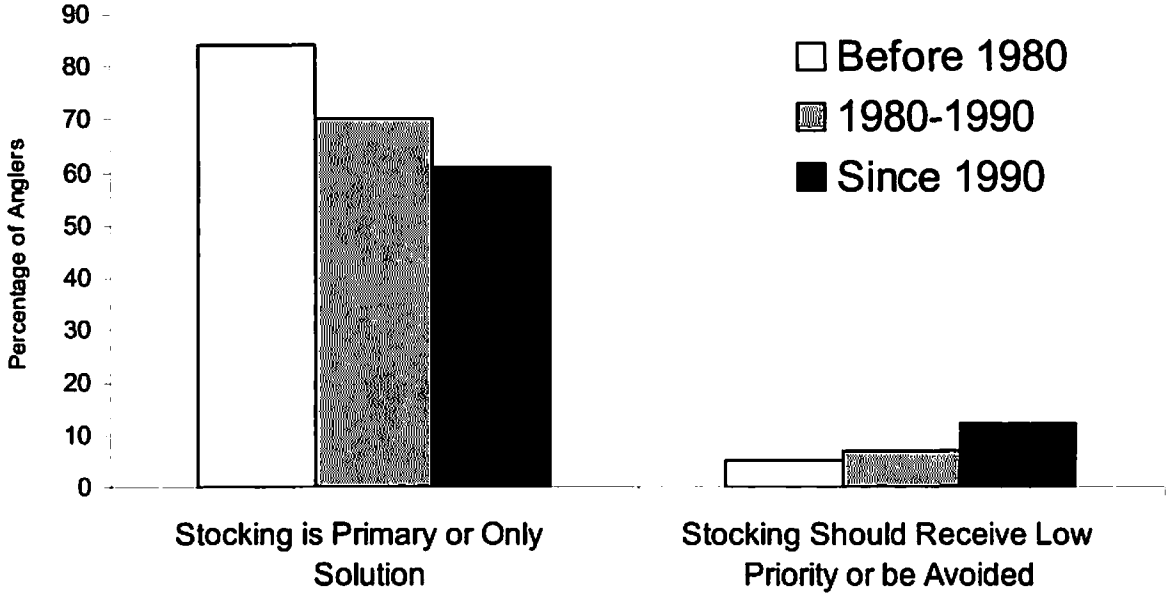

Figure 9. Trends in angler opinions about the importance of stocking as a solution to low fish abundance.

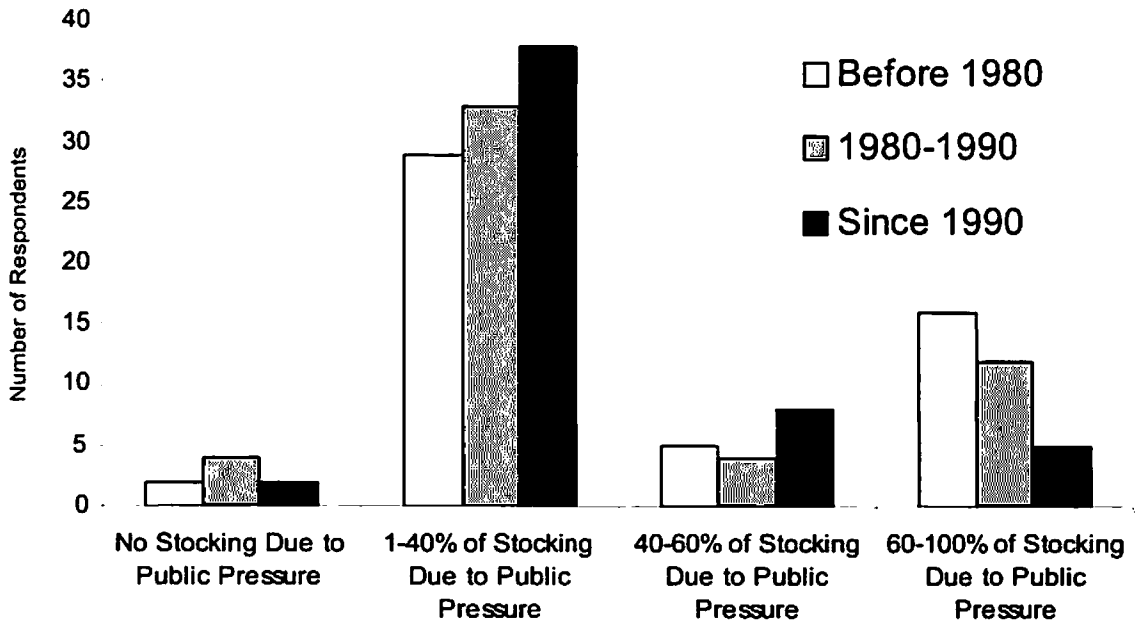

Figure 10. Trends in the percentage of agency stocking decisions that are influenced by public pressure to stock.

cies had increased to 34 (SE = 9.6) by 1990, and to 51 (SE = 15.5) at present. Currently, 81% of responding agencies have policies in place whereby private groups can obtain permission to stock public waters, up from 62% in 1990 and 57% in 1980.

According to respondents, the nonangling public has not shown a strong interest in agency stocking programs. Of the 53 agencies responding to this question, 34% said they currently receive no expressions of concerns about stocking from the nonangling public, down from 44% in 1990 and 56% in 1980. While 32% of respondents reported that their agencies currently receive expressions of concern about stocking from nonanglers in at least some of the waters they stocked, only three respondents indicated this occurred in more than 25% of the waters that their agency stocked.

Agencies are increasing public education and outreach efforts regarding the pros and cons of stocking. At present, 63% of responding agencies invest in public education programs. For the period between 1980 and 1990, 50% of the survey respondents reported increases in agency efforts at public education, with only 2% reporting decreased efforts. In the years since 1990, 71% of respondents indicated higher levels of effort in public education, while 6% reported less effort was being expended.

Discussion

Stocking of cultured fishes continues to play a major role in the fisheries management programs of agencies in the United States and Canada, but there was no indication from our survey that reliance on cultured fishes has increased in the last 10 years. More agencies reported reduced emphasis on stocking relative to other management techniques since 1990 than reported increases, and expenditures on alternative approaches to fish population enhancement such as habitat management have risen steadily over the last 20 years in most agencies. Despite indications by respondents that stocking was receiving less emphasis in their agencies, the number of water bodies stocked by agencies in our survey has continued to increase over the last 20 years, although the number of agencies reporting increases dropped between 1990 and the present.

Our survey results demonstrate that fisheries management agencies have made substantive changes in their policies toward and use of cultured fishes over the past 20 years. Reported changes were consistent with recognition of concerns regarding potential negative impacts of cultured fishes that have been identified in the past few decades, and specifically detailed in two previous AFS symposia on cultured fishes. While most of our respondents indicated some level of familiarity with the previous symposium proceedings, the perceived impact of these publications appears to be modest. Despite this, our survey results show that most agency policies and practices have shifted in directions consistent with the "Considerations for the Use of Cultured Fishes in Fisheries Resource Management" that were developed during a facilitated workshop following the 1994 symposium (Anonymous 1995).

The workshop recommendations included a call for more explicitly stated management objectives, detailed prestocking assessments of whether cultured fishes are appropriate for meeting those objectives, and careful consideration of alternative management approaches within the context of a broader management plan. The majority of agencies responding to our survey reported that measurable objectives have been incorporated in and are used to evaluate stocking programs in at least some of the waters where cultured fishes are used, and the percentage of agencies using such criteria on 50% or more of the waters they stock has risen steadily since 1980. Similarly, the percentage of agencies establishing criteria as part of prestocking assessments to determine the appropriateness of cultured fishes has also steadily increased since 1980. More than half of respondents reported current policies that require specific criteria be met before cultured fishes are used.

Our survey results also identified a clear trend toward increased development of broader management plans within which use of cultured fishes can be evaluated relative to other possible management actions or within the context of larger suites of objectives. Responses to our specific questions regarding the relative importance of stocking and habitat management suggest that currently agencies are more likely to employ other management approaches in lieu of stocking than they were 20 years ago. While trends in agency practices indicate more careful consideration of the appropriateness of stocking for meeting management objectives in the context of other management alternatives, responses suggest that this is an ongoing process with room for improvement. Many agencies continue to use cultured fishes without development of formal management plans or prestocking evaluations, or do so only on a small percentage of waters stocked.

The 1995 workshop recommendations included a series of prestocking considerations directed at protecting native fish stocks and preserving the genetic integrity of local fish populations. Survey responses indicated that agencies have to a large degree responded to these concerns. Most respondents reported a sharp increase in the likelihood that their agency would not stock cultured fishes in situations where serious genetic or biodiversity risks were identified. Potential impacts of cultured fishes on existing fish communities and the possibility of escapement were commonly among the criteria used in prestocking assessment by the agencies that conducted such analyses, and emphasis on use of native fishes in stocking programs has increased.

Genetic analyses of recipient populations and hatchery broodstock plans (often including use of broodstock only from recipient waters or at least from the same watershed) have become much more common in the last 20 years, and the development of hybrid and sterile strains of fishes that will not interbreed with wild populations represented the largest area of increase in new culture products. Additionally, there has been substantial growth in the use of hatcheries in native fish restoration programs, with almost half of the agencies responding to our survey having developed such programs in the last 20 years. In the area of genetic and biodiversity concerns, the practice of conducting genetic evaluations on recipient populations has developed most slowly. While 40% of our respondents reported that these analyses were conducted most of the time, genetic analyses are not standard protocol for many agencies.

The 1995 workshop guidelines also recommended more careful poststocking assessments, not only for potential negative impacts but also the success of stocking practices at meeting stated objectives. The frequency with which poststocking assessments were conducted increased over the last 20 years. Similarly, the majority of our respondents reported refinement of hatchery methods designed to increase survival of stocked fishes and presumably make stocking programs more cost-effective. While assessments of survival and performance of stocked fishes have become common in the agencies we surveyed, cost effectiveness analyses are relatively rare in assessments. We had anticipated that cost effectiveness would be more commonly assessed.

The 1995 guidelines encouraged agencies to allow for a larger public role in decisions regarding the use of cultured fishes. Despite the trends toward greater agency awareness of and attention to potential negative impacts of cultured fishes, and consideration of alternative management approaches, the perceptions of our respondents indicated that the sector of the public with which they interact with still commonly views fish stocking as the primary solution to low fish abundance. We recognize that our survey reflects agency perceptions of angler attitudes and as such should not be interpreted as a direct measure of angler attitudes, but the perceptions of stakeholder attitudes held by agency personnel are likely what drive efforts to incorporate public priorities in management decisions. Respondents reported that more than half of anglers still consider stocking to be the primary or only solution to poor fishing, and agencies continue to conduct a substantial amount of stocking

due to pressure from the public. Similarly, as many agency stocking programs have been scaled back, interest by public groups such as fishing organizations in sponsoring stocking of public waters has risen. Conversely, most respondents reported that their agencies have received few or no expressions of concern from the nonangling public concerning potential environmental impacts of cultured fishes. While agencies have increased investment in public education and outreach over the last 20 years, changes in the attitudes of anglers appear to change slowly.

Our results demonstrate that fisheries management agencies are by and large responding to concerns and criticisms about the use of cultured fishes that have been brought to light in the last 20 years. The direction of agency programs in terms of incorporation of more careful evaluation of stocking programs and policies to minimize negative impacts is consistent with the concerns that have been identified by the fisheries profession during the course of two AFS-sponsored symposia. While the direction of change is encouraging, some areas, particularly the genetic analyses of recipient populations, development of broodstock plans, assessments of cost-effectiveness, and incorporation of measurable stocking objectives that might facilitate identification of waters where stocking is ineffective, have progressed more slowly than others.

When asked to forecast, our respondents identified genetics as the issue they most thought would influence the future direction of their agency culture and stocking programs. The second most common emerging issue was funding. Agency budgets are finite, and in many cases declining in the face of increased areas of responsibility, so it is perhaps not surprising that adoption of new expenses in management programs has met with some resistance. We also wonder if the frequency with which practices such as pre- and post- stocking assessments were conducted in only a subset of stocked waters may reflect shortages of personnel and time rather than a lack of concern or knowledge. While there is clearly room for improvement and a need for continued progress in agency programs where cultured fishes are used, it is probably unrealistic to expect that progress will be rapid.

Interestingly, one of the areas in our survey where progress appears to be slowest is in the attitudes of anglers about the importance of stocking. There has been substantial acceptance by anglers of the importance of alternative management approaches, but the majority still appear to view stocking as the panacea for poor fishing that our profession did such an effective job convincing them it was some 125 years ago. As the constituents of public fisheries management agencies, anglers can and do exert pressure on agencies to conduct the programs they want. Before substantial decreases in the use of cultured fishes can take place, agency biologists likely will first need to invest in more effective public education and outreach programs to modify some of the current paradigms surrounding the benefits of fish stocking programs. The onus should not be placed entirely on the agencies, as the entire profession should take some degree of responsibility for how fisheries management is perceived by the public.

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