Temporal and Seasonal Closures used in Fisheries Management: A Review with Application to Hawai`i

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August 2007

Background

Temporal and seasonal closures in many variations are marine resource management strategies that are easily enforced and often accepted by fishers because of their simplicity. These strategies are usually implemented to control fishing effort, to improve spawning potential by protecting adults during spawning season, or to protect juveniles from depletion during times of recruitment (Gulland 1977). Gulland stated that there is little theoretical justification for seasonal closures in most instances. Temporal/seasonal closures are also used for other management goals and may have both direct and indirect effects. In many fisheries, seasonal closures are the first management strategy employed and subsequently supplement or replaced with more effective measures.

The seasonal closure management strategy is primarily based on effort control. Its purpose is to reduce catching power and fishing mortality by limiting the amount of fishing to a desired level, which would then supposedly increase stock size. However, it is difficult to predict the response of fishing mortality based on the amount of effort control since it depends on how fishers respond to the specific regulations set forth. With seasonal closures, effort may only be reallocated to open periods with greater effort (Anderson 2004). For example, if fishing mortality and effort are high in a fishery and a closed season is established, fishers may respond with greater effort by using more gear and/or boats during the open season. Seasonal closures, especially when coupled with gear restrictions (such as net size or boat number), will result in gear changes (e.g., bigger and more powerful boats; Gulland 1977). When fishing effort is reduced using a seasonal closure, fishing effort may diverted to other resources that may be overfished or nearing an overfished condition. Economic efficiency should also be a primary consideration and may not be realized using seasonal closures (Waugh 1984). Caddy (1984) suggested that seasonal closures are an indirect method for controlling fishing mortality and that more direct methods, such as controlling the level of catches or landings or controlling access to the resource, should be more effective. Effort controls, such as seasonal closures, are unlikely to be effective if not imposed with other measures like catch control and gear restrictions (Jennings et al. 2001).

This report is focused on the evaluation of temporal/seasonal closures, especially as they related to successes and failures in tropical/subtropical regions and in relevant

species groups for the Hawaiian Archipelago. Seasonal area closures and area closures were not reviewed, but a brief section on this important topic is provided.

Successes in the Use of Seasonal Closures in Fisheries Management

Seasonal closures have documented benefits, particularly for invertebrate fisheries such as shrimp (NOAA 1985). In one study of seasonal closure effects in the Gulf of Mexico shrimp fishery, increases in overall yield and values were documented in the first year, although no benefits were observed in the second year. Study results can be inconclusive, especially when conducted over short periods, suggesting that evaluation of success should be based on analysis of data from several years. Seasonal closures have also been argued as beneficial in the Florida lobster fishery (reviewed by Everson 1986).

Seasonal closures may also improve habitat quality. Off the southern coast of England, gear restrictions in combination with seasonal closures increased the abundance and biomass of benthic fauna. The assumption was that improved habitat conditions provided fishes with a habitat for the increased probability of survival (Sinclair and Valdimarsson 2003).

Both direct and indirect benefits have been attributed to seasonal closures. Caddy (1984) suggested that when seasonal closures are adequately applied economic benefits can be realized. Proper application of seasonal closures can protect the resource when particularly vulnerable, improve economic return when the market or resource conditions are poor, and restrict harvest during seasonal toxicity or unpalatability of some species. In some cases, non-target species, especially species common in by-catch, may incur benefits. Even a few heavily-depleted species have avoided apparent extinction due to seasonal closures, e.g., barndoor skates on Browns and Georges Banks (Casey and Myers 1998).

Seasonal closures have certainly been evaluated by managers as useful and beneficial management strategies, even if quantitative analyses of the specific value of the strategy have not been conducted. The apparent benefits and simplicity of seasonal closures have continued to make them commonly used in fisheries managements (refer to the subsequent section "Recent Uses of Seasonal Closures in Fisheries Management").

Failures in the Use of Seasonal Closures in Fisheries Management

Seasonal closures have numerous documented failures, particularly when used as the only management strategy in a fishery. The most notable failures have been in large temperate fisheries, such as in the Pacific Halibut fishery (Skud 1985) and in the groundfish fishery off the New England coast (Sinclair and Valdimarsson 2003). Failures have also been documented for invertebrate fisheries; Everson (1986) provided several cases of seasonal closures being an insufficient management strategy in lobster fisheries.

In the Pacific halibut fishery, seasonal closures were enacted and considered economically beneficial by resource agencies. However, Skud (1985) concluded that seasonal closures "failed to reduce fishing effort and was considered to be of limited

conservation value" and that "regulatory measures that are most effective in controlling effort are more critical than measures concerned with gear, protection of young, etc".

In the New England groundfish fishery, seasonal closures were enacted since the 1970's but had little impact on the decline of ground fish stocks. However, the use of other management strategies (such as gear restrictions) in combination with seasonal closures was found to protect flatfish, skates and scallops (Sinclair and Valdimarsson 2003).

In some cases, seasonal closures are not deemed effective strategies and alternative strategies are implemented. An example is the elimination of the closed season in the Hawaiian longline swordfish fishery, in which alternative measures were deemed more beneficial for protection of threatened and endangered species [sea turtles] (Federal Register 69:64, 2004). Seasonal closures and other management strategies did not reduce overfishing in the multi-species snapper-grouper fishery in the U.S. South Atlantic region and were replaced with a complement of strategies (Federal Register 69: 59, 2004).

Recent Uses of Seasonal Closures in U.S. Fisheries Management

Seasonal closures are commonly used management strategies by US Fisheries Management Councils in US Fishery Management Plans. Closed seasons may be used for diverse assemblages, taxonomic/functional groups or individual species, e.g., closed seasons for deepwater bottomfish in Hawai`i (Federal Register 72:92, 2007), Pacific tuna (Federal Register 72:106, 2007), sharks in the Atlantic (Federal Register 64: 56, 1999), groupers in the South Atlantic, Gulf of Mexico, and US Caribbean (Federal Register 71: 222, 2006), and Pacific whiting along the US West Coast (Federal Register 71: 105, 2006). Additionally, several invertebrate fisheries, notably shrimp, are managed throughout the United States using closed seasons to prevent overharvest. Closed seasons are also used to restrict specific gear (seasonally-adjusted gear restriction), such as in the Alaska groundfish fishery (Federal Register 68:45, 2003).

Although seasonal closures may be used as single management strategies, most seasonal closures are used in combination with other management strategies. Probably the most common use of seasonal closures as a single strategy is in single species (or taxonomic group) fisheries, such as shrimp fisheries in the South Atlantic and Gulf of Mexico Regions of the US. These usually protect the resource when most vulnerable to intensive fishing, such as during spawning or migration aggregation periods. Seasonal closures used in combination with other management strategies may also protect the resource during peaks in vulnerability, but incorporates other strategies for a more balanced, and usually more effective, result.

A five-month seasonal closure was enacted for the bottomfish fishery in federal and state waters in Hawai`i, effective during May 15 through September 30, 2007 (Federal Register 72: 92, 2007). This action was taken by the National Marine Fisheries Service (NMFS) following determination that overfishing was occurring on the bottomfish multi-species complex (6 snapper species; 1 grouper species) around the

Hawai`i Archipelago, with the primary problem being excess fishing effort in the main Hawaiian Islands (MHI). Although bottomfish fisheries throughout the United States are managed using seasonal closures, similar fisheries (e.g., snapper/grouper fisheries) are more frequently managed using various effort controls, such as limits, quotas, limited entry. The deep-water snapper-grouper fishery in the South Atlantic is managed with a combination of strategies, including a closed area (Federal Register 69: 59, 2004).

Seasonal closures are also implemented for other purposes, such as reducing by-catch in a fishery, protection of threatened and endangered species, and spawning stock protection. By-catch reduction measures include protection of for halibut and crabs in Alaska trawl fisheries (Witherell and Pautzke, 1997), protection of cod in the haddock fishery on Georges Bank (Federal Register 70:83, 2005), and protection of Southern bluefin tuna in the longline fishery in Australia (Australian Fisheries Management Authority, 9 March 2000). Seasonal closures implemented for protected species are usually used to decrease accidental harvest during migration events, such as seasonal gill net restrictions for turtle protection in the Mid-Atlantic (Federal Register 67:173, 2002). Multiple management goals may be set for seasonal closures, such as in the Atlantic sea scallop fishery for turtle protection and by-catch reductions (Federal Register 71:110, 2006). Documentation of evaluation of the effectiveness of implementation of season closures for these purposes was not located.

Seasonal Area Closures/ Area Closures

This review was not inclusive of area closures, which has a large and rapidly growing literature with the increased focus on Marine Protected Areas (MPAs). Area closures have been demonstrated to have positive effects on local biological and ecological characteristics (numbers, biomass, diversity), but the demonstration of large-scale fisheries benefits have been limited, due to the small scale of most area closures (Roberts et al. 2001). Evaluation of large-scale reserves and networks will provide benefits of this strategy to fisheries and ecosystem management (Avasthi 2005, Mora et al. 2006, Worm et al. 2007).

Rotational closed areas may have short-term beneficial effects for reefs resources in Hawai`i (Williams et al. 2006). Fish biomass increased in the Waikiki-Diamond Head Fishery Management Area during the 1-2 year rotational closures. However, trends over the entire period (1978-2002) were negative for fish abundance and biomass. During the 22 year period, fish biomass declined approximately 66% and large fishes (with the greatest reproductive output) became uncommon. Rotational closures may be beneficial in cases, but the effectiveness should be measured in terms of rebuilding resources to sustainable conditions.

Seasonal closed areas have been demonstrated to have positive results for many resources, particularly during periods of greatest vulnerability and/or spawning activity. Beets and Friedlander (1999) documented a significant increase in average size and improved sex ratio at a grouper spawning aggregation site seven years after a seasonal closed area was enacted. Many seasonal closures have area restrictions, such as the seasonal closure for bottomfish in Hawai`i (Federal Register 72: 92, 2007). Scientific

evaluations of the effectiveness of these management strategies are limited and greatly needed.

Considerations for the Implementation of Temporal/Seasonal Closures

Although seasonal closures have apparently been successful in ensuring the conservation of marine resources in certain areas, many problems have been encountered from their implementation. Some scientists and managers believe that the only effect of a seasonal closure is a psychological one or a demonstration that an action has been taken (Gulland 1974). In other areas, particularly in traditional cultures, seasonal closures may be viewed negatively because of cultural and ceremonial obligations that would be disrupted because the timing and level of effort for fishers (Severance 1989).

Negative economic outcomes can result from implementation of seasonal closures. Following a seasonal closure, a subsequent increase in landings may be observed, but usually not without a cost. In most cases, seasonal closures result in small reductions in costs in the fishery for employers and consumers. Unless alternative resources are available, fishers may be unemployed during the closure and employers may be forced to lay off workers (Gulland 1974). Fishers are then challenged and obligated to work harder to make the same profit. It is thought that fish are in high concentrations during closed seasons, which would make it a highly profitable incentive to violate regulations unless enforcement efforts are strong. With multiple violators a seasonal closure will not be effective (Charles 2001). During closed seasons fishing may be discontinuous with fishers and boats inactive for long periods of time, which could greatly affect economic success in the fishery (Gulland 1974, King 1995). Seasonal closures may not result in economic benefits for the fishery for several reasons, some being variable and difficult to predict (Gordon 1954).

Ecologically, there are numerous uncertainties related to seasonal closures. As pointed out by Gulland (1974) if the number of adult fish decreases, there would then be a decrease in competition for resources and habitat space, which should result in an increase in juvenile survival. The population dynamics, predator-prey dynamics, and system response are poorly understood for most marine environments, especially under various levels of fishing mortality and management regimes. Evaluations of seasonal closures conducted using simulation models have provided both positive and negative population effects (e.g., Arendse et al. 2007). Such results can be used to support arguments on the beneficial and detrimental effects of seasonal closures and should be carefully considered.

Ecological considerations in fisheries management have increased in importance during recent years with the developing interest in Ecosystem-Based Fisheries Management (Pikitch et al. 2004). Fishing is known to have large effects on marine ecosystems (Jennings and Kaiser 1998), and numerous investigations have documented the benefits of maintaining size/age structure, genetic structure, sex ratio, spawning biomass, and other population characteristics. Essential population characteristics may not be maintained using management strategies such as seasonal closures. In

development of the deep-water snapper-grouper fishery management plan, the South Atlantic Fisheries Management Council eliminated consideration of the Seasonal Closure Alternative because of potential negative impacts on fish populations (Federal Register 69: 59, 2004). As stated in Comments and Responses: "Seasonal closures would not protect the density, sex ratio, or age, size, and community structure of fishes found in the [closed area], because of harvests made in the open season. Fishing effort applied outside the closed season could remove the largest, oldest individuals with the best genetic makeup and greatest reproductive potential."

Seasonal closures have been used and viewed beneficial during specific life history periods of many species. Sadovy et al. (2005) documented the use and benefits of seasonal closures and other strategies for protecting spawning aggregations. Several species form large aggregations prior to and during spawning periods, which fishers target and frequently overfish. Closed seasons and/or areas have been documented to be very effective in sustaining and improving the abundance aggregating species. Seasonal closures would be more beneficial for species whose aggregation sites or unknown and for species that have significant variability in spawning aggregation location or timing.

Closed seasons have the potentially large problem of creating intensive effort by fishers at end of the season (pulse, or "derby", fishing) that can harm the resources more than large sustained effort would. Fishing effort will inevitably increase following a closed season, but fishers may respond with destructively large effort, especially when recognized as a recreational seasonal activity as was documented in snapper/grouper fisheries in the Gulf of Mexico (Coleman et al. 2004). Bohnsack (1994) provided three examples of negative impacts of pulse fishing that resulted in rapid stock depletion and requiring several years to rebuild. He emphasized that closure periods in a multi-species fishery would need to be considerable since various species have different life cycles and, therefore, different optimal response periods.

Numerous biological, economic, and social factors must be evaluated when temporal/seasonal closures are considered. The duration of closure may play a large role in the effectiveness. Using a simulation for a Hawaiian fishery, Somerton and Kobayashi (1990) found that seasonal closures that were longer in duration seemed to result in a greater average spawning biomass of bottom fish, specifically opakapaka (*Pristipomoides filamentosus*). However, extended closures could face serious social and political obstacles (Cheng and Townsend 2006). Competing resource use with subsequent political pressure may yield a reduction in effectiveness of management strategies, such as closed seasons (Russell 2003). Management decisions will only be effective when all aspects are evaluated and implemented in an adaptive management approach.

Traditional Pacific Marine Tenure and Seasonal Closures

The use of temporal and seasonal closures are widely used and well documented in traditional Pacific marine tenure systems (Johannes 1978, 1981). Most seasonal closures were based on the intimate knowledge of the behavior and life history of fishes. Seasonal closures were most often applied to reduce intensive harvest of spawning fishes or aggregations that occurred during lunar, seasonal or annual cycles. However,

management was also adaptive and flexible dependent on the local conditions and complete autonomy of local leaders. Traditional marine tenure and management methods have been shown to be effective in modern applications when local communities have the responsibility of management (Cinner et al. 2005, McClanahan 2006, Poepoe et al. 2007).

In Hawai`i, the traditional native culture used seasonal closures as one of their marine resource management systems. A primary use of this strategy was to ensure the sustainability of their two staple fishes, the aku and `opelu (Titcomb 1972). Closed seasons for the `opelu and aku usually alternated every six months. There were different times of kapu (fishing prohibited), but the common time was in February and usually lasted for approximately ten days (Titcomb 1972). The motive was to protect the supply of fishes and their habitats during spawning and large juvenile abundance seasons. A good example of a successful seasonal closure was found in the fishing village of Miloli`i on the island of Hawai`i, where they relied heavily on `opelu not only for food, but possibly fuel as well (Friedlander 2004).

Traditional Hawaiian culture was recognized to engage in wise use and conservation of their natural resources (Titcomb 1972, Friedlander et al. 2002, Poepoe et al. 2007). There was never a time when all fishing was prohibited. When inshore fishing was kapu, deep sea fishing was open and vice versa. During summer months, fishes were plentiful and inshore fishing was permitted, whereas, in winter months, deep sea fishing was allowed. Local chiefs made all decisions of harvest regulations (Titcomb 1972). Seasonal closures, along with other restrictions, were strictly enforced with severe penalties of breaking regulations. A strong conservation ethic was inherent in the sustainability of the Hawaiian culture and its resources.

Conclusion

Although temporal/seasonal closures are used commonly throughout in world, very little literature is available that rigorously evaluates the effectiveness of specific temporal/seasonal closures. Most literature on temporal/seasonal closures is related the perceived benefits or stock effects without presenting quantitative analyses. Seasonal closures have frequently been applied as the first measure until more effective measures can be evaluated and applied.

Temporal/seasonal closures have been considered successes and failures dependent on the resource, fishery, and/or complementary management strategies utilized. Few documented successes of the use of temporal/seasonal closures as a single management strategy applied in a fishery exist, and no examples were identified for multi-species finfish fisheries. The management strategy has one apparent benefit, which is the overall reduction of fishing effort and by-catch for that specified period. Regardless, analytical evaluation is required to determine benefit to fishery resources.

Several evaluations of temporal/seasonal closures have concluded that the management strategy does little to control total fishing effort or will generally be ineffective and/or economically inefficient unless fishing effort is controlled with other measures (Waugh 1984, Skud 1985, Everson 1986, Anderson 2004). Conversely, a few

sources have suggested that seasonal closures can result in an overall reduction of fishing effort (King 1995). Seasonal closures applied with other management strategies, such as catch quotas and gear restrictions, can lead to the successful preservation of marine resources (Jennings 2001). Properly applied and enforced seasonal closures as a management strategy may be effectively used to ensure a productive economic fishery and stable marine ecosystem under specific circumstances. However, temporal/seasonal closures used as a single management strategy have little support for conserving resources in most fisheries. Improvements in management strategies to address larger-scale perspectives at the ecosystem level are needed to address the challenges in resource management (Botsford et al. 1997).

Acknowledgments

We would like to thank Dr. Paul Dalzell at the Western Pacific Fisheries Management Council and Dr. Bob Nishimoto and Dr. Bill Walsh of the State of Hawai`i, Department of Land and Natural Resources, Division of Aquatic Resources who were valued contributors due to their knowledge of notable temporal/seasonal closures. Thora Abarca, Public Services Librarian at UH-Hilo, assisted the search for useful and relevant information. Funding for this review was provided by the State of Hawai`i, Division of Land and Natural Resources, Division of Aquatic Resources (Contract: P.O. C32755).

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