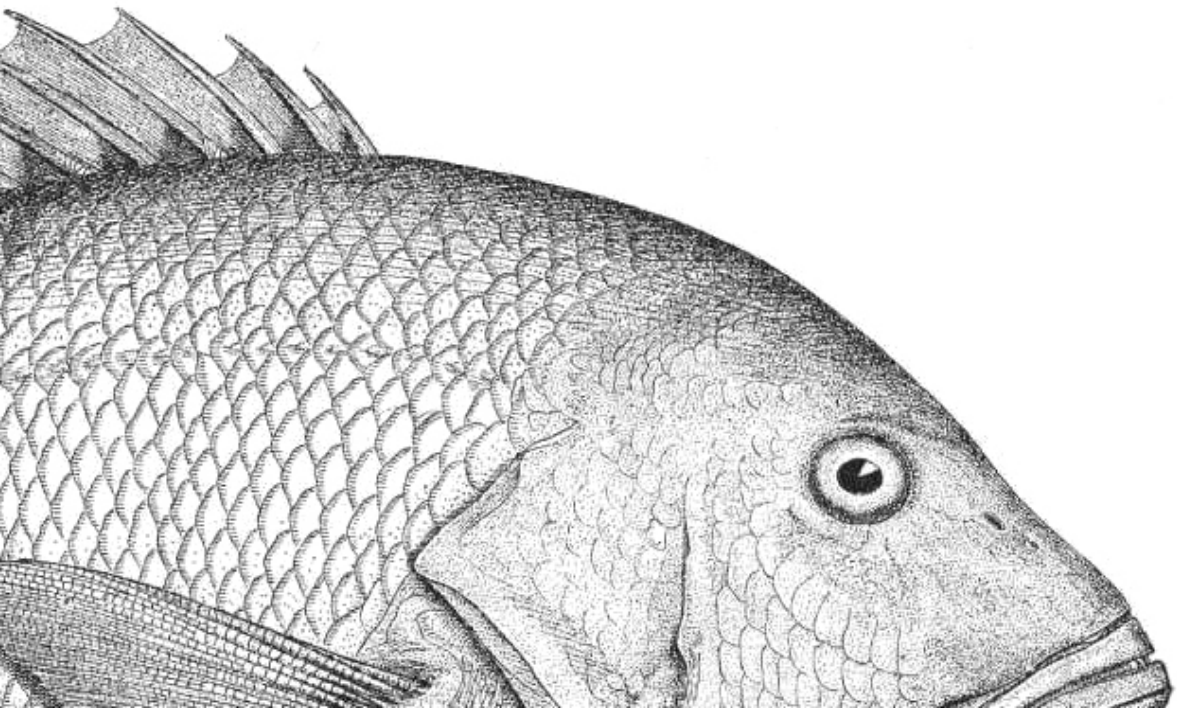
Catch Share Design Manual

A Guide for Managers and Fishermen

By Kate Bonzon, Karly McIlwain, C. Kent Strauss and Tonya Van Leuvan



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Introduction

Fishery managers and stakeholders have been increasingly interested in catch shares as an approach for managing fisheries (Dean, 2008; Winter, 2009; Chauvin, 2008). This interest has been bolstered by recent reports indicating that catch share implementation "halts, and even reverses,…widespread [fishery] collapse"(Costello et al., 2008) and helps drive economic growth (World Bank and Food and Agriculture Organization of the United Nations [FAO], 2008). Specific case studies highlight other potential benefits of catch shares, including increased compliance in meeting catch limits (Griffith, 2008; Essington, 2010) and enhanced safety, job stability and profitability for fishermen (Beddington et al., 2007; Gomez-Lobo et al., 2007; Rose, 2002). Understanding different design options and how they can achieve various economic, biological and social objectives will help managers and stakeholders make informed decisions about catch share programs.

This Design Manual is the first-ever comprehensive overview and roadmap of catch share design, drawing on hundreds of fisheries in over 30 countries, and expertise from over 60 fishery experts from around the world. However, the Design Manual is not prescriptive: It is a series of questions whose answers help guide and inform the catch share design process. Detailed discussions of design elements are coupled with case studies to outline and highlight options. Certainly, various design options should be developed for their potential to meet the particular biological, economic and social goals of the fishery under consideration.

Catch share design is an emerging focal point of innovation and growth in fisheries management. Thus, new ideas and applications are increasingly being developed and tested, and are therefore not yet included in the Design Manual. To capture new information, the Design Manual will function as a living document with regular updates. This first edition is focused on commercial fisheries. Future editions and additional chapters will discuss other emerging topics.

WHAT IS A CATCH SHARE?

A catch share program allocates a secure privilege to harvest a specified amount of a fishery's total catch to an individual or group (groups can be community-based). Under a catch share program, managers establish a fishery-wide[1] catch limit, assign portions of the catch, or shares, to participants and hold participants directly accountable to stay within the catch limit.

Catch shares are fundamentally different from other management approaches and are generally implemented after a variety of other approaches are insufficient at meeting specific goals. Most commercial fisheries start as open access where anyone who puts in the effort is allowed to catch fish. As competition increases, managers often limit access through licensing of participants.

When licenses do not effectively control fishing effort and catches, managers implement more and more effort-based regulations to control catches. Examples of these regulations include limitations on the amount of catch allowed per trip, the size of vessel, fishing days and more. In many cases, these management efforts have not succeeded in maintaining stable fish populations or in promoting profitable, safe fisheries. As an alternative, over the past four decades many fisheries worldwide have implemented catch share programs. See Figure A: Catch Shares Over Time.

By allocating participants a secure share of the catch, catch share programs give participants a long-term stake in the fishery and tie their current behavior to future outcomes. This security provides a stewardship incentive for fishermen that was previously missing or too uncertain to influence his/her behavior toward long-term conservation. Catch share programs align the business interests of fishermen with the long-term sustainability of the stock, and provide more stability and predictability within a fishing year and over time. Furthermore, catch share fishermen are held accountable for their share of the catch. They are simply not allowed to catch more than their share. And, if participants do exceed their shares, they must lease or buy additional shares in order to cover their overage, or they are subjected to a penalty, which could include revocation of the privilege or stiff fines. By

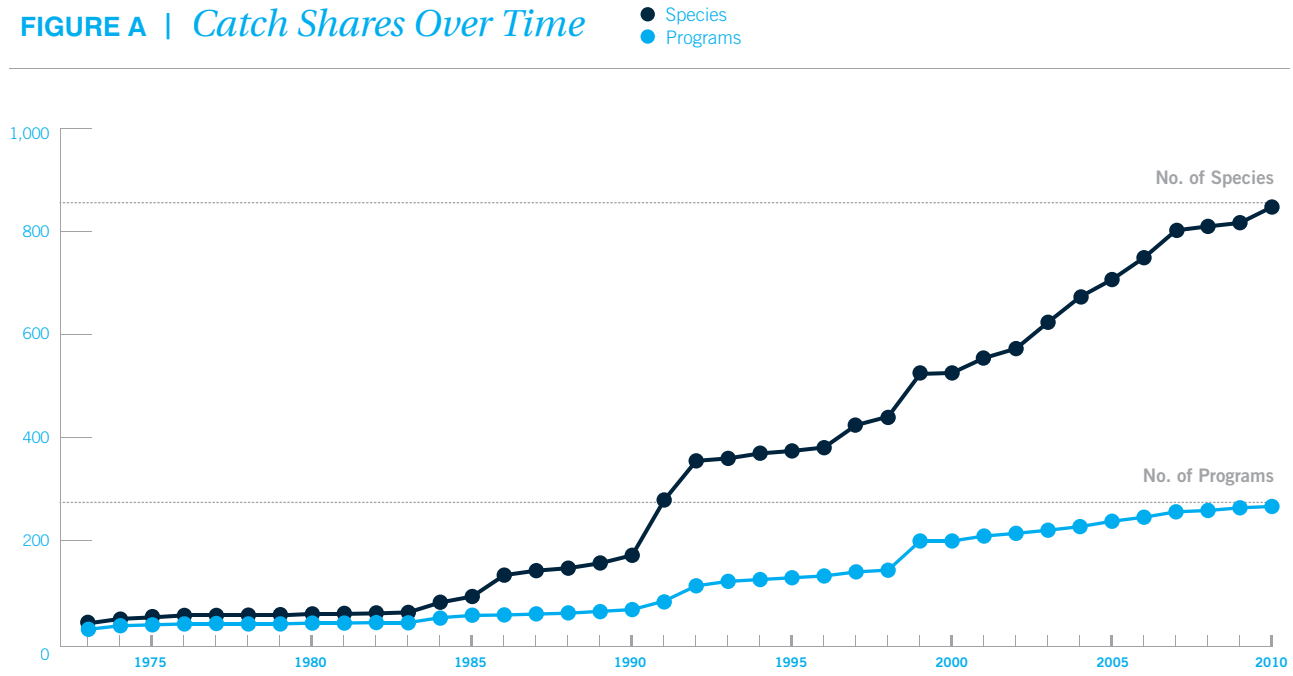
TABLE A | CATCH SHARE TYPES

	ALLOCATED TO	TRANSFERABLE
INDIVIDUAL QUOTA (IQ)	Individual	No
INDIVIDUAL TRANSFERABLE QUOTA (ITQ)	Individual	Yes
INDIVIDUAL VESSEL QUOTA (IVQ)	Vessel	Sometimes
COOPERATIVE[2]	Group	Sometimes
COMMUNITY FISHING QUOTA (CFQ)	Community	Sometimes
TERRITORIAL USE RIGHTS FOR FISHING (TURF)	Individual, Group or Community	Sometimes

1 In this instance, "fishery-wide" refers to the group participating in the catch share. There may be other participants targeting and landing the same species that are not included in the catch share program, e.g. recreational anglers.

2 The term "cooperative" has many meanings and generally refers to any group that collectively works together. Throughout the Design Manual, "Cooperative" is capitalized when referring to a group that has been allocated a secure share of the catch limit, i.e., when it is a type of catch share. When not capitalized, "cooperative" refers to an organized group that has not been allocated secure shares, but may coordinate other activities, such as marketing.

FIGURE A | *Catch Shares Over Time*



contrast, traditional fisheries management holds fishermen accountable to regulations that are not directly tied to the catch and do not necessarily limit the catch.

Today, over 520 unique species of fish are managed by catch shares in 35 countries worldwide. Catch shares are used by 18% of the world's total countries and 22% of the world's coastal countries. There are over 275 programs comprised of more than 850 catch share managed species units worldwide.[3]

For the purpose of this analysis and discussion throughout the Design Manual, a catch share is a management approach that allocates shares of the catch to specified entities, either individuals or groups. Most well-documented catch shares allocate shares to individuals, but there is growing interest in the use of group-allocated approaches such as Cooperatives, permit banks and Community Fishing Associations. In addition, most catch share programs are transferable, meaning participants can buy, sell and/or lease shares. This market allows the fishery to internally adjust to changes in the catch limit and allows participants to enter and exit the fishery.

See Table A for the six basic catch share types. Other common names for catch shares include: Individual Fishing Quotas, Dedicated Access Privilege Programs, Limited Access Privilege Programs, Statutory Fishing Rights, Quota Management System, Rights-based Fisheries Management and more.

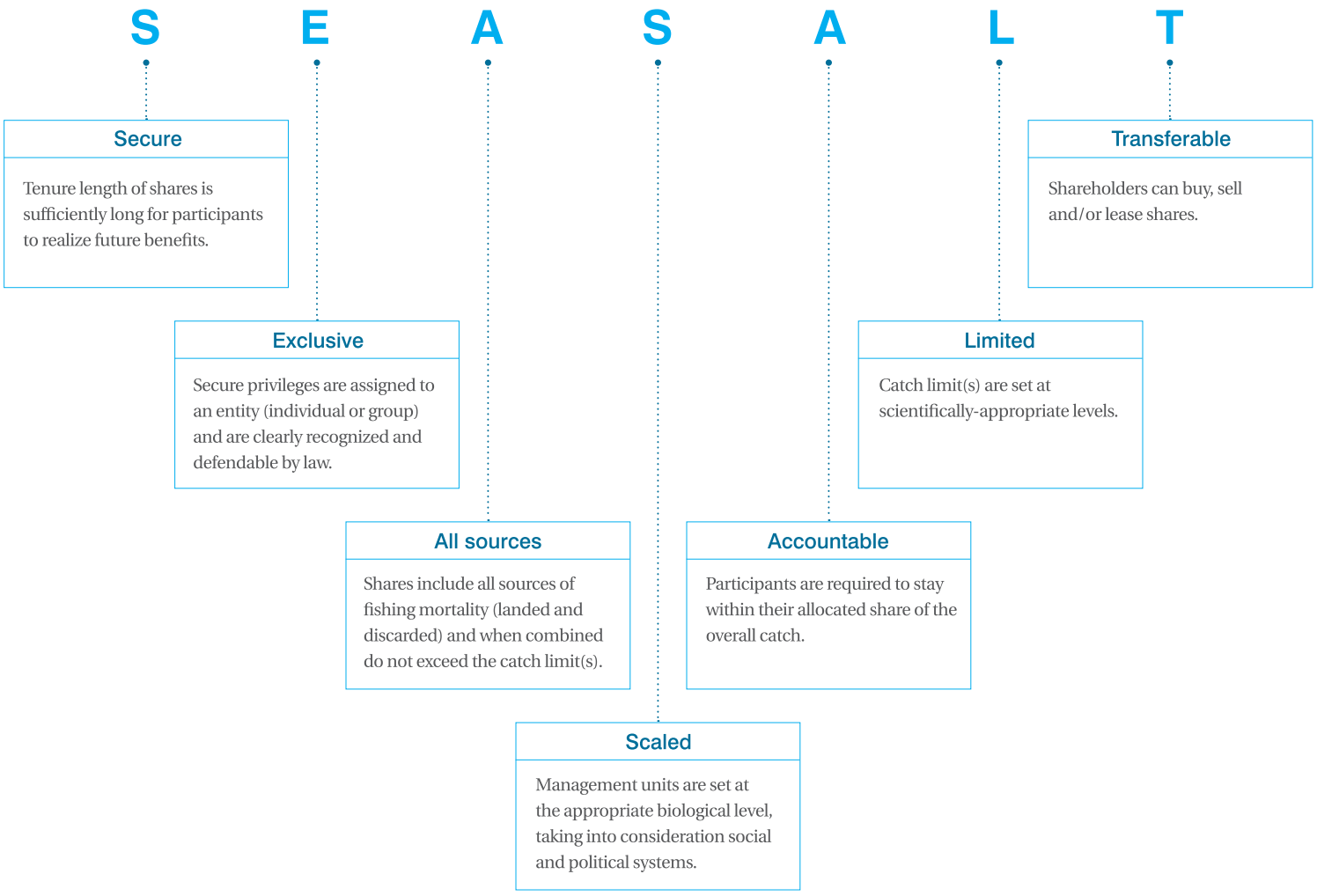
Managers, practitioners and academics debate whether area-based and tradable effort-based approaches qualify as catch shares. The debate centers on whether a catch limit is a required component of a catch share. *The purpose of the Design Manual is to describe catch shares that have a catch limit.*

Tradable effort-based programs and area-based programs without a catch limit may be effective approaches for managing certain fisheries, especially those in which it is difficult or prohibitively costly to identify a scientifically-based catch limit. See **Appendix B: Managing Without a Catch Limit** for more explicit discussion about species and area-based catch shares without a catch limit, and effort-based approaches.

3 Unique species are counted once, regardless of how many countries or management authorities are managing the species under a catch share. A managed species unit will count a species more than once if multiple countries or management authorities include the species under different catch share programs. For example, both Canada and the U.S. manage halibut on the west coast under catch shares. Under the unique species designation, halibut counts as "one," whereas under the managed species units it counts as "two."

WHAT ARE THE KEY ATTRIBUTES OF A CATCH SHARE?

In order to better understand catch share programs, it is useful to outline their key attributes. The SEASALT mnemonic – developed for this Design Manual based on a review of existing catch share programs and theoretical literature – describes commonly occurring attributes of catch share programs. Not all of these components are required for a catch share to be successful. However, the more completely a program is designed to incorporate each of these attributes, the higher the likelihood of a biologically sustainable and economically profitable fishery. The Design Manual systematically addresses these key attributes through the outlined Design Steps. At the beginning of each Step, germane SEASALT attributes are highlighted.



Look for SEASALT throughout the Design Manual to track which attributes are addressed by completing each Step:

WHAT ARE THE RESULTS OF CATCH SHARES?

There is general agreement among policymakers, practitioners, stakeholders and academics that fisheries should be biologically sustainable and provide economic benefits to the public, fishermen and communities. A review of catch shares from around the world shows that catch shares can assure the long-term sustainability of fish stocks and maximize social and economic value created by the sustainable use of the fishery. Furthermore, catch shares consistently succeed where traditional management approaches have failed. Specifically, research and experience shows catch shares:

- Prevent, and even reverse, the collapse of fish stocks (Costello et al., 2008)
- Ensure participants comply with catch limits (Branch, 2008)
- End the race for fish (Essington, 2010)
- Stabilize fishery landings and catch limits (Essington, 2010)
- Reduce ecological waste, such as discards and bycatch (Branch, 2008; Essington, 2010)
- Provide stability to industry through well-paid, safer, sustainable jobs (McCay, 1995; Crowley and Palsson, 1992; GSGislason and Associates, Ltd., 2008; Knapp, 2006)
- Increase the profits and value of fisheries (Grafton et al., 2000; Newell et al., 2005)

Despite the positive track record of catch shares, there are some challenges that require special attention regardless of the management system in place. While well-designed catch shares are likely to help address some of these challenges, they will require continued innovation:

- *Evolving science* If a catch limit is set too high, any fishery – including a catch share fishery – is at risk of becoming overfished. This was seen in the early days of the New Zealand orange roughy (*Hoplostethus atlanticus*) catch share program where available science was limited, leading managers to set unsustainably high catch limits. Participants did not exceed their shares, but they did catch the fishery's full catch limit and had significant discards at-sea, which resulted in overfishing. Since orange roughy are slow to reproduce, this had a devastating impact. Though better science has been developed and limits have been lowered, some orange roughy fish stocks are still recovering (Straker et al., 2002).

- *Effective monitoring and fishery information* Collecting good fishery information and ensuring effective monitoring and compliance is important for all fisheries, and catch shares are no different. For most catch shares, the management system must track catch in relation to the shares issued. Though all fisheries should have good data and monitoring, a transition to catch shares is often used as an opportunity to implement more robust and effective monitoring and fishery information systems. When this is done effectively, data quality and reporting accuracy improve along with trust among fishermen and managers. Importantly, catch shares commonly create a willingness among all to improve data (Griffith, 2008).

- *Species life cycle*
  Fisheries of long-lived, slow-growing, highly migratory, ephemeral, variable and/or high seas species pose unique problems for fishery managers. These challenges persist under catch shares.

  For long-lived species, especially ones that are already depleted, an individual fisherman today may not hold the share long enough to reap the benefit of a rebuilt, healthy stock. This limits the incentive to work toward that goal. In this scenario, setting a scientifically-appropriate catch limit and ensuring comprehensive monitoring will be even more important.

Management of highly-migratory stocks or fisheries on the high seas is challenging because of the difficulty in coordinating large numbers of participants. It is possible to create a catch share that can work for numerous participating countries and fleets, but developing and implementing the program will require significant incentives, diplomacy and shared information.

- *Social pressure for the old way*
  Many fishermen hark back to past generations when commercial fishing was open, and even encouraged, for all. Regulations were few, boats were small, gear was less sophisticated, and the only limitations were one's ability and dedication. Though it may be desirable to return to this past, it is unfortunately not possible. Most fish stocks around the world are fully exploited or overfished, and with human population growth, it is unreasonable to think that we can allow open, unregulated access to stocks *and* have sustainable fisheries.

WHAT ARE THE KEY PRINCIPLES OF CATCH SHARE DESIGN?

Throughout the Design Manual, 13 design principles highlight clear lessons learned from around the world and basic rules of thumb for a successful catch share program. They are summarized here for quick reference and are discussed in further detail in their respective Steps.

1. Design the catch share program based on clearly-articulated goals with measures of success.
2. Consider including in the catch share program species that are commonly caught together.
3. Create separate catch limits and shares for each species, stock and zone in the catch share program. The catch limit should account for all sources of fishing mortality and should prevent overfishing. If the stock is already overfished, the catch limit should be set at a level that will rebuild the stock.
4. Develop mechanisms for accommodating new entrants during the design of the catch share program and prior to initial share allocation.
5. Allocate shares for sufficient length to encourage stewardship and appropriate investment by shareholders and associated industries. This can be achieved by allocating in perpetuity and/or for significant periods of time with a strong assumption of renewal, provided rules are adhered to.
6. Employ percentage shares, when possible, of the overall cap rather than absolute weight units for long-term shares.
7. To increase program flexibility consider transferability of shares, permanent and/or temporary, which is generally a hallmark of catch share programs.
8. Develop a transparent, independent allocation process that is functionally separate from the rest of the design process. Allocations that retain the relative equity positions of stakeholders are the least contentious.
9. Employ an allocation appeals process that allows eligible participants to refute allocated amounts with verifiable data.
10. Encourage cost-effective, transparent trading that is easy for all participants.
11. Employ transparent catch accounting completed regularly enough to ensure the catch limit is not exceeded.
12. Design and implement a fishery information system that keeps costs low and is effective for conducting catch accounting, collecting scientific data and enforcing the law.
13. Assess performance against goals and encourage innovation to improve the program over time.

SNAPSHOT A

How to Use the Design Manual to Design an Effective Catch Share

This Design Manual is intended to help you – whether you are a manager, a fisherman, a scientist or another interested party – design successful catch share programs. Specifically, it guides you through the design process Step-by-Step, and discusses various design elements in detail, including how they may address biological, economic and social goals. The Design Manual should be used in conjunction with additional research, analysis and consultation of experts in order to design the most appropriate catch share program for your fishery.

The guide generally assumes some basic goals: You want what successful catch shares can achieve – long-term sustainability of fish stocks, maximization of the social and economic value created by the sustainable use of the fishery, and joint stewardship by fishermen and managers. Or, put simply, you want to achieve sustainable, stable and profitable fisheries. For many fisheries, this requires a big change. Therefore, it is important to clearly define your specific management goals for the fishery at the outset of the catch share design process. Because catch shares are customizable with many design options, the process should proceed thoughtfully, and implementation should be adaptive, with regular reviews to ensure achievement of those goals.

Decades of experience from around the world illuminate how good design and accompanying tools can address existing challenges and maximize potential benefits. This Design Manual draws on that global expertise to create a seven-Step process for catch share design.

Step 1 - Define Program Goals

Step 2 - Define and Quantify the Available Resource

Step 3 - Define Eligible Participants

Step 4 - Define the Privilege

Step 5 - Assign the Privilege

Step 6 - Develop Administrative Systems

Step 7 - Assess Performance and Innovate

Each Step is a critical component of catch share design; the Design Manual sequences these Steps to ensure decisions flow logically, when possible. Use it as a roadmap for the process and as a reference for specific ideas and examples.

There are a number of recurring tools throughout each of the seven Steps to help you navigate:

- *At a Glance*
  Each Step includes a one page summary that you can use for quick reference.
- *SEASALT Tracking*
  At the beginning of every Step, the SEASALT icon appears and highlights which key attributes of a catch share you will address by completing the Step in question.
- *Sub-Steps*
  Each Step is organized by a series of key design questions or sub-Steps. Each of these includes a discussion of various design options and may include additional considerations or trade-offs.
- *Principles*
  Some sub-Steps highlight important, noteworthy design recommendations as key principles.
- *Special Features*
  Each Step includes one or more special features, such as detailed tables, figures and/or snapshots on relevant existing catch share programs.
- *Step in Practice*
  A table at the end of each Step briefly summarizes and compares the design decisions for each of the case study fisheries.

The **Catch Shares in Practice** section, starting on page 103, includes four in-depth case studies[4] on fisheries that have implemented catch shares:

- Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program
- British Columbia Integrated Groundfish Program
- Chilean National Benthic Resources Territorial Use Rights for Fishing Programme
- Danish Pelagic and Demersal Individual Transferable Quota Programs

The case studies accompany the Steps to provide comprehensive, real-life examples of design decisions in action. These narrative case studies include histories of the fisheries, performance under the catch share programs and key design decisions made for each of the Steps.

Embedded at the end of each Step is a Step-specific **Catch Shares in Practice** table that succinctly summarizes the design choices for each of the four case study fisheries, thereby providing an opportunity to quickly compare the programs.

4 For the case studies and all other specific catch share programs discussed throughout the Manual, the authors have attempted to use the country's identified program name. Due to differences in language, culture and history, the names may not perfectly translate.

Icons Key | Icons used throughout the Design Manual to highlight key catch share design features


Single-species


Individually-allocated


Species-based


Transferable


Multi-species


Group-allocated


Species & area-based


Non-transferable

Before You Begin

Before you begin designing a catch share program, you should assess the existing state and context of the fishery. Most fisheries already have an existing management structure with established regulations, institutions, participants and stakeholders. Years or decades of fishing and management influence the current state of the fishery, and these traditions should be taken into account when considering, designing and implementing a catch share approach.

ASSESS LEGAL, REGULATORY AND INSTITUTIONAL CONTEXT

Most jurisdictions have existing fishery laws, regulations and management institutions. This context must be considered throughout the design and implementation of catch share programs. As with any management approach, all catch share programs must comply with the law and existing regulations may impact various design choices. The Design Manual does not pointedly address the existing legal and regulatory context, as this is specific to each jurisdiction. You should keep in mind your fishery's legal and regulatory context as you read the Design Manual.

CONSIDER A HOLISTIC APPROACH

A holistic approach can mean a number of different things. Most importantly, managers need to think holistically about how all of the different decisions will interact with each other. Different design elements will impact each other in various ways and should add up to meet the goals set forth. The Design Manual addresses this to some degree by identifying how design elements relate to each other. For a complete understanding, modeling and additional analysis may be helpful to inform decisions.

A holistic approach may also relate to how quickly and completely a jurisdiction transitions to catch shares. Some countries have chosen to implement catch shares widely in a comprehensive fashion. For example, New Zealand transitioned many of their fisheries to catch shares in 1986, with most of the remaining stocks under catch shares by the mid-1990s. This wholesale conversion was largely due to the government's response to an economic crisis and an ensuing overhaul in natural resource management to increase economic returns.

Finally, a holistic approach not only includes addressing problems beyond just the fishery, but also within other institutions that affect the fishery. For example, New Zealand linked the design of the catch share program to a review and revision of ancillary and supporting systems such as the country's justice, taxation, business, financial and government research systems. By modifying all systems together, they were able to ensure that fisheries management worked in concert. New Zealand's experience supports the benefits of a holistic approach.

IDENTIFY WHICH FISHING SECTORS TO INCLUDE

Fisheries are frequently managed via discrete sectors based on some common characteristic such as gear type (trawl, hook and line, pot, etc.), focus of effort (nearshore vs. offshore), size of vessel (smaller vs. larger), purpose of activity (recreational vs. commercial) and more. While sectors may be logical for many management reasons, these divisions often do not represent the true nature of fishing, either economically or ecologically.

Many fishermen hold multiple permits and fish a variety of species, stocks and aggregations using a multitude of gears. This is especially true for smaller vessels and nearshore fishermen where flexibility is the key to making a living. In addition, various biological species, stocks and aggregations interact ecologically and the increasing scientific trend toward ecosystem-based management reflects a growing recognition of the importance of managing these collectively. When fishing is governed by numerous permits with multiple rules, it becomes complicated to oversee participants effectively, achieve ecological goals and run successful businesses.

There are some clear benefits – biological, economic and/or social – from including multiple sectors in the catch share program regardless of previous management distinctions. For example, if all fish under a catch share program can be freely traded across different sectors, then managers no longer have to determine yearly allocations of the catch among gear types, vessel types and/or different groups of fishermen. These allocation decisions can be highly contentious and time-consuming. Under an integrated catch share program, the market will dictate where shares move. Of course, there still may be good reasons to incentivize certain gears or practices, particularly to reduce habitat impacts.

Regardless of existing sector definitions and/or potential benefits of a comprehensive program, you must clearly identify which sector(s) will be included in the catch share to inform design. This could include all commercial fishermen targeting a specific species or some sub-group, such as those using a specific gear type. Program design should be driven by the targeted sector, but keep in mind how other sectors may be added to the program over time and how other sectors interact with one another. Many programs have evolved to incorporate additional sectors into a single catch share program over time.

INCLUDE STAKEHOLDERS IN DESIGN PROCESS

Fisheries tend to have a wide variety of stakeholders, many of whom participate in management decisions. Fishery stakeholders include:

- Current and historical license holders
- Captains
- Crew
- Fishing-dependent communities
- Participants from other fishing sectors, e.g., recreational fishermen
- Historical participants such as indigenous communities
- Seafood business owners
- Environmental non-governmental organizations
- Scientists
- Consumers and consumer advocates
- The public

Including key stakeholders in the design process requires a balance. On the one hand, inclusion of multiple viewpoints generally improves design and increases support for the program. On the other hand, too many participants and a lengthy process can needlessly slow down progress. Many catch share design processes include stakeholder participation via existing management arenas, such as the U.S. Fishery Management Council process. For example, the Gulf of Mexico Red Snapper Individual Fishing Quota Program was developed through the Gulf of Mexico Regional Fishery Management Council process, which allows for stakeholder participation. Prior to program implementation, active fishery participants voted 87% in approval of the program (NMFS Southeast Regional Office, 2006).

Checklist

Step 1

Define Program Goals

- [ ] Identify the program's biological and ecological goals
- [ ] Identify the program's economic goals
- [ ] Identify the program's social goals
- [ ] Balance trade-offs

Step 2

Define and Quantify the Available Resource

- [ ] Determine which species will be included
- [ ] Determine which stocks will be included
- [ ] Delineate the spatial range and identify zones
- [ ] Determine the allowable catch limit for each species, stock and zone

Step 3

Define Eligible Participants

- [ ] Decide if the privilege will be allocated to individuals or groups
- [ ] Determine who may hold and fish shares
- [ ] Establish limits on the concentration of shares
- [ ] Determine how new participants will enter the fishery

Step 4

Define the Privilege

- [ ] Decide whether the privilege will be species-based or species and area-based
- [ ] Determine the tenure length of the privilege
- [ ] Define the long-term share
- [ ] Determine the annual allocation unit
- [ ] Decide if the catch share will be permanently and/or temporarily transferable
- [ ] Determine any restrictions on trading and use of shares

Step 5

Assign the Privilege

- [ ] Establish a decision-making body for initial allocation
- [ ] Determine when allocation will occur
- [ ] Establish an appeals process
- [ ] Determine who is eligible to receive shares
- [ ] Decide whether initial shares will be auctioned or granted
- [ ] Determine how many shares eligible recipients will receive
- [ ] Identify and gather available data for allocation decisions

Step 6

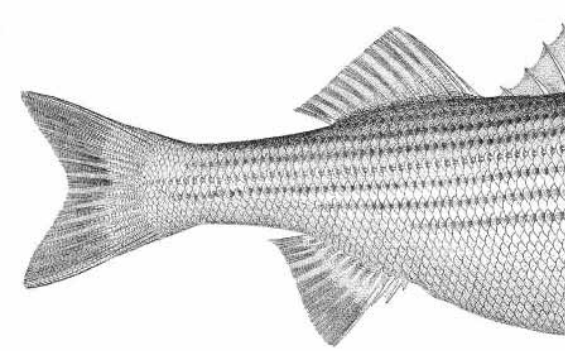
Develop Administrative Systems

- [ ] Establish how trading will occur
- [ ] Determine how catch accounting will work
- [ ] Determine what fishery information is required for science, catch accounting and enforcement
- [ ] Determine who covers the program cost

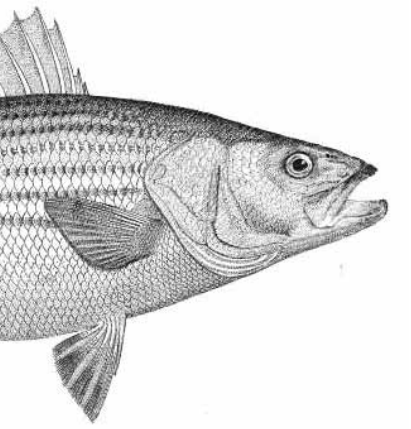
Step 7

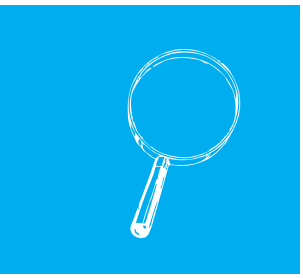
Assess Performance and Innovate

- [ ] Conduct regular program reviews
- [ ] Assess performance against goals
- [ ] Encourage innovation



1 Define Program Goals





At a Glance

Defining goals is perhaps the most important Step to ensure a well-designed catch share program. Goals should be clearly articulated prior to catch share design: They will drive design decisions and provide a basis for evaluating success.

KEY PRINCIPLES

Design the catch share program based on clearly-articulated goals with measures of success. | **16**

SUB-STEPS

SPECIAL FEATURES

1 Define Program Goals

The first and most important Step in designing a catch share is to articulate the goals of the program. As with any management system, knowing the goals from the beginning is vital to making good decisions about program design and evaluating success. Identified goals will help determine what design elements are most appropriate for your catch share program.

Catch share program goals are generally dictated by existing laws, the current state of the fishery (biological, economic and social) and the desired future for the fishery. See Snapshot 1.4. Though it may be challenging to articulate a suite of goals, due to the sometimes competing interests of various stakeholders, it is still vital to the process.

Often, managers identify multiple goals for a program. Meeting multiple goals may prove challenging and will require more thoughtful and intricate design. Furthermore, it may not be possible to optimize all goals, as would be the case if one goal was to increase profits and a second goal was to preserve all existing participants.

PRINCIPLE 1

Design the catch share program based on clearly-articulated goals with measures of success.

It is helpful to review identified goals for other catch share programs. They commonly fall into three categories: biological and ecological, economic and social. All three are discussed in more detail below. Reducing management complexity is another oft-cited goal. The rest of the Design Manual, including the **Catch Shares in Practice**, highlights how well various design options help achieve specific goals. Designing your catch share based on defined biological and ecological, economic and social goals can also help ensure the program is properly **Scaled** for the biological and ecological benefit of the resource, while also working well within the social and political systems of the participants.

1.1 WHAT ARE THE PROGRAM'S BIOLOGICAL AND ECOLOGICAL GOALS?

Conservation of fish stocks is often dictated by national or state law and therefore is a required goal for a catch share program. In particular, conservation may include ending overfishing, rebuilding overfished stocks and/or increasing productivity of stocks.

According to U.S. law, overfishing occurs when the rate of fishing mortality exceeds the ability for the stock to reproduce at the maximum biological level on a continuing basis (16 U.S.C. 1802). Ending overfishing requires setting catch limits at the appropriate level and holding fishermen accountable for staying within the limits.

Another common ecological goal is to reduce non-targeted catch. Non-target catch may include regulatory discards (i.e., marketable fish that fishermen are not allowed to keep due to regulations), economic discards (i.e., non-marketable fish that fishermen choose not to keep because it is not economically valuable to do so) and/or incidental take of ocean wildlife such as birds, mammals and turtles.

Biological goals are generally the most important for fisheries management and drive the design of a catch share program. Catch shares are commonly implemented in fisheries that are not meeting one or more biological goals (or are in danger of not meeting them). See Snapshot 1.4. Additional biological or ecological goals may include conserving key habitats or increasing knowledge of the stock and ecosystem.

SNAPSHOT 1.1 | Meeting Biological and Ecological Goals

Gulf of Mexico Red Snapper Individual Fishing Quota Program

On January 1, 2007, the Gulf of Mexico Red Snapper commercial fishermen commenced fishing under a transferable Individual Fishing Quota Program. Prior to 2007, the commercial fishery experienced frequent catch limit overages, significant discards, shortened seasons, declining profits and more (NOAA Fisheries Service, 2009a). Managers have worked since the late 1980s to institute measures to restore the greatly overfished stock, with little success. Biological goals, including catch limit compliance and reduction in discards, were primary reasons for implementing the catch share program.

After two years, the Gulf of Mexico Red Snapper Individual Fishing Quota Program has experienced many successes. The commercial season which was once open for only 77 days is now open year-round (NOAA Fisheries Service, 2009a). The discards to landings ratio of red snapper *(Lutjanus campechanus)* decreased by nearly 70%, in large part because of the reduction in the minimum size limit implemented as part of the IFQ Program. The dockside price of snapper has increased by nearly 20% over the 2006 price (NOAA Fisheries Service, 2009a). And in 2010, for the first time since 1996, managers increased the catch limit (from 5 million pounds to 6.95 million pounds) due to the success in rebuilding the stock. The commercial sector now enjoys greater flexibility and profitability and is a good example of successful implementation of a catch share program to meet biological goals.

1.2 WHAT ARE THE PROGRAM'S ECONOMIC GOALS?

Economic goals are commonly identified as critical to the design and performance of a catch share and generally relate to both fleet-wide performance (such as fishery value) and individual business performance (such as per vessel profits). Such goals may include reducing overcapitalization (i.e., promoting efficiently operating fleets), promoting the economic viability of industry and supporting stable, long-term employment.

Overcapacity in a fishery, increasing regulations to manage fishing effort and/or dwindling fish stocks often combine to reduce fleet-wide profits (Beddington et al., 2007; Grafton et al., 2006) and negatively impact the businesses of many fishermen. Overcapacity also increases pressure on fish stocks, bycatch and habitat because fishermen need to maximize catch in a very limited time. To compete in such fisheries, fishermen often use excessive gear, cut gear loose rather than recover it, fish in areas that may have lower yields and fish at non-optimal times. All of this can lead to decreased safety, increased costs and decreased profits. Many catch share programs have been implemented in order to reverse these conditions.

Additional economic goals may include minimization of government and industry costs of administration and management.

SNAPSHOT 1.2 | Meeting Economic Goals

New Zealand Quota Management System

New Zealand was the first country to comprehensively implement catch shares for their commercial fisheries. In 1983, they implemented catch shares for a handful of species, and in 1986, they incorporated other major stocks, creating what is now called the Quota Management System (QMS) (Lock and Leslie, 2007). By the mid-1990s, the majority of New Zealand's fisheries were incorporated into the country's QMS and today approximately 100 species and species groupings are included in the program, accounting for over 70% of the country's catch (by weight) of assessed stocks (New Zealand Ministry of Fisheries, 2010).

Economic goals were of primary concern for New Zealand in implementing the catch share program. Specifically, goals were to increase the economic and export value and profitability of fisheries, all while ensuring sustainability. More than 20 years after implementing catch shares, they are meeting their goals. The value of New Zealand commercial fisheries has skyrocketed under the QMS. From 1996 to 2009, the value has increased from $2.76 billion New Zealand dollars (U.S. $1.96 billion) to over $4 billion New Zealand dollars (U.S. $2.84 billion) (Heatley, 2010).

Additionally, many of the once-depleted stocks have been rebuilt under the program and now nearly 70% of the catch share stocks are at or near target levels. New Zealand fishermen participate substantially in the management process, including paying for many of the costs of management and science. The country's fisheries are held in high regard for sustainable, profitable management.

1.3 WHAT ARE THE PROGRAM'S SOCIAL GOALS?

Catch shares are often implemented in fisheries that are highly overcapitalized and/or during periods when catch limits are declining. Participants in fisheries such as these are already feeling the pain of declining stocks and increasing regulations through decreased job opportunity, instability and declining wages. As a result, social goals are often at the forefront for fishermen.

Social goals generally address the character and makeup of fishing fleets and communities, as well as fairness and equity issues. These goals have substantially driven the design of eligibility requirements, trading provisions, concentration caps and more.

A common social goal is to retain the character and historical geographic distribution and structure of the fleet. This is expressed in numerous ways, including promoting certain fleet sectors, limiting consolidation and concentration, maintaining fishing communities by ensuring local, resident fishermen have access to shares and more. Fairness of the process and fair distribution of benefits may also be important. Another stated goal of catch share programs has been to protect specific sectors of a fishery or specific fishing communities.

SNAPSHOT 1.3 | Meeting Social Goals

Georges Bank Cod Hook and Fixed Gear Sectors

In 2004, a group of hook fishermen on Cape Cod formed the Georges Bank Cod Hook Sector. For the previous decade, Cape Cod hook fishermen were suffering as cod stocks were declining and the existing days-at-sea management regime was severely restricting their ability to access fish and run profitable businesses. Due in part to the nature of hook fishing (specifically, the ability to selectively target fish), fishermen proposed a different approach to managers: In return for a secure annual share of the overall catch, sector fishermen would guarantee that they would not exceed the catch limit (NOAA Fisheries Service, 2009g). Sector goals were to increase fishermen's flexibility and profits, stop wasteful discarding of fish and ensure the future of hook fishermen on Cape Cod.

In 2006, a second sector, the Georges Bank Cod Fixed Gear Sector, was developed and implemented to provide similar opportunities to gillnet fishermen (NOAA Fisheries Service, 2009h). Under the sector program, fishermen work collectively to harvest a combined annual quota of fish. The two sectors have provided substantial benefit to the fishermen and the fish stocks. Under sector management, hook and fixed gear fishermen have stayed within their catch limit. In 2009 alone, they were able to land nearly 450,000 pounds of codfish *(Gadus morhua)* they would have been forced to discard under previous rules (Cape Cod Commercial Hook Fishermen's Association, 2010). Without the sector program, many fishermen would have likely gone out of business. The biggest challenge for fishermen was to shift from competing with other local fishermen to cooperating with them and managing their collective share together. The sectors have a local manager who works directly with the fishermen to ensure they comply with the sector catch limit while maximizing their collective goals.

In 2010, the sector model was expanded with implementation of the Northeast Multispecies Sector Management Program. Now, at least 98% of groundfish will be landed under 17 voluntary sectors in ports throughout New England (NOAA Fisheries Service, 2010).

1.4 BALANCE TRADE-OFFS

There is often tension among the identified goals for a fishery. Meeting biological goals should be paramount since managers are generally required by law to do so, and sustainable, well-managed fish stocks contribute to meeting social and economic goals.

Economic and social goals often present trade-offs. For example, the economic goal of maximizing fleet profitability and reducing overcapitalization may be at odds with the social goal of maintaining fleet structure and participants. This may be especially true in the case of a highly overcapitalized fishery and/or a highly constrained stock due to biological status. Table 1.1 summarizes analyses of the economic impact of specific design features for two catch share programs. Most of the analyzed design features were intended to meet specific program goals. The results highlight the economic trade-off of meeting those goals.

Catch share design can be customized to balance goals, but it is unlikely that any fishery management system can achieve all stated goals equally well. Ranking goals by importance and revisiting them over time can help ensure the program is meeting its objectives.

TABLE 1.1 | ESTIMATED ECONOMIC COST OF SELECT DESIGN FEATURES

	DESIGN FEATURE	ANALYSIS
BRITISH COLUMBIA HALIBUT FISHERY	Eligibility for holding and fishing shares **(Step 3.2)**	Increased fleet-wide profits were moderated due to requirements that limited vessel length. Harvesting efficiency could increase by up to 400% if vessel length restrictions were removed.
	Transfer unit size **(Step 4.3)** Transferability **(Step 4.5)**	Fleet-wide profits could have been ~4% higher if initial quota shares had been transferable and divisible.
ALASKA HALIBUT FISHERY	Transfer unit size **(Step 4.6)**	Fleet-wide profits were lower due to non-divisible quota "blocks." Prices for quota blocks were approximately 10% below non-blocked quota.

Chart adapted from: Kroetz and Sanchirico, 2010. Source data from: Grafton et al., 2000; Wilen and Brown, 2000.

SNAPSHOT 1.4 | Common Drivers for Implementing a Catch Share Program

Fishery managers and stakeholders have implemented catch share programs for a variety of reasons, including:

Biological conditions

- Overfished target or non-target species
- Current overfishing of target or non-target species
- Significant discards or bycatch
- Uncertain science due to lack of fishery information

Economic conditions

- Declining revenues
- Derby-style fishing; race for fish
- Overcapitalized fleet
- Excess gear deployment
- Buy-out under consideration
- Management costs exceeding revenues

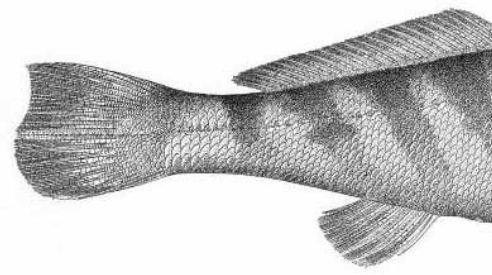
Social conditions

- Exceedingly complicated regulations
- Desire for increased stability and predictability
- Significant safety concerns
- Conflict between different fishing sectors
- Declining or unstable jobs

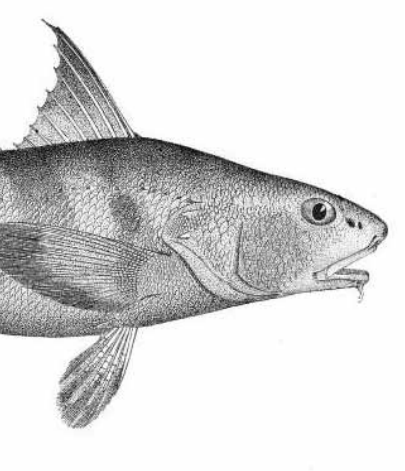
Step 1 – Define Program Goals

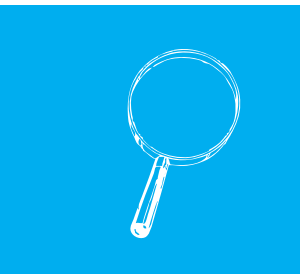
This chart provides a brief summary of the Step 1 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

	1.1 BIOLOGICAL & ECOLOGICAL GOALS	1.2 ECONOMIC GOALS	1.3 SOCIAL GOALS
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Improve long-term productivity of fisheries Reduce bycatch	Reduce overcapitalization	Retain character of fishing fleet Reward participants who invested in the fishery
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	Conserve fish stocks Account for all catch Precautionary management for species of concern	Increase benefits from fishery Allow for controlled rationalization of the fleet	Ensure fair distribution of benefits Stabilize employment Ensure fair treatment of crew
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	Conserve benthic resources Maintain or increase biological productivity Increase knowledge of ecosystem	Ensure sustainability of artisanal economic activity	Promote participative management
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Ensure sustainable harvests Reduce discards	Balance fleet capacity with fishing opportunities Create economic growth in the fishing sector	Ensure future entrance of young fishermen Maintain competitive coastal fisheries and communities



2 Define and Quantify the Available Resource





At a Glance

Defining and quantifying the available resource provides the biological basis for the catch share program. By carefully completing this Step, you will ensure that you have included sources of significant mortality and established an effective, science-based catch limit.

KEY PRINCIPLES

Consider including in the catch share program species that are commonly caught together. | 29

Create separate catch limits and shares for each species, stock and zone in the catch share program. The catch limit should account for all sources of fishing mortality and should prevent overfishing. If the stock is already overfished, the catch limit should be set at a level that will rebuild the stock. | 34

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2 Define and Quantify the Available Resource

Nearly all fisheries considering a move to catch shares will already have some existing management traditions in place. In U.S. federal fisheries, that means a Fishery Management Plan (FMP) has been developed by a Regional Fishery Management Council and approved by the Secretary of Commerce. FMPs are generally implemented through issuing permits or licenses with terms and conditions by which participating fishermen must abide.

Many of the decisions outlined in this Step will require biological data and information. Both data-poor and data-rich fisheries have transitioned to catch shares. More scientific information can strengthen a program over time, but a workable catch share program can be implemented by cleverly using available information. Future addenda to the Design Manual will highlight specific approaches for setting catch limits in data-poor fisheries.

By carefully defining and quantifying the available resource you will ensure that you have appropriately **Limited** access to the catch through an effective, science-based catch limit, and that you have included **All sources** of significant mortality.

2.1 WHICH SPECIES WILL BE INCLUDED?

Catch share programs can be either single-species or multi-species, accommodating any number of targeted, non-targeted or bycatch species. Worldwide, there are more single-species programs than multi-species programs. However, there are far more species under multi-species catch share programs than in single-species programs. A few key questions to consider when determining which species to include:

- Which species are caught by the fishery under consideration?
- Are multiple species commonly caught together?
- Do management objectives require accounting for the mortality of those species (such as overfished vulnerable species)?
- What is the amount of mortality from the catch and its impact on species sustainability?

If you do not allocate shares for all encountered species in a fishery, you should identify additional measures to control catch and mortality of those species.

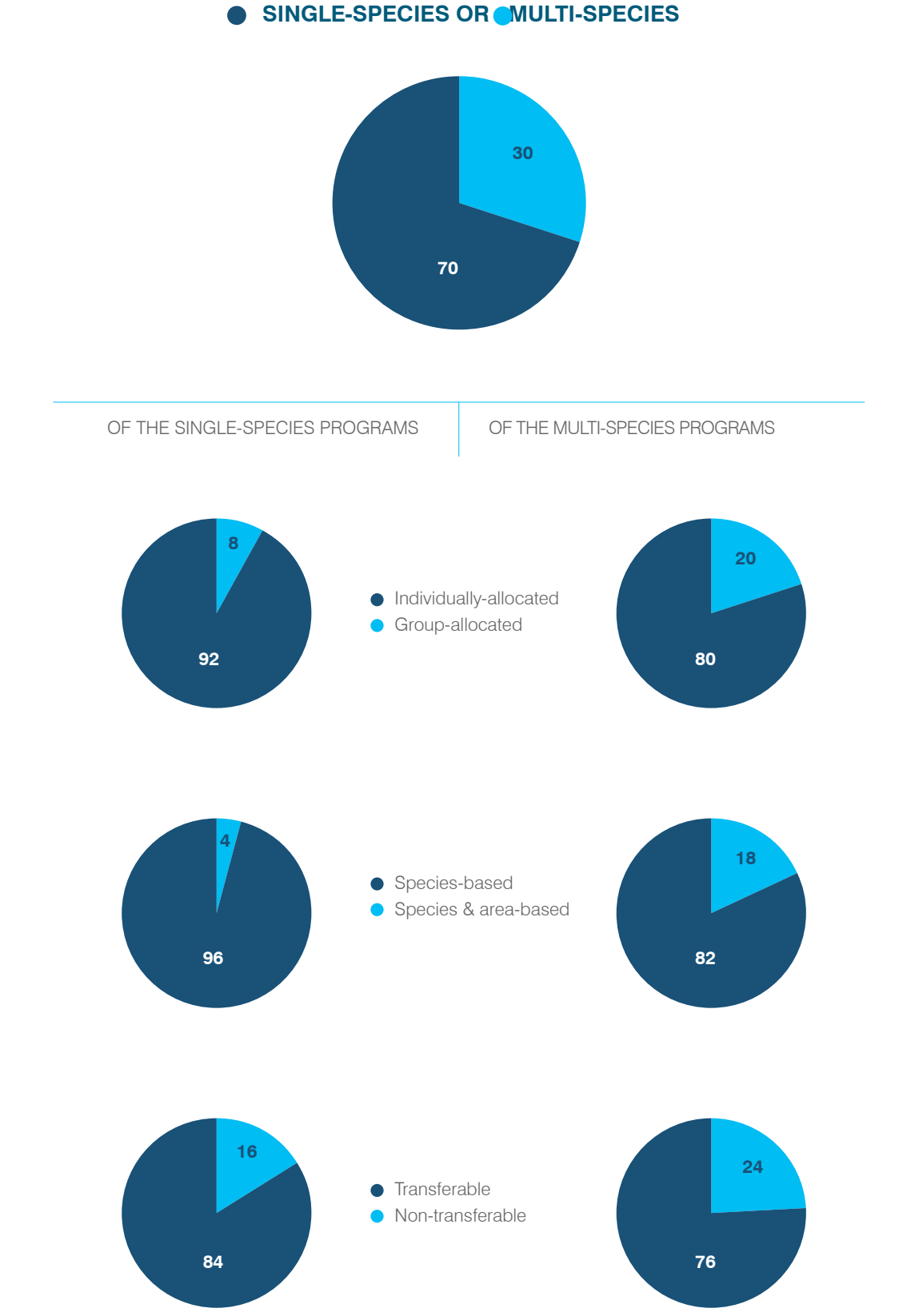
Single-species

About 70% of the catch share programs worldwide are single-species, but this comprises only 25% of the species under catch shares (see Figure 2.1). Single-species catch share programs have been commonly used in two instances: (a) when there is relatively little bycatch or a low target to non-target catch ratio or (b) when existing management has already created single-species management through limited-access licensing. In the case of a fishery with low bycatch, a single-species approach is likely to be highly effective. If there are significant interactions with multiple species, then it is advisable to consider a multi-species catch share.

Multi-species

Managers often distinguish between targeted and non-targeted catch or directed and non-directed effort. In reality, most fishermen encounter and catch multiple species whether or not they are targeting all caught species. It is possible both to have multiple target species

FIGURE 2.1 | *Percent Use of Catch Share Design Features Worldwide*



and incidentally caught species (bycatch is a commonly used term to describe incidentally caught species). When fishermen commonly catch more than one species, a multi-species catch share program may be more effective. Seventy-five percent of the species managed under catch shares are in a multi-species program, and about 30% of catch share programs worldwide include multiple species (see Figure 2.1).

Many of the challenges of managing multi-species fisheries will still exist under a catch share approach. For example, when one or more of the stocks is of low abundance, there is often a fear that those stocks will constrain the ability to access higher abundance stocks. The benefit under catch shares is that fishermen have an incentive to find innovative ways to avoid stocks of low abundance while continuing to access higher abundance stocks. For example, in the British Columbia Integrated Groundfish Program, many fishermen have successfully modified practices in order to minimize their take of species that are of low abundance and for which the shares are more costly. In order to ensure the health of all stocks and species, real-time accounting of catch and landings will be important. Some common approaches have emerged to make multi-species catch shares easier to administer:

- *Transferability with retrospective balancing*
  Transferability with accurate catch accounting and balancing is a proven, effective method for administering multi-species catch shares. Under this approach, fishermen are generally not required to have shares for all their catch as they land it, but they are required to obtain shares equal to their catch within a certain period of time, such as on a quarterly, monthly or weekly basis. This allows fishermen some flexibility in their fishing practices while still requiring a complete accounting of all the fish caught and/or landed on a regular basis. If there are certain vulnerable stocks that have low limits, then it would be advisable to require retrospective balancing more frequently. See **Step 6.2** for a more complete discussion of catch accounting, including retrospective balancing.

- *Quota baskets*
  A quota basket is a group of species that are allocated to participants based on a total limit for all species in the grouping. Each fish species does not have its own individual quota, so fishermen are allowed to land any species within that quota basket up to the overall limit. While this may be easier for fishermen, a large potential risk is unequal depletion of species which is especially dangerous for vulnerable or low abundance species. Quota baskets have been used in a few places, especially when catch shares were first implemented, but most systems have abandoned this approach due to the depletion risks (Harte, personal communication, 2008; Peacey, personal communication, 2008).

- *Weighted transfers*
  Some multi-species catch shares allow participants to substitute the shares from one species to cover catch of a different species. For example, shares for species "a" may be allowed to cover catch and landings for species "b." In many cases, more vulnerable or more valuable species will "cost" more in terms of shares from a different species so that participants weigh the benefit of using that share allocation. Similar to quota baskets, this approach provides more flexibility for participants, but there are some clear risks, especially for vulnerable species or species of low abundance. In addition, it is complex and challenging to administer (Harte, personal communication, 2008; Peacey, personal communication, 2008).

- *Innovations*
  Catch share programs support and reward fishermen innovation in solving key challenges such as compliance in multi-species fisheries. In fact, by setting a performance standard on non-directed catch, fishermen are often able to develop their own methods for staying within the limits. For example, members of the U.S. Bering Sea Pollock Conservation Cooperative have a voluntary monitoring agreement under which information on salmon bycatch is shared throughout the fleet and temporary closures of bycatch "hotspots" are set (Griffith, 2008). In other catch share fisheries, fishermen pool quota of low abundance

PRINCIPLE 2

Consider including in the catch share program species that are commonly caught together.

fish in "insurance pools" to provide enhanced fleet-wide flexibility.

Bycatch

Bycatch is any non-target species that is caught and discarded. Bycatch can be a commercially valuable fish that is not allowed to be landed in the fishery for a variety of management reasons such as minimum or maximum size, prohibited species or trip limits. Bycatch can also be non-marketable species that are caught and discarded. It is possible to include bycatch as part of a catch share program either by setting a catch limit and allocating shares or by continuing to manage it via other methods. Other methods can include prohibition of retention, fines for landing, deployment of gear and effort, time and/or area closures and more.

Trade-offs

In order to successfully manage your fishery, you must consider how to control the catch of all species caught. If your fishery is single-species, then this is relatively straightforward. However, for a multi-species fishery, this becomes more challenging. From a biological point of view, it is preferable to include all species and stocks in the catch share program, each with a distinct catch limit. This approach is more likely to improve management on an ecosystem level and may increase economic benefits since participants could maintain shares (via allocation and transfers) that accurately reflect the composition of their catch. While this is biologically preferable, there may be important administrative reasons, such as need for reduced complexity or lack of information, to exclude some species.

Managers have often implemented simple systems at first and then incorporated additional species over time. For example, Iceland first implemented IVQs for the herring fishery in 1975, and by 2004 all vessels had been incorporated into the program (Arnason, 2008). Similarly, New Zealand experimented with catch shares in the early 1980s, transitioned most major species to a catch share program in 1986, and then added most remaining species throughout the subsequent years (New Zealand Ministry of Fisheries, 2007). When all species are not included in the catch share, other management approaches must be used to control catch on those species, such as effort-based controls, input controls, gear restrictions, time and area closures and more. While these may be the best options, they may also make the program more onerous to navigate (Anderson and Holliday, 2007). This will require careful management over time.

If you can not set a catch limit for all species, you need to analyze the reason for bycatch and design an approach that focuses on achieving the greatest possible reduction. For example, if the bycatch is regulatory discards of fish with high mortality, you might need to reduce minimum size requirements; if you have periodic encounters with endangered species, then you need to have real-time accounting and you may need to periodically close the fishery.

2.2 WHICH STOCKS WILL BE INCLUDED?

Most fisheries encounter multiple, biologically-distinct fish stocks. Many catch share fisheries distinguish between different stocks and successfully account for this by establishing stock-specific catch limits and quota allocations. This provides managers with a greater ability to ensure sustainability of each stock (Lock and Leslie, 2007). Other arrangements are also possible. For example, in the New Zealand hoki *(Macruronus novaezelandiae)* fishery, there are two recognized stocks, but they are not completely geographically separated. In this case, there is a single catch limit and a voluntary "catch splitting" agreement between the government and shareholders which provides, in effect, separate catch limits for the two stocks.

Lumping multiple fish stocks into the same catch share pool can be biologically detrimental since it is possible to overfish one stock while not exceeding the total catch limit for the entire fishery. On the other hand, when fish from various stocks are commonly caught together, it may be impossible to determine which stock is represented. In this case, it may be necessary to come up with additional methods (e.g., identifying geographic zones that largely distinguish stocks, or creating different counting methods based on known abundance of different stocks). Fishery managers who have already been faced with these challenges under existing management systems may have developed approaches that can be easily adapted to a catch share.

TABLE 2.1 | SPECIES AND ZONES INCLUDED IN SELECT PROGRAMS

	# OF SPECIES	# OF ZONES
PACIFIC WHITING CONSERVATION COOPERATIVE	1	1
ALASKA HALIBUT AND SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM	2	8
BAJA CALIFORNIA FEDECOOP	5+	9
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM	30	8
AUSTRALIAN SOUTHERN AND EASTERN SCALEFISH AND SHARK FISHERY STATUTORY FISHING RIGHT PROGRAM	50+	Multiple, based on species and gears
NEW ZEALAND QUOTA MANAGEMENT SYSTEM	119	10, varies by species

Source data from: Fisheries and Oceans Canada, 2010a; Pacific Whiting Conservation Cooperative, 2005; AFMA, 2008; Anderson and Holliday, 2007; Meany, 2001; Lock and Leslie, 2007; and Chafee, 2006.

2.3 WHAT WILL THE SPATIAL RANGE BE, AND WILL THERE BE DIFFERENT ZONES?

The spatial range of a catch share can also be customized and is largely related to species and stock boundaries. Existing political or socio-cultural boundaries may also be important in defining managed areas.

Biological considerations

Spatial range and zone boundaries of catch shares are usually driven by the species and stock biology. For example, a pelagic fish like anchovies will likely have a large, single zone, whereas stocks more subject to localized depletion, such as abalone, may benefit from smaller, multiple zones. See discussion of stocks in **Step 2.2**.

Social considerations

Social goals can also be accommodated through zones. You can define and allocate resources to a particular group (such as a community, specific gear types, etc.) and/or require fishermen to land their catch in specific geographic areas. For example, Mexico has created a series of species and area-based catch shares along the Pacific coast of Baja California that coincide with community boundaries (Defeo and Castilla, 2005).

Trade-offs

While creating different catch share areas may help achieve specific biological or social goals, multiple zones will also increase complexity, making it more challenging for fishing businesses, monitoring and administration. If zones are implemented, it is important to identify them based on existing biological, geographical or social boundaries.

When the area of jurisdiction is smaller than the stock or species boundary, it may be more difficult to implement effective management of any kind, because activities outside jurisdictional control can negatively impact the fishery. This is a common issue in fisheries, both between multiple countries and within one country, such as when there is a state or provincial fishery and a federal fishery. In this instance, there may be a benefit to implementing a nested system of catch shares. For example, a portion of the overall catch could be allocated to each of the jurisdictions that manage fishing activities for a particular fishery (multiple countries, states, etc.). Then, each of these jurisdictions could implement their own catch share program or use a different management approach.

Depending upon the reasons for the zones and the importance of keeping the catch in that specific area, you could allow or disallow trading between areas. For stocks that span multiple jurisdictions, cooperation that ensures compliance in all zones will be important for any fishery management system, including catch shares.

SNAPSHOT 2.1 | Multiple Species, Sectors and Zones

Australian Southern and Eastern Scalefish and Shark Fishery Statutory Fishing Right Program

Australia's Southern and Eastern Scalefish and Shark Fishery (SESSF) is a multi-species, multi-gear, multi-sector catch share fishery that came under a single management plan in September 2003. Prior to 2003, there were a number of distinct fisheries that overlapped in terms of effort and species interaction, many of which were already managed under their own catch share programs (AFMA, 2003).

The catch share program has grown from 16 species to over 50 species, and includes fishermen using ten gear types including demersal trawls, otter trawls, Danish seines, midwater trawls, scalefish hooks, shark hooks, gillnets, dropline, fish traps, and long lines (AFMA, 2003). There are about 15 area closures created to protect fishing stocks, breeding groups, critical habitat and endangered species. The closures vary between sectors and gear type (e.g., some closures might be closed for a specific gear sector such as trawling). Annual catch limits are determined for each species or species groupings. Orange roughy *(Hoplostethus atlanticus)*, gemfish *(Rexea solandri)* and deepwater sharks are further subdivided into multiple zones for specific species management or specialized regulations. For example, orange roughy has five management zones with individual TACs to prevent localized depletion and to recognize stock boundaries (AFMA, 2008). As a complex array of species, gears, zones and fishermen constituting an active fishery, the SESSF represents the reality of many fisheries worldwide and provides an example of how to coordinate multiple species under one catch share program.

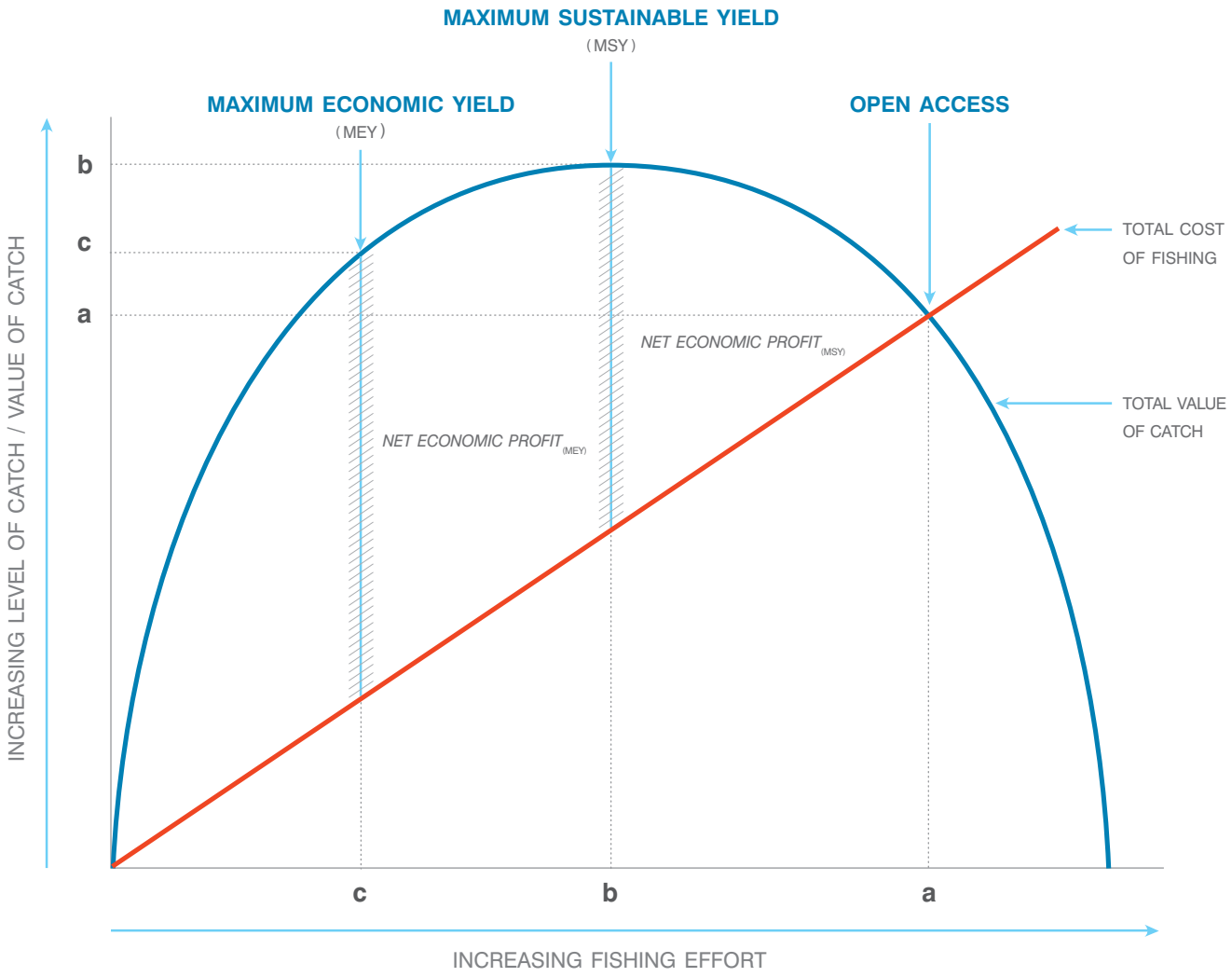
2.4 WHAT WILL THE ALLOWABLE CATCH LIMIT BE FOR EACH SPECIES, STOCK AND ZONE?

Setting the appropriate catch limit is a vital component of any fishery's management plan. In general, effective fisheries management requires managers to set a biologically sound catch limit and ensure the catch limit is met. There is significant literature and experience regarding how to set an appropriate catch limit. This body of literature and experience is evolving rapidly, and in the U.S. the search for methods to set catch limits – even in the absence of high quality data sets – is urgent due to a new federal mandate to set catch limits for all U.S. stocks. Naturally, these data-poor methods will be valuable in other countries as well, since many fisheries suffer from inadequate data. This discussion provides a very brief overview in the context of designing a catch share.

If a catch limit is set too high, any fishery, including a catch share fishery, is at risk of becoming overfished. To be effective, a catch limit must not only account for the number of fish taken by the directed fishery, but it must also account for all sources of mortality, whether from different sectors of a directed fishery, other sectors that catch the species as incidental catch, or from fish that are discarded dead or dying. Depending on the biology of the species, limiting the take of certain size classes may also be important.

The catch limit is generally derived by calculating the amount of take that would theoretically meet national or state policy objectives by conducting a stock assessment

FIGURE 2.2 | *Theoretical Cost and Value of Fishing*



The graph above depicts the theoretical cost and value of fishing under three different scenarios: open access without a catch limit, a catch limit set and enforced at Maximum Sustainable Yield (MSY), and a catch limit set and enforced at Maximum Economic Yield (MEY). The dark blue line shows the total fleet-wide value of catch for sustained effort levels and the red line shows the total fleet-wide cost of fishing. The difference between the two lines is the net economic profit for the fishery. Under open access (or a fishery with no identified catch limit), fishermen generally increase the number of vessels and total effort until there is no net economic profit, i.e., until the total cost of fishing equals the total value of catch (a). Under MSY, the catch limit is set to maximize the amount of catch. The level of effort decreases from open access, but the level of catch increases. Net economic profit also increases compared to open access, but profits are not maximized (b). Under MEY, the catch limit is set to maximize the economic profit of the fishery. The level of catch is lower than MSY, but costs also decrease and therefore net economic profit is maximized (c). Catch shares can operate within any scientifically appropriate catch limit. Setting the catch limit at MSY will maximize the amount of fish removed and setting the catch limit at MEY will maximize the net economic profit of the fishery.

PRINCIPLE 3

Create separate catch limits and shares for each species, stock and zone in the catch share program. The catch limit should account for all sources of fishing mortality and should prevent overfishing. If the stock is already overfished, the catch limit should be set at a level that will rebuild the stock.

(a synthesis of existing data with the aim of determining the capacity of the stock to sustain fishing mortality). For example, in Australia the policy is to set the catch limit at the Maximum Economic Yield (MEY), which is the level at which the fishery would be expected to maximize profits and achieve optimal economic value. In the U.S., the catch limit is usually set at Maximum Sustainable Yield (MSY), and then modified to achieve the Optimum Yield (OY), which is the harvest level for a species that achieves the greatest overall biological, economic and social benefits (16 U.S.C. 1802). In a perfect market, MEY removes less fish from the stock than MSY, because the cost of catching another fish does not exceed the value of that fish. See Figure 2.2 for a graphical description of open access, MSY and MEY.

Catch share fisheries are superior to other management approaches at staying within their catch limit (Essington, 2010). However, there have been instances where catch share fisheries have set catch limits too high and the stock suffered as a result. In the early days of the New Zealand orange roughy fishery, science was inadequate and certain assumptions were made, resulting in a catch limit that was too high for sustainability. In addition, the fishery experienced a high level of wastage due to gear deployment techniques. Participants effectively caught the entire catch limit and overfished the stocks. Better science has been developed and catch limits were lowered, but at considerable financial and political cost, since it is difficult to lower catch limits after fishermen have set their expectations to comport with a higher limit. Despite these lowered catch limits, some orange roughy stocks are still recovering (Straker et al., 2002; Peacey, personal communication, 2008). Recovery is hampered by the fact that orange roughy is a long-lived species that is slow to reproduce.

Managing uncertainty

Fisheries management is inherently uncertain. Ocean productivity varies naturally in ways that are not well understood. Human activities can also impact habitat and fish productivity in a variety of ways. Moreover, market demand and prices can have strong effects on catch and result in volatility. Hence, managers must almost always make decisions based on uncertain information and imperfect projections of the consequences of the decisions.

The manner in which uncertainty is managed has strong impacts on many important facets of the fishery, ranging from the quality and quantity of data to the risk of stock collapse. A tiered approach to managing uncertainty around catch limits can be useful. In such approaches, the method of setting catch limits varies depending on the level of scientific uncertainty. If very little is known about the stock (i.e., data-poor stocks), catch limits are set only on what is known and then reduced to hedge against uncertainty and the risk of adverse outcomes such as stock collapse and overfishing. When more is known about the stock (i.e., data-moderate and data-rich stocks), then managers can employ more scientific approaches and moderate their adjustments based on the state of the science. Even for data-rich stocks, uncertainty will persist, and so precautionary adjustments are still required. Harvest control rules can be useful for managing uncertainty and creating clear, objective rules that can be followed when circumstances require tough decisions to be made. For example, managers can establish a series of

catch thresholds that trigger a reduction in the catch limit or a cessation of fishing.

Other approaches

Long-term sustainability of any fishery depends on having a sufficient stock that can effectively support an ongoing level of catch. A catch limit is an important component of a catch share program. Many fisheries have existing processes and protocols for setting a catch limit. It is necessary for a catch share fishery to work within those protocols or to alter the process over time as new information becomes available.

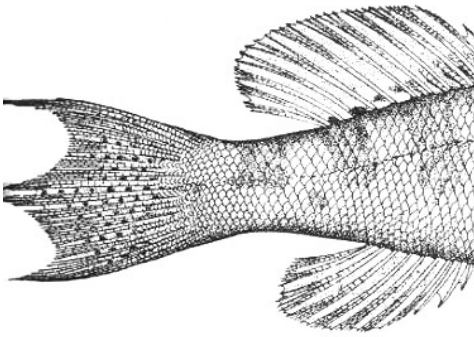
Your fishery may not have a catch limit or an established process for setting a catch limit. This often occurs when there is insufficient data to set a catch limit. While data-poor fisheries may currently not have enough information to set a sound, science-based catch limit using conventional stock assessment methods, new techniques have been developed for setting catch limits in data-poor fisheries that should be considered in these cases (Honey et al., 2010).

Some fisheries that have not been able to set a meaningful catch limit have implemented species and area-based catch shares without a catch limit or tradable effort-based systems in which a cap is set on the amount of fishing effort deployed, i.e., through number of traps or number of tows made. These approaches do not meet many of the key characteristics of a catch share and are beyond the scope of this document. For more discussion on area-based approaches with a catch limit, see **Step 4 – Define the Privilege** and **Appendix B: Managing Without a Catch Limit**.

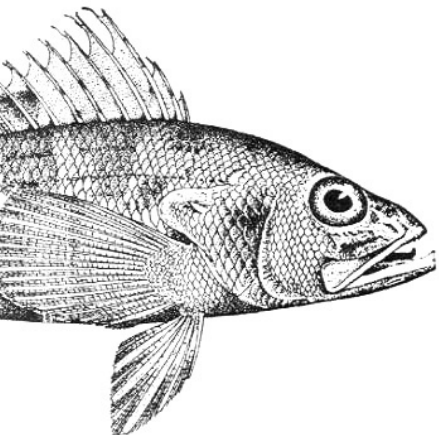
Step 2 – Define and Quantify the Available Resource

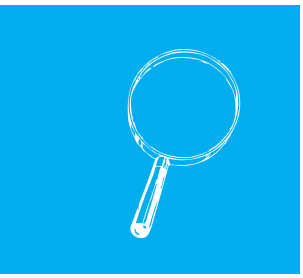
This chart provides a brief summary of the Step 2 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

	2.1 SPECIES INCLUDED	2.2 STOCKS INCLUDED	2.3 SPATIAL RANGE AND ZONES	2.4 SCIENCE-BASED CATCH LIMIT
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Halibut, Sablefish	Halibut: 8 stock-based zones Sablefish: 6 stock-based zones	Federal waters of the Bering Sea, Aleutian Islands and Gulf of Alaska	Consistent with national policy Maximum Sustainable Yield
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	30 groundfish species	55 species-area combinations	Federal waters of Canada's Pacific Coast	Consistent with national policy Precautionary management
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	Loco 62 additional species in various areas	Multiple stocks	Over 500 TURFs along Chile's entire coast	Initial baseline study required for loco and some additional species
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Numerous pelagic and demersal species	Multiple stocks	Numerous zones in Danish waters of the North Sea, the Skagerrak, the Kattegat and the Baltic Sea	Determined by the European Commission Maximum Sustainable Yield



3 Define Eligible Participants





At a Glance

In completing this Step, you will identify the parameters for participation in the catch share program. This will govern the ways in which current and future shareholders are permitted to operate within the program.

KEY PRINCIPLES

Develop mechanisms for accommodating new entrants during the design of the catch share program and prior to initial share allocation. | 48

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3 Define Eligible Participants

Now that you have defined and quantified the available resource, the third Step in designing a catch share is to define who is eligible to participate. Once again, existing management plans will help guide this decision. For example, the existing licensing structure may determine who the privilege holder will be. The identified goals, in particular social and economic goals, will guide most of the decisions about eligible participants.

By carefully defining eligible participants, you will help ensure that participants have **Exclusive** access to shares that is recognized by the management authority, and you may be able to effectively **Scale** the program to existing social units.

3.1 WILL THE PRIVILEGE BE ALLOCATED TO INDIVIDUALS OR GROUPS?

Catch shares allocate a secure portion of the allowable catch to a privilege holder. The choice of privilege holder can range from individuals to groups, independent businesses to communities. About 90% of catch share programs worldwide are individually-allocated systems (see Figure 3.1).

There are a number of types of individually-allocated catch shares. The three basic categories are:

- *Individual Quotas (IQs)*
  Shares allocated to individuals or individual entities. Recipients are generally fishermen and shares are non-transferable.
- *Individual Transferable Quotas (ITQs)*
  Shares allocated to individuals or individual entities. Recipients are generally fishermen and shares are transferable.
- *Individual Vessel Quotas (IVQs)*
  Shares allocated and attached to an individual vessel. Shares may or may not be transferable. This has been used most commonly in Canada.

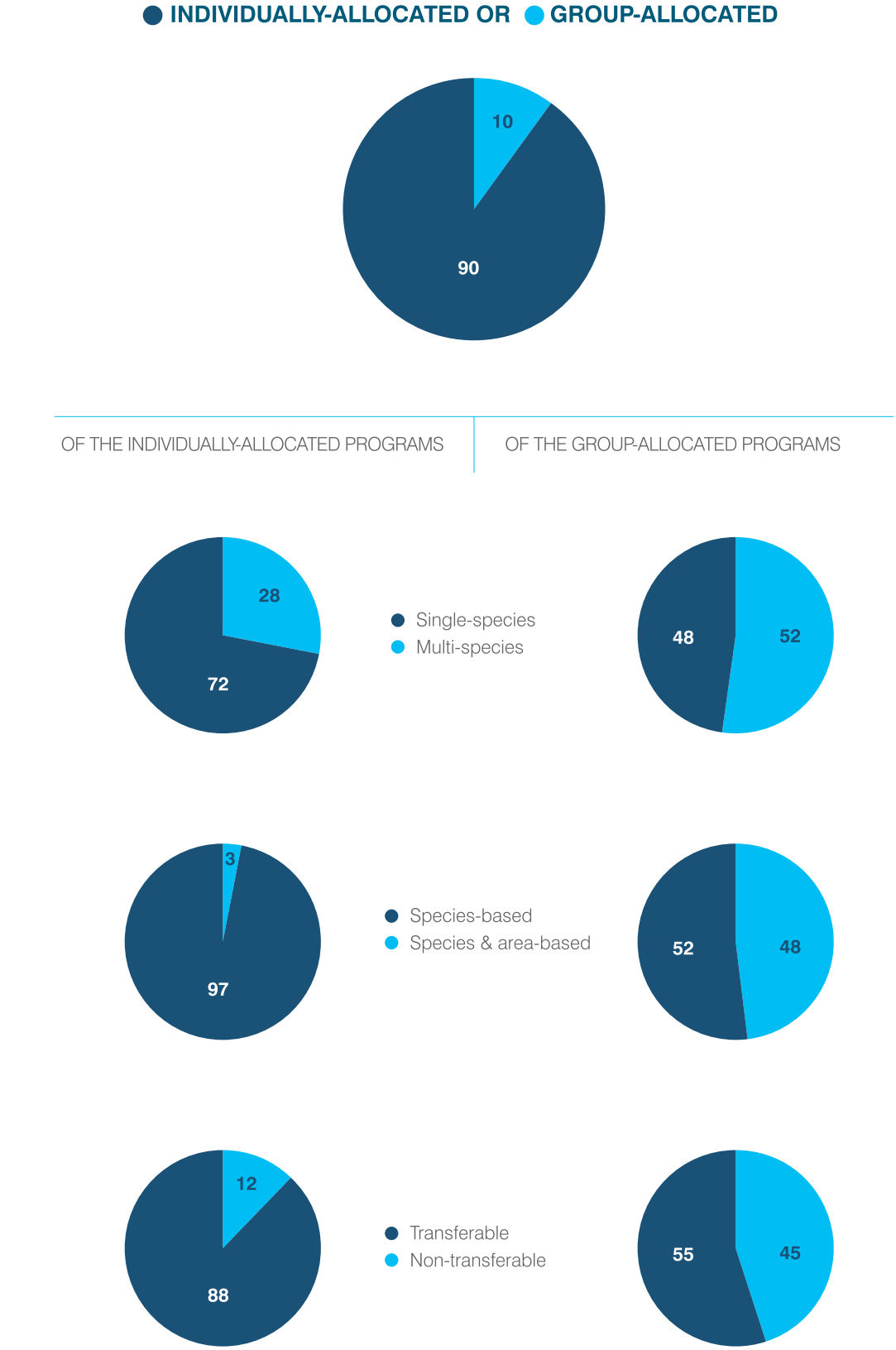
Other commonly used names to describe individually-allocated catch shares include:

- *Individual Fishing Quotas (IFQs)*
  Shares allocated to individuals or individual entities. Recipients are generally fishermen and shares may or may not be transferable. The term IFQ is more commonly used in the U.S. rather than IQs or ITQs.
- *Company Quotas*
  Shares allocated to a fishing company who determines the management of the shares. Shares may or may not be transferable between different companies. Canada uses this approach in some fisheries and calls it "Enterprise Allocations."

The majority of catch shares studied worldwide are individually-allocated systems. Individually-allocated systems hold individuals accountable for their catch and provide flexibility to individuals. When there are existing individual fishing businesses and/or a goal to encourage flexibility and economic efficiency, an individually-allocated system may be preferable. Individually-allocated catch share programs have often been implemented when there is a goal of maximizing the economic efficiency or value of the entire fishery. For example, both Australia and New Zealand chose individually-allocated systems as the best way to achieve their goals of increasing economic efficiency and value and increasing the value of fishery products (Straker et al., 2002).[5]

5 It is possible to design a Cooperative to also increase economic efficiency. For example, a Cooperative could choose to coordinate effort, share information on stock locations and time harvests to decrease costs, and increase revenues (Deacon, Parker and Costello, 2008).

FIGURE 3.1 | *Percent Use of Catch Share Design Features Worldwide*



Group-allocated

There are two main types of group-allocated catch shares:

- *Cooperatives*
  Shares allocated to a group of fishermen or other entities. The entire catch can be allocated to one Cooperative or it can be split among multiple Cooperatives. Cooperatives historically have been organized around a common feature such as gear type or location. Some Cooperatives are built by individual shareholders who opt to pool their annual share allocations such as Denmark's system of Fishpools, which facilitates temporary transfers (see **Catch Shares in Practice: Danish Pelagic and Demersal Individual Transferable Quota Programs**).

- *Community Fishing Quotas (CFQs)*
  Shares allocated to a specific community with certain rules and stipulations that tie the share, or the proceeds of the share, to that community. These have also been called Community Development Quotas (CDQs), and Community Quotas.

  Permit banks, community license banks and Community Fishing Associations are also beginning to emerge, and these entities may be appropriate recipients or holders of catch share privileges. Alaska has both CDQs and Community Quota Entities (CQEs). The CDQs allocate shares to 65 native communities, which are then allowed to fish or lease shares. CQEs are entities that are not granted shares, but are allowed to purchase and fish shares.

Group-allocated catch shares are more common when the goal of the catch share is to promote or benefit a specified group of participants. Organizing a group of fishermen, boats and/or fishing businesses can be challenging. Therefore, Cooperatives and community shares have generally been implemented where one or more of the following characteristics exist: discrete fishing units with strong social bonds, common interests and values; ability of group to monitor and enforce rules; or mutually agreed upon laws, norms and methods for functioning as a group.

There are significant costs of managing a Cooperative that need to be covered. These can be especially expensive where organized groups do not yet exist and most models charge the participating fishermen a fee for the group services. In some cases, a Cooperative can be used to consolidate quota into a few entities, which may not fit the goals of the catch share program.

Despite the challenges, some group-allocated catch shares have been successful in meeting key social and/or economic goals. When there is a cohesive, tight-knit group that can collectively manage a fishery, or there is a goal of promoting a certain group of fishermen (i.e., based on location or gear type), a group catch share may be preferable.

Combinations

It is possible to combine these individual and group approaches. For example, a Fishery Management Plan may identify an individually-allocated catch share, but various fishermen can choose to create agreements among themselves and act as a group. On the flip side, when a management plan creates a group-allocated catch share, each group may choose to implement individual shares among themselves in order to effectively fish and manage their shares. A combination approach, either formal or informal, may be the most effective for a fishery.

All of these approaches are feasible and can work. The key is to assess the goals of the program and how the overall design will affect incentives of participants in order to achieve those goals.

Additional considerations

One important purpose of allocating shares is to eliminate, or minimize, the incentive for fishermen to competitively race for fish. Any time the program design encourages an individual to race, the catch share program will not achieve full benefits. This could happen under both individually-allocated systems – e.g., if individuals want to maximize a limited, higher value fish – or under group-allocated systems – e.g., when group activities are not coordinated

and members need to race for good fishing grounds or a competitive share. In these instances, systems that enforce accountability will be even more important. See **Step 6 – Develop Administrative Systems** for further discussion.

Communication and coordination of fishing activity are often important components of a catch share program, especially when there is a high likelihood of encountering prohibited bycatch or species with low catch limits. Both individually-allocated and group-allocated approaches have successfully addressed this challenge. For example, the Pacific Whiting Conservation Cooperative has a protocol for tracking and avoiding bycatch hotspots through real-time reporting of catch composition and the enforcement of closures in real-time. The British Columbia Integrated Groundfish Program requires real-time trading and catch accounting to ensure that all species are accounted for as they are caught.

Once you have decided whether to allocate shares to individuals, groups or a combination of both, the specific privilege holders must still be determined. In the case of individually-allocated systems, existing licensing conditions will be important determinants. In almost all cases where a fishery has moved from a limited entry system to an individually-allocated catch share program, the catch share privilege holder has been the license holder. For example, in British Columbia the allocation is based on the vessel, because vessels, rather than individuals, are licensed (Grafton et al., 2005). In the U.S., permits are generally held by an individual (though it may have to be tied to a vessel) and U.S. catch shares have generally reflected that by allocating catch shares to individual participants (Redstone Strategy Group, LLC and Environmental Defense Fund, 2007). Following existing licensing conditions makes allocation administratively easier and ensures that existing participants are included in the program.

For group-allocated catch shares, there must be an actual entity to hold the shares. Entities that hold and manage the shares could be an existing fishermen's association, a non-profit corporation, local government or another recognized and organized entity. If a suitable entity does not exist, then it must be created. For example, when NOAA approved (upon the recommendation of the New England Fishery Management Council) a cod *(Gadus morhua)* sector allocation for the George's Bank Cod Hook and Fixed Gear Sectors, the fishermen were required to create a legal entity with the responsibility of managing the allocation and reporting to the government on a regular basis.

Furthermore, when catch shares are group-allocated, there are two different levels of interaction to consider. First, the interaction among groups, i.e., can shares be traded across groups? And second, the interaction within a group, i.e., how do group members divide up the catch share?

3.2 WHO IS ALLOWED TO HOLD AND FISH SHARES?

You can identify who is eligible to both hold shares and participate in a catch share program, as well as how those shares are used throughout time. Establishing criteria and rules for eligible shareholders has often been important to participants and managers. Generally, criteria are identified to accommodate existing fishery participants, encourage fairness and promote a particular characteristic of the fishery in the short and long term – such as an owner-operated fleet.

Decisions regarding eligibility occur both when designing a catch share program and when allocating initial shares. For more information on allocation, see **Step 5 – Assign the Privilege**.

Shareholder eligibility

There are a number of reasons to carefully consider who is allowed to hold catch share privileges and who may participate in the harvesting of shares. Because catch shares

are often a valuable asset there may be an interest among a variety of stakeholders, fishermen and others to obtain access to them.

Managers have often considered the following criteria in determining eligible catch shareholders:

- Citizenship
- Participation in fisheries, as indicated by holding a license
- Membership in an identified Cooperative or fishing community
- Reliance on fishing for income
- Membership in a fishing family
- Connection to the resource
- Connection to the fishing industry
- Investment in the fishery
- Catch history
- Conservation behavior

When designing a group-allocated catch share, managers must also specify criteria for allocation to particular groups, such as whether it needs to be a non-profit corporation, as well as criteria for membership within the group, such as those outlined above. In some cases, groups may identify additional criteria required for membership.

Shareholder specifications

You may also choose to stipulate who is allowed to fish the shares and whether the shareholder and the fisherman on the water must be one and the same, i.e., prohibit leasing of shares. There are social, economic and biological reasons to consider the impact of "absentee owners," or shareholders that do not actively engage in harvesting the resource. One of the benefits of catch shares is the positive feedback between the sustainability of the resource through good stewardship action and the financial benefit gained by shareholders as a result of increased yield, increased efficiency and stock sustainability. When the harvester and the privilege holder are separated, this feedback may be weakened. There is some concern from New Zealand that those participants who do not own shares in the fishery have less incentive to ensure long-term sustainability of the resource than shareholders (Gibbs, 2008).

Some fisheries have established owner-on-board provisions such as in the Alaska halibut *(Hippoglossus stenolepis)* and sablefish *(Anoplopoma fimbria)* fisheries, in which shareholders are required to be present on the vessel when catch is landed (with some exceptions for those granted initial share allocations). This may also increase the likelihood that shareholders are good stewards, that they are local residents (thus benefiting local communities) and that they are members of fishing families. Additionally, it may also increase the chance that shares will be offered for sale, thereby opening the fishery to newcomers.

While an owner-on-board provision has some benefits, there are also distinct drawbacks. There may be a conflict between requiring an owner-on-board provision and maximizing the effectiveness of Cooperatives. Some Cooperatives allow shareholders to pool their shares to be fished by a subset of members in order to increase efficiency and overall profits. If owners are required to be onboard the vessel, then this arrangement would not be possible. Multi-species catch share programs that require participants to cover all catch with quota may also be in conflict with owner-on-board provisions. It is generally most effective for participants to lease (rather than purchase) additional shares on an annual basis in order to balance their shares and catch. An owner-on-board provision limits such flexibility.

Consideration of crew

Crew is an important component of fisheries, and it may be prudent to provide a mechanism for crew to thrive in a fishery and eventually own their own boat. Some catch share programs have allocated shares to crew. For example, the Bering Sea and Aleutian Islands Crab Rationalization Program allocated 3% of shares to eligible crew based on

historical landings (NMFS Alaska Regional Office, 2010). The Gulf of Mexico Red Snapper Individual Fishing Quota Program allocated shares to historical captains based on landings (NOAA Fisheries Service, 2009a).

Fishing communities

Fishing communities are comprised of a complex web of constituents and service providers including fish dealers, fish processors, boat service providers, harbor services and more. As outlined in **Step 3.1**, some catch share programs allocate shares directly to a community rather than (or in addition) to individuals. It is also possible to allow community businesses to hold shares of the quota.

Grandfathering

Sometimes, certain entities or individuals upon initial allocation may exceed limits or violate requirements set by the program, such as a concentration cap or the use of a specific gear. You may choose to implement desired limits for a fishery and then allow exceptions for existing participants so as not to impact them unfairly. For example, if a fisherman has shown a long history of catch at levels higher than the desired concentration limit, you could allow the fisherman to continue his or her historical level of participation whereas others will have to abide by the lower limit. This may be beneficial in order to respect certain individuals' businesses while not setting a precedent for future participants.

Trade-offs

All constraints will come with costs. Constraints limit flexibility, which may therefore reduce innovation and/or limit economic performance (Kroetz and Sanchirico, 2010). Owner-on-board provisions, limited eligibility, grandfathering and other constraints may achieve certain social goals of the fishery, but they will also limit flexibility. When participants have too many provisions, they may be unable to implement economically efficient and profitable business models.

SNAPSHOT 3.1 | Identifying Eligible Participants
Gulf of Alaska Rockfish Pilot Cooperative Program

The Gulf of Alaska Rockfish Pilot Cooperative Program was implemented in 2007 as a five-year pilot program with the goals of ending the race for fish, addressing overcapitalization, preserving the historical participation of vessel and processors, providing opportunities for new entrants, improving product quality, protecting shoreside communities and more (NOAA Fisheries Service, 2009i). To achieve these goals, the program includes deliberate design elements in regard to eligible participants. First, managers and fishermen developed a group-allocated Cooperative program with two categories of vessels: catcher-processors and catcher vessels, each with their own concentration limits. There are two catcher-processor Cooperatives and five catcher vessel Cooperatives including 80% of the total vessels in the fishery (North Pacific Fishery Management Council, 2009). Currently catcher vessel Cooperative members cannot hold more than 4% of the harvest allocation (unless grandfathered) and a catcher vessel Cooperative cannot hold more than 20% of the shares (Jenson, 2010). Catcher-processor Cooperatives cannot hold more than 30% of the shares and no vessel can harvest more than 8% of the catch (Jenson, 2010; NOAA Fisheries Service, 2009i). Second, 5% of the initial shares were set aside for new entrants that did not qualify for the program. After three years, the program is meeting its goals. Fleet consolidation has not occurred as a result of the program and the value of landings has increased. Job stability and working conditions have improved in the Kodiak processing plants (a key goal) and coordinated delivery of catch has benefited processing jobs.

3.3 WILL THERE BE LIMITS ON THE CONCENTRATION OF SHARES?

Most fisheries that have transitioned to catch shares were overcapitalized prior to implementation. Overcapitalization is a natural outcome of traditional fishery management approaches and is often the source of many problems in the fishery (Gréboval, 1999). In fact, reducing overcapitalization is often a primary goal of catch share programs. Unlike other capacity reduction programs, catch shares allow participants to leave the fishery voluntarily and receive payment for their shares as they exit. This is in contrast to other overcapitalized fisheries where participants gradually leave, often once they cannot survive any longer and they are left with nothing. Reducing capacity usually, but not always, means a decrease in the number of fishery participants. In some cases, the number of participants may remain constant, but their capital assets, such as boats and gear, may be reduced. Furthermore, reducing capacity does not have to correspondingly change the structure of the fleet. It is possible to design consolidation so that it reduces all portions of the fleet evenly, regardless of size and/or gear type.

Despite the need to reduce overcapacity, many stakeholders want to prevent "excessive" concentration and support a minimum number of fishery participants. Concentration limits specify a limit on what percentage of the share any one participant or entity can hold and/or fish and are a useful and commonly used design feature (see Table 3.1 for examples). Some catch share programs have set high limits (e.g., up to 45% consolidation cap for New Zealand QMS fisheries), while others have set low limits (e.g., 0.5% – 1.5% consolidation cap for Alaska halibut *(Hippoglossus stenolepis)* under the IFQ Program). Concentration caps usually reflect the structure and relative concentration of a fishery prior to catch share implementation. Social and biological attributes of the fishery are important determinants in setting appropriate caps. What often drives concentration more than the presence of catch shares is the way in which fisheries are targeted. For example, offshore fisheries that require lots of expensive gear and capital investment will be more likely to have a high level of concentration than nearshore fisheries that are easily accessed by smaller boats. This is true for conventionally-managed and catch share-managed fisheries alike.

Trade-offs

Different levels of concentration may be appropriate and desirable for various fisheries, so concentration limits should be determined on a fishery-by-fishery basis. Often, managers and stakeholders choose to implement concentration limits in order to meet certain social goals, such as maintaining a certain minimum number of shareholders or encouraging local participation. Understanding the true underlying goal will help you determine whether a concentration limit is the best approach. For example, if your goal is to ensure the vessels remain owner-operator, then an owner-on-board provision may be more appropriate. If your goal is to protect certain communities, then community shares may be more appropriate.

While concentration limits have been a very important design feature of catch shares, there are clear trade-offs. A concentration limit directly influences the number of shareholders in a fishery. Setting a low limit may inhibit the profitability on a fleet-wide and individual level. In a highly overcapitalized fishery, a low concentration limit could prevent right-sizing of the fleet. In extreme cases, fishing will be unprofitable for all participants and fishermen may cut essential costs such as insurance, boat maintenance, crew wages and more. Your goals, costs and benefits must be weighed in making this important decision about concentration limits.

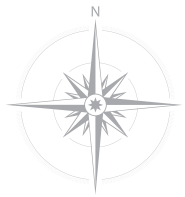
TABLE 3.1 | CONCENTRATION LIMITS FOR SELECT PROGRAMS

	LONG-TERM SHARE LIMIT	ANNUAL ALLOCATION UNIT LIMIT
ALASKA HALIBUT AND SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM	0.5%–1.5% of the halibut or sablefish shares, varying by management area with exceptions for grandfathered vessels	0.5%–1.5% of the halibut or sablefish shares, varying by management area with exceptions for grandfathered vessels
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM	2% of the total pounds for all species	4% to 10% of a species' yearly catch limit; percent varies by species
GULF OF MEXICO RED SNAPPER INDIVIDUAL FISHING QUOTA PROGRAM	6.0203% of total IFQ shares	6.0203% of total IFQ shares
NEW ZEALAND ROCK LOBSTER QUOTA MANAGEMENT SYSTEM	10% of the shares in any one rock lobster stock without a Ministerial exemption	None
BERING SEA AND ALEUTIAN ISLANDS NON-POLLOCK COOPERATIVE PROGRAM	30% of the quota shares unless grandfathered in during initial allocation	20% of the initial non-AFA trawl catcher/processor sector catch limit
NEW ZEALAND SNAPPER QUOTA MANAGEMENT SYSTEM	35% of combined total allowable commercial catches for New Zealand waters	None
NEW ZEALAND HOKI QUOTA MANAGEMENT SYSTEM	45% of combined total allowable commercial catches for New Zealand waters	None
PACIFIC SABLEFISH PERMIT STACKING PROGRAM	3 sablefish-endorsed permits unless grandfathered in during initial allocation	3 sablefish-endorsed permits unless grandfathered in during initial allocation
NEW SOUTH WALES ABALONE INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	210 shares	Twice the amount of the shareholder's initial quota
BERING SEA AND ALEUTIAN ISLANDS AMERICAN FISHERIES ACT POLLOCK COOPERATIVE PROGRAM	No limit between Cooperatives Cooperatives can determine rules for members	A Cooperative entity is not permitted to harvest more than 17.5% or process more than 30% of the pollock directed fishery allocation
NEW ZEALAND ABALONE QUOTA MANAGEMENT SYSTEM	None	None

3.4 HOW WILL NEW PARTICIPANTS ENTER THE FISHERY?

PRINCIPLE 4

Develop mechanisms for accommodating new entrants during the design of the catch share program and prior to initial share allocation.



It is vital to think about program longevity and transfer to the next generation of participants while designing a catch share program. Significant attention is paid to current participants during the initial allocation of shares, but any successful program will depend on introducing new shareholders over time.

The most straightforward and common way for new participants to enter a catch share program is to lease or purchase shares on the open market. This option is a key benefit of a transferable catch share program (see **Step 4.5**), and allows the market, rather than the government, to accommodate new entrants. Access to small amounts of shares or low-cost shares may facilitate new entrants by allowing them to purchase shares as they can afford them.

Because catch shares are often granted to existing participants for free (see **Step 5.5**), some are concerned that potential new entrants are at a disadvantage for purchasing shares and that catch share fisheries will be prohibitively expensive for new participants (MFCN, 2004). Catch share fisheries are generally more expensive to enter than open access or other limited access fisheries because catch shares provide more security, stability and predictability. In other words, they are more valuable. Indeed, the cost of a catch share is often close to the net present value of future profits (Newell et al., 2007). While the cost may be high, it is a reflection of the benefits from current and future harvests. Artificially reducing the price can undermine the stewardship incentives to the detriment of the program.

To address this issue, stakeholders and managers are exploring methods to facilitate new entrants other than buying and leasing, including the options outlined below. Few of these approaches have been tried in catch share programs. Careful consideration of the potential impacts on program performance and existing participants is necessary before implementing any of these options. While some of these options may make sense in order to attract new entrants, they may undermine the very purpose of the catch share program – to provide stability and predictability in the fishery and reward participants for being good stewards. See **Catch Shares in Practice: Danish Pelagic and Demersal Individual Transferable Quota Programs** for Denmark's approach to accommodating new entrants.

In addition to purchase and leasing of shares, here are a few other ideas for accommodating new entrants:

Share holdbacks

Holdbacks reserve shares at the outset of the program for the purpose of making them available at a later date for new entrants (or to address other social goals). For example, 80% of the available shares or catch limit could be initially distributed as shares to historical participants, and 20% could be held in reserve for alternate distribution. This could include a one-time or annual auction of shares to eligible new entrants or annual leasing of the shares. Presumably, leasing would be cheaper on an annual basis and new entrants may be able to participate in the fishery through leasing. Lease-to-own provisions could also be developed.

Share holdbacks are gaining support as an important design feature for a variety of purposes, including accommodating new entrants. The Pacific Groundfish Trawl Rationalization Program, approved by the Pacific Fishery Management Council in 2008 and scheduled for implementation in 2011, includes an Adaptive Management Program, which retains 10% of the shares to promote public trust purposes, including assisting skippers and crew in acquiring shares.

Share redistribution

Redistributing shares is another option for accommodating new entrants. There are a variety of ways to achieve this, but in general, it requires taking some amount of shares from existing shareholders and then redistributing them to new entrants. Specifically, you could allocate to new entrants increases in the catch limit or shares revoked from non-compliant fishermen. Another approach might be to collect a percentage of all shares from participants annually or at punctuated times for redistribution to new entrants. Shares could also be attenuated upon transfer, e.g., a percentage of the traded share reverts back to the management for future distribution. Another form of share redistribution could be achieved by placing terms on shares in which shares expire after a certain period of time and can then be redistributed by the government. This approach may have a significant impact on existing participants and is a good example of trade-offs between goals. While share redistribution may achieve certain social goals, requiring participants to return a portion of their shares for new entrants may make them fish very differently and undermine biological and/or economic goals.

Financial assistance

Providing appropriate financial assistance is another viable method for accommodating new entrants. Similar to homes or cars, shares are being treated more and more as a bankable asset that can be borrowed against. Lending institutions can offer loans to new entrants using purchased shares as collateral, and some are beginning to do so. Financial assistance and access to shares through leasing or buying is an attractive option, but may be limited. Banks are just beginning to understand catch share programs, and it is not yet a common practice for them to provide loans using shares as collateral. Programs at banks and other lending institutions that have a history of financing catch shares may provide good examples for banks in regions with less catch share experience.

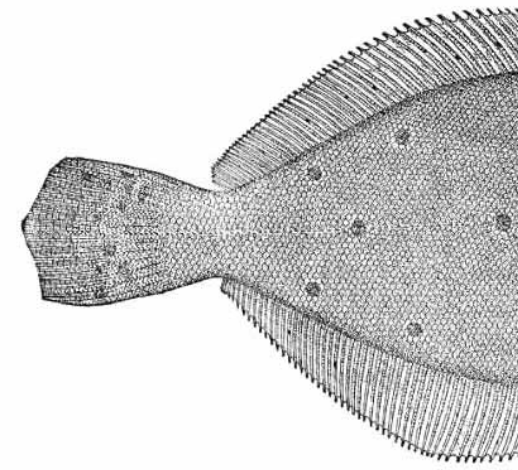
Community-based permit or quota banks

Permit or quota banks are a new concept that is gaining significant attention as a way of enhancing community benefits, including access to new entrants. A permit or quota bank holds shares and leases them out to participants based on particular criteria, one of which could be focused on accommodating new entrants. For example, the permit or quota bank could charge a lower lease rate to new entrants. Group-allocated catch shares may also develop internal protocols for encouraging and accommodating new entrants. For example, under the Danish Pelagic and Demersal Individual Transferable Quota Programs, quota holders can group shares under Fishpools. While Fishpools are predominantly used to facilitate temporary transfers of these shares, one operates to provide access to new entrants. Existing quota holders can bring quota into this Fishpool and allow new entrants to access shares in return for an entrance fee. For more information see **Catch Shares in Practice: Danish Pelagic and Demersal Individual Transferable Quota Programs**.

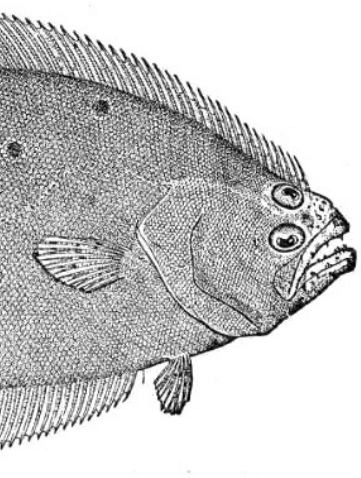
Step 3 – Define Eligible Participants

This chart provides a brief summary of the Step 3 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

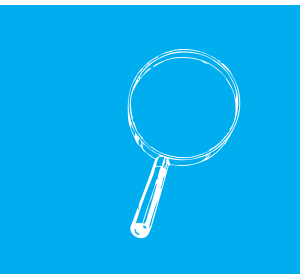
	3.1 ALLOCATED TO INDIVIDUALS OR GROUPS	3.2 ELIGIBILITY REQUIREMENTS	3.3 CONCENTRATION LIMITS	3.4 NEW PARTICIPANTS
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Individuals and community-based groups	U.S. citizen Initial shareholder 150 days fishing experience Owner-on-board	From 0.5% – 1.5% based on species and stock	Enter by purchasing or leasing shares Loan program available
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	Individuals	Groundfish license holders	From 0.4% – 15% based on species, area and license	Enter by purchasing or leasing shares Special programs for First Nations
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	Community-based groups	Only fishermen organizations can apply All participants must be artisanal fishermen	n/a	Groups create own requirements for membership
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Individuals Some participants voluntarily pool shares	Operators with 60% or more of income derived from fishing Non-eligible operators continue under alternative regulations	Yes	Enter by purchasing shares Quota set-asides Entrance fee to access pooled shares



4 Define the Privilege



SEASALT
Secure
Scaled
Transferable



At a Glance

This Step requires you to define the privilege and its main attributes. Many of these decisions will determine ongoing management of the program, as well as the stability and flexibility participants will have under the program.

KEY PRINCIPLES

Allocate shares for sufficient length to encourage stewardship and appropriate investment by shareholders and associated industries. This can be achieved by allocating in perpetuity and/or for significant periods of time with a strong assumption of renewal, provided rules are adhered to. | 57

Employ percentage shares, when possible, of the overall cap rather than absolute weight units for long-term shares. | 59

To increase program flexibility consider transferability of shares, permanent and/or temporary, which is generally a hallmark of catch share programs. | 60

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4.3 How is the long-term share defined? | 58

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4 Define the Privilege

The next Step in designing a catch share is to define the privilege and its main attributes. The program goals will largely determine the design decisions in this Step. For example, the rules on transferability should reflect the economic and social goals, including how much flexibility is desired in order to increase value and whether there are certain social goals such as promoting the historical fishery structure.

By effectively defining the privilege, you will ensure participants have **Secure** access to the fishery so they can effectively make long-term business decisions and determine **Transferability** of shares to support flexibility. You may also address whether the privilege is effectively **Scaled** to the biological, social and political systems.

4.1 WILL THE PRIVILEGE BE SPECIES-BASED OR SPECIES AND AREA-BASED?

Catch shares can be either species-based or species and area-based. Under species-based catch shares, a total amount of allowable catch, i.e., a catch limit, is identified (see **Step 2 – Define and Quantify the Available Resource**) and the privileges conferred to participants relate to the amount of fish each entity is allowed to catch. Species and area-based catch shares, commonly called Territorial Use Rights for Fishing (TURFs), also allocate a specific area to either a group or an individual (see **Catch Shares in Practice: Chilean National Benthic Resources Territorial Use Rights for Fishing Programme**).

Over 90% of the catch share programs worldwide are species-based. However, nearly 20% of the species under catch shares are in species and area-based programs, meaning that species and area-based catch shares have proportionally more species than species-based programs (see Figure 4.1). This makes sense when you consider that most area-based approaches manage a suite of species in an area, rather than just one.

Many TURFs use catch limits for at least some species and are thus species and area-based. TURFs that do not have a catch limit, due to lack of science or administrative capacity, are outside the scope of this Design Manual. They present special problems such as how to monitor and avoid overfishing the resource. See **Appendix B: Managing Without a Catch Limit** for further discussion.

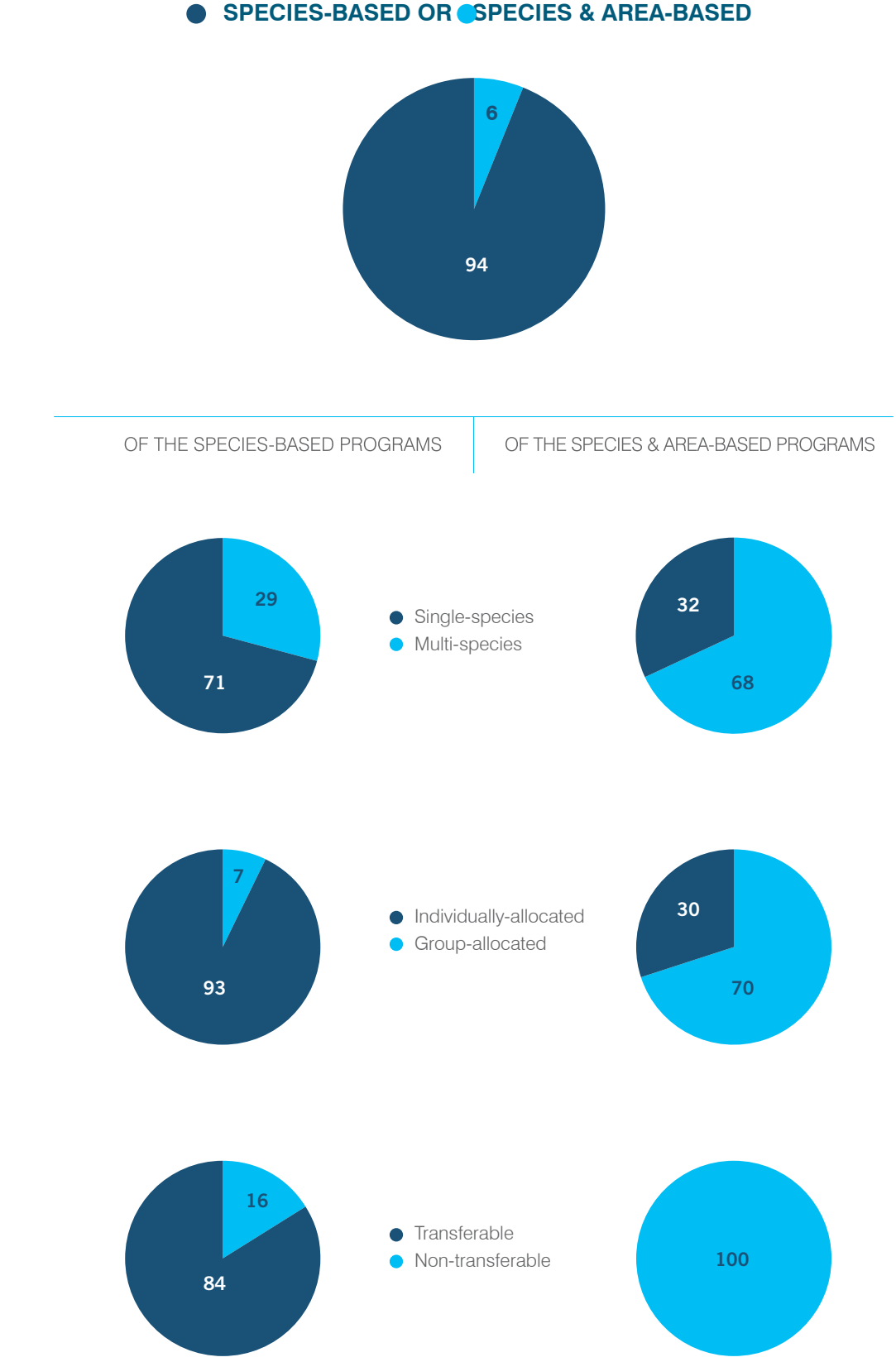
Species-based

The majority of systems recognized and defined around the world as catch shares are species-based systems. In species-based systems, participants are allowed to fish in a broad area; thus their effort will undoubtedly overlap with other fishermen. Though fishing activities may be limited in certain places to achieve other management objectives – such as protecting spawning stocks, protecting key habitats, or for scientific research – species-based systems do not identify and assign a specific area to an individual or group.

Species & area-based

TURFs have frequently been used in locations where there are clearly defined and enforceable boundaries and for species that are relatively sedentary. Lobsters, snails and urchins, and shellfish, such as oysters, clams and scallops, have been successfully managed by TURFs. Enclosed lagoons and bays or easily defined kelp beds and reefs may also be good candidates for TURFs. TURFs, and similar area-based management approaches, have been used by

FIGURE 4.1 | *Percent Use of Catch Share Design Features Worldwide*



many indigenous cultures and communities for centuries and are still in common use today in developing countries (Cancino et al., 2007).

An additional benefit of TURFs is the ability for fishermen to more closely associate their fishing activities with a particular area. This potentially creates a more explicit feedback loop between their fishing activities and the condition of the habitat and ecosystem in the TURF and it may make fishing more efficient due to reduced travel time and trips.

SNAPSHOT 4.1 | TURFs to Benefit Communities
Baja California FEDECOOP

Baja California Regional Federation of Fishing Cooperative Societies (FEDECOOP) is a species and area-based Cooperative catch share program that targets spiny lobster *(Panulirus interruptus)*, abalone *(Haliotis fulgens, Haliotis corrugata)*, sea snails *(Astraea undosa, Astraea turbanica)* and several other benthic species along the central Baja California Pacific coast, ranging from Punta Abreojos to Isla Cedros. The program allocates secure and exclusive access areas to Cooperative members. Nine Cooperatives with participation from 10 villages form FEDECOOP. In 2004, there were over 1,000 participating fishermen harvesting approximately 80% of all spiny lobsters and abalone caught in the waters of Baja (Bourillon and Ramade, 2006).

Access to fishing areas is limited to community members in the designated villages of FEDECOOP, thus ensuring that the benefits from fishing accrue to the local communities. Exclusive fishing access has been granted to the fishing areas through 20-year concessions from the Mexican government. In 2004, FEDECOOP became the first small-scale community fishery located in a developing country to achieve the Marine Stewardship Council certification for sustainability. This achievement allowed expansion and diversification on a global level, focusing on U.S. and European markets (Bourillon and Ramade, 2006). This success would not have been possible without coordination by FEDECOOP's members to carry out fishery management, monitoring, enforcement and scientific research with little government assistance (Leal et al., 2008).

4.2 FOR HOW LONG WILL THE PRIVILEGE BE ALLOCATED?

Most fishery management systems use permits to manage the number of participants. Under an open access system, the number of permits is unlimited. Under limited access systems, the number of permits is limited, but there is not a secure, allocated amount of fish associated with each permit. Fishermen with permits have the opportunity to compete for catch, which can be destructive to people and ocean resources. In a catch share program, there are a limited number of shares that equal the catch limit: Catch share programs allocate a secure share of the catch via weight or percentage shares rather than the opportunity to compete with other fishermen for catch. These shares are allocated to participants for a period of time, as short as a year or as long as in perpetuity.

PRINCIPLE 5

Allocate shares for sufficient length to encourage stewardship and appropriate investment by shareholders and associated industries. This can be achieved by allocating in perpetuity and/or for significant periods of time with a strong assumption of renewal, provided rules are adhered to.

Tenure of shares, as well as other attributes such as legal status, affects the security of the catch share and signals to shareholders that their actions today are more directly tied to their future in the fishery. If the stock rebounds due to good science and compliance with catch limits, then their share will also improve. Conversely, if the stock declines, their share will decline. While fisheries are certainly dynamic and are influenced by many factors (i.e., environmental factors, market conditions, etc.), security of the share provides tighter feedback and encourages better conservation behavior.

Many countries, including New Zealand, Australia and Iceland, allocate shares in perpetuity. U.S. federal law says that catch shares can be allocated for 10 years with a presumption of renewal (16 U.S.C. 1853a). Some programs issue catch shares on an annual basis, with renewal subject to satisfactory performance. For example, the Canadian Minister of Fisheries retains the right to cancel or reissue licenses at any time based on performance. In practice, licenses are rolled over every year (Gislason, 2006).

In determining the tenure of the share, the key is to make sure that shareholders have predictability and stability in the catch share program and that they are rewarded for good behavior, such as compliance. Generally, a longer tenure induces a stronger sense of stewardship and recognition that short-term decisions and actions directly influence future profitability (Costello and Kaffine, 2008). If shares are only granted for one year without a strong assumption of renewal, then there is little or no incentive for holders to invest in the long-term health of the stock. If shares are reallocated, either with or without warning, it should be done in a way that does not undermine sufficient tenure, which would in turn undermine the health of the fishery.

Security of catch share programs extends beyond the privilege holder to other fishery-related industries as well. When there is more predictability and stability in the fishery management system, communities can more readily invest in supporting infrastructure – such as jetties, wharves, docks, and transportation – bringing additional benefits to community businesses.

Trade-offs

The length of tenure and the security of the privilege are important components of a catch share in order to ensure stewardship and sustainability. The program must strike a balance between creating appropriate incentives for stewardship and maintaining appropriate access to the public's fishery resource.

Catch shares are a privilege granted by the management authority to those who qualify for them under the rules and regulations established to manage access to the public's resource. If a participant violates stated rules or regulations, then it is appropriate for the management authority to revoke privileges under due process.

A common concern about the length of tenure is the impact on potential new entrants. Under a transferable catch share program, new entrants can purchase quota shares on the open market. A number of design options are also outlined in **Step 3 – Define Eligible Participants** to address the concern about new entrants. It is important that any reallocation of shares does not undermine sufficient tenure for participants.

It may be instructive to review other public resources and their approach to management. Most other public resources

in the U.S. have been allocated to users, via granting or auction, for a specific period of time with a strong assumption of renewal (White, 2006).

Finally, regular reviews of the program are strongly recommended to ensure that the program is meeting its goals.

4.3 HOW IS THE LONG-TERM SHARE DEFINED?

As discussed above, catch shares are commonly allocated for more than one year. Managers must determine the long-term share unit, which generally falls into two broad categories, either a percentage of the overall catch limit or an absolute weight measurement. The key difference between these two approaches is that under a percentage-based system, the weight or number of fish a shareholder can catch from year to year will vary based on changes in the catch limit, whereas under an absolute weight approach, the weight or number of fish will stay constant from year to year (assuming there are no trades). In the case of a species and area-based catch share, the unit of allocation will be one of these approaches as well as a secure area of exclusive access.

Percentage approach

Catch share fisheries have overwhelmingly favored the percentage approach to allocating catch shares. Under this approach, a shareholder gets a certain percentage of the catch limit for a specific species as shares. These represent a proportional amount of the overall catch. While the proportion in relation to other participants will stay the same (assuming no trading or leasing has occurred), the amount of catch allowed in any given year may change. In each year, an individual's shares (total percentage) are multiplied by the catch limit for that species to determine an individual catch allocation for the year. For example, if a shareholder has 1% of the species share and the catch limit is 100,000 tons, then that shareholder is allowed to catch 1,000 tons that year. If the overall catch limit increases to 150,000 tons the following year, then the same shareholder would be allowed to catch 1,500 tons. The program's catch limit can change based on stock status, such as an increase in stock abundance, or other factors, such as a change in allocation between the commercial and recreational sectors.

Absolute weight approach

Absolute weight units allocate a specific amount of fish to a participant in the form of pounds or tons. Each year, the participant is ensured the same amount of fish. If the catch limit is adjusted from year to year, then the government plays a role in the market. For example, if the catch limit goes down, the government must buy a corresponding amount from participants in the fishery, and if the catch limit goes up, the government sells additional shares. Governments can also use a prorated cut to reduce all participants' quota holdings by a certain amount.

Number of long-term shares

The number of long-term shares will influence the size of the annual allocation, trading of shares and administration. The number of long-term shares may stay constant or increase or decrease due to changes in program rules. Essentially, managers divide the number of long-term shares in the program by the catch limit in order to determine how many pounds each share is worth for that fishing year. If there are relatively fewer long-term shares, then each share will equate to a relatively larger amount of fish. The number of long-term shares is often arbitrary. For example, all of New Zealand's catch share programs allocate 100 million shares regardless of the fishery size. The Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program has over 330 million shares, which originally approximated the landings during the qualifying period of the catch share program. The number of shares also influences trading. If there are more shares, then participants are able to trade smaller amounts of fish. A program can also dictate how divisible the shares are. For example, the Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program has "blocked" and "unblocked" quota. Participants are not allowed to split

SNAPSHOT 4.2 | Absolute Weight Units

New Zealand's Experience

New Zealand used an absolute weight unit approach when first implementing catch shares in 1986. If the sum of quota allocated was less than the catch limit, additional shares were sold. If the sum exceeded the catch limit the government would purchase shares. A prorated cut was made if the government could not purchase as much quota as needed. The total quota allocated was often higher than historical annual landings for two reasons: first, a number of successful appeals were made resulting in additional allocations and second, allocations were based on the best two-out-of-three years, so the sum of these was likely to be more than any one year's total landings. After the initial allocation, the government spent $42.4 million New Zealand dollars (U.S. $29.8 million) to purchase 15,200 metric tons as well as a prorated cut, further reducing quota allocation by 9,500 metric tons. In the three years after initial allocation, the government did not enter the market to reduce any quota holdings, but did sell $84.2 million New Zealand dollars (U.S. $59.2 million) in additional quota. It is believed that quota holdings for some stocks should have been reduced during this time period. To eliminate the need for the government to enter the market and to allow for the inherent variability in fisheries, the government redefined shares as portion of the catch limit in 1990. At this time, the government also froze quota fees for five years to compensate participants for the reductions that were made (Sissenwine and Mace, 1992).

"blocked" quota with the goal of keeping the price for these blocks lower than unblocked shares. Blocked quota is slightly less expensive (Dock Street Brokers, 2010).

Discussion

Experience has shown that a percentage-based system is superior to an absolute weight system. Importantly, a percentage approach directly ties shareholders' actions to outcomes in the stock, either increases or decreases, and thus instills stewardship. When a catch limit increases, then the amount of fish a participant is allowed to catch in a year increases. This increase allows participants to directly reap the benefits of conservation choices and provides a direct incentive for conservation.

Often, percentage-based systems have increased industry participation in collecting science and sponsoring research in an effort to learn more about the stock and increase catch limits (Hilborn, 2004). Improved science increases understanding of stock dynamics. If industry-led science is encouraged, the government should establish protocols and appropriate standards.

Furthermore, experience has shown that governments are ill-equipped to bear the financial burden of declining stocks and catch limits and may face internal conflict about the cost of lowering limits, potentially even to the point of going against recommended science.

PRINCIPLE 6

Employ percentage shares, when possible, of the overall cap rather than absolute weight units for long-term shares.

4.4 WHAT WILL THE ANNUAL ALLOCATION UNIT BE?

Most catch share programs differentiate between the long-term privilege and the annual catch allocation. The annual allocation is the measurement of the seasonal allocation that is issued to privilege holders and is computed based on their long-term share. The allocation can be expressed in weights or numbers. Either can be effective, but the measurement used must be verifiable and enforceable. Jurisdictions use various names for this annual allocation: New Zealand calls it Annual Catch Entitlement (ACE), Alaska calls it IFQ pounds and Gulf of Mexico calls it IFQ allocation.

An annual allocation unit is clearly needed with a percentage-based approach so that shareholders know exactly how much fish they can catch that season based on their long-term privilege. There are other benefits to separating the long-term privilege from the annual allocation, especially under tradable catch share programs, so participants can lease their annual allocation within one fishing year without selling the long-term privilege.

Weight

Many catch share programs describe the annual catch allocation in weight, such as pounds or kilograms. Under a percentage-based system, this is calculated by multiplying the shareholder's long-term percentage share by the annual catch limit. Under an absolute weight system, the long-term share and the short-term share would be the same amount.

Number

In certain fisheries, it may be desirable to identify a number of individual fish or another specified quantity such as a bushel or cage. Again, this annual amount would be determined by a calculation based on the shareholder's long-term privilege and the catch limit. Under a number-based approach, tags are commonly used to keep track of the catch.

4.5 WILL THE PRIVILEGE BE PERMANENTLY AND/OR TEMPORARILY TRANSFERABLE?

PRINCIPLE 7

To increase program flexibility consider transferability of shares, permanent and/or temporary, which is generally a hallmark of catch share programs.

When privileges are transferable, participants are allowed to buy and sell shares, either permanently or temporarily, or both. Transferability increases flexibility in the program and can enhance economic and biological goals, especially reducing overcapitalization and increasing fishery value. Allowing transfers, either permanent or temporary, is also the easiest way to provide access to future participants. Eighty percent of catch share programs worldwide are transferable.

In the case of individually-allocated catch shares, transferability refers to trades made between individual participants. In the case of group-allocated catch shares, transferability can refer to trades between different groups and/or within a group. Inter-group trading is generally determined in the design of the program while intra-group is determined by the group itself.

Permanent transferability

Permanent trading refers to buying and selling of the long-term shares (see Figure 4.2). Permanent transfers offer the opportunity for shareholders to make business decisions about whether to stay in the fishery or sell their shares and exit. In the case of multi-species fisheries, permanent trades also allow fishermen to develop and pursue a business model based on the suite of fish that they want to target. Permanent trading is also a mechanism for accommodating new entrants who purchase shares from an exiting shareholder or for existing participants to grow their business by purchasing additional shares. Typically, when fisheries are overcapitalized, some holders find it more profitable to sell their shares and exit the fishery, thereby removing excess capacity. By implementing a tradable catch share, the fishery can essentially size itself appropriately rather than allowing fishermen to simply go out of business or employing a government sponsored buyback to remove excess capital.

Temporary transferability

Temporary transferability, i.e., leasing, is a transfer of shareholders' annual allocation (see **Step 4.4**). Leasing is common and occurs on an annual basis once each participant's annual share has been calculated for the year (see Figure 4.3). Therefore, participants generally lease a certain weight of fish. Participants will usually lease for three reasons: to improve economic efficiency (including through regionalization, specialization and better economy of scale); to cover catch overages for directed catch or bycatch; and/or to maximize catch and carryover annually. Leasing increases the flexibility of a fishery within a season, especially in the case of a multi-species program. Leasing or temporary transfers are also commonly used as the first level of access to a fishery for new entrants.

It is possible to allow one type of transferability but not the other. For example, Community Development Quotas (CDQs) in Alaska are allowed to lease their annual shares but they are not allowed to sell the long-term share (Committee to Review the Community Development Quota Program et al., 1999). Under this arrangement, revenues from the share are tied to the CDQ, and therefore the community. Alternatively, the Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program allows permanent transfers but largely disallows temporary transfers (there are some exceptions). Often called an owner-on-board provision, this is designed to keep active fishermen on the water.

Most economists and managers experienced with catch shares argue that fishermen must be able to buy and sell shares in a competitive market in order to actually end overfishing and ensure long-term sustainability (Anderson and Holliday, 2007).

Trade-offs

Permanent and temporary transfers of shares are important design features of catch shares. When trading is allowed, participants have more flexibility in how to run their businesses in order to stay within catch limits, and new entrants can more easily enter the fishery. If trading is not allowed, then there is no clear mechanism for exit or entry into the fishery.

At the same time, unfettered transferability of shares may lead to negative social outcomes. For example, when shares can be permanently transferred, and in absence of other controls, a few participants may concentrate shares, limiting the number of participants in a fishery. (If this is a concern, consider setting concentration limits, as discussed in **Step 3.3**.) In addition, the cost of leasing shares becomes an additional operating cost that may reduce the payment of crew and/or hired captains. However, crew in many catch share fisheries have seen a substantial increase in wages regardless of active leasing (Hiatt et al., 2007; GSGislason and Associates Ltd., 2008). Finally, a transferable catch share program will require a trading platform or other mechanism to facilitate and track trades.

FIGURE 4.2 | *Permanent Transferability*

TWO SCENARIOS

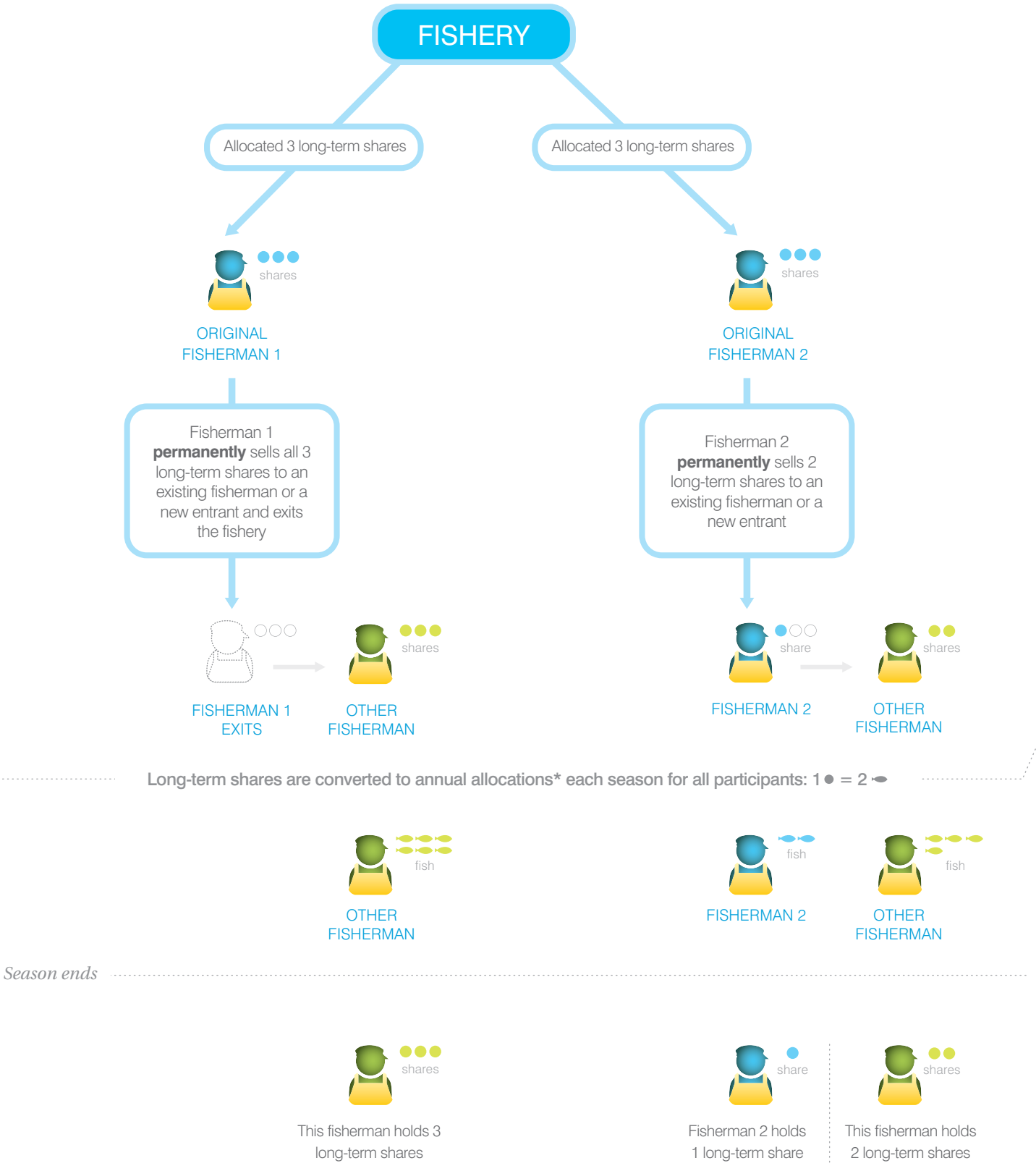
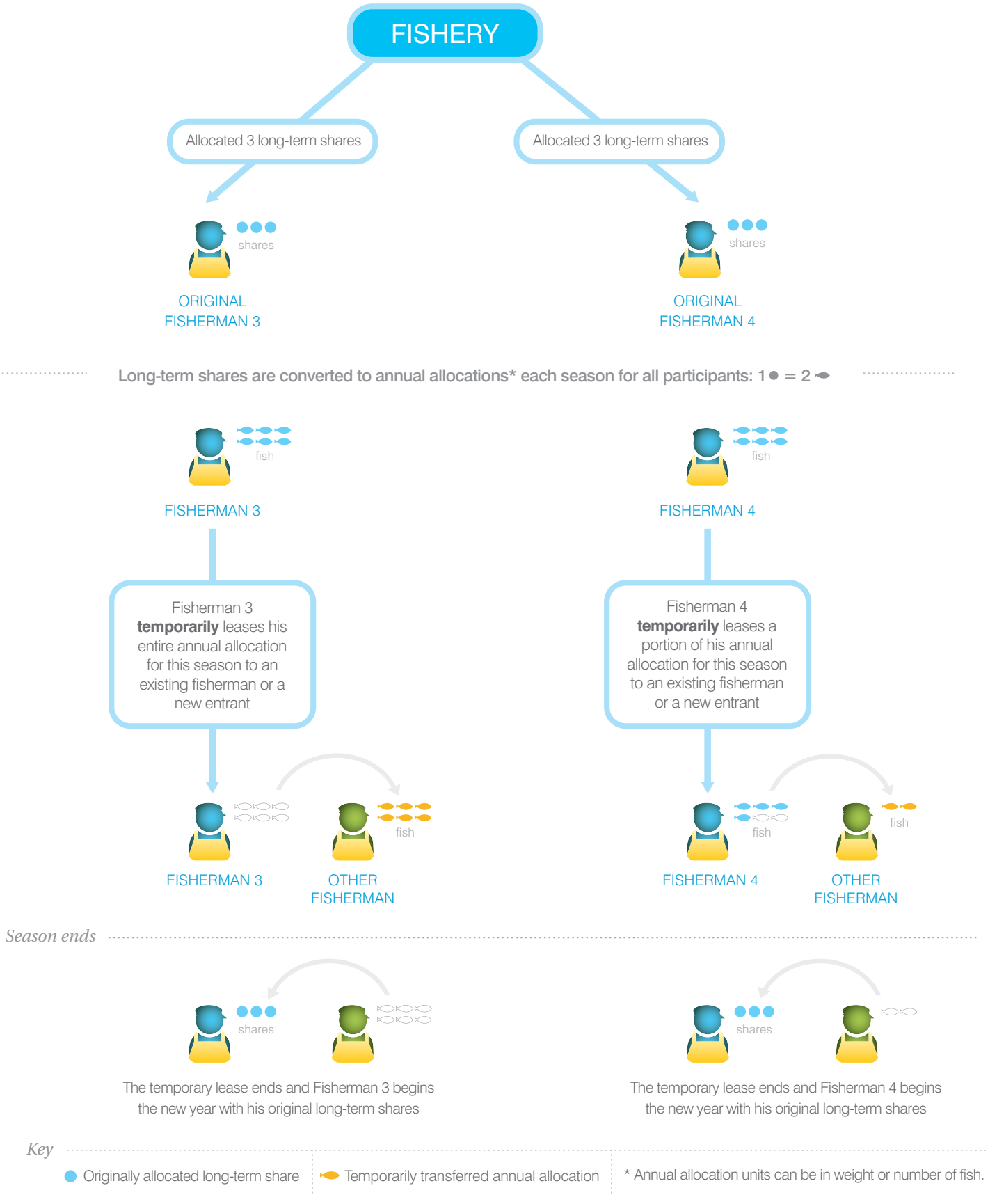


FIGURE 4.3 | *Temporary Transferability*

TWO SCENARIOS



4.6 WILL THERE BE RESTRICTIONS ON TRADING AND USE OF SHARES?

You can limit the selling, buying and leasing of shares in a variety of ways. Limitations generally fall into three broad categories: geographic trading limits, based on either biological or social boundaries; social trading limits, based on community or fleet characteristics; and administrative trading limits, based on the management of share trading, including timing. When there are clear goals to promote a certain class of participants, or when there are clear biologically-based divisions that are important to recognize, then creating trading groups may be advisable. Sometimes there are laws prohibiting certain restrictions. For example, in the U.S., there are clear legal impediments to establishing shareholder eligibility based on state residence (16 U.S.C. 1851).

Geographically-based limitations

Geographic trading limitations are important when there are specific goals regarding fish stocks and populations, such as preventing localized depletion. In this case, shares can be divided into a number of geographic areas, with only intra-area trading allowed (Newell et al., 2005). Many fisheries that cover a larger area, such as the British Columbia groundfish fishery and the Alaska halibut and sablefish fishery, have been divided into a number of

SNAPSHOT 4.3 | Trading Between Years

Carryover and Borrowing

Many catch share systems allow shareholders to trade shares between years, either by carrying over a certain amount of their unused shares into the following year or by borrowing shares from future years. For example, if a shareholder had enough shares to catch 100,000 pounds in one year, but only caught 90,000, then they could catch an additional 10,000 in the following year.

Carryover and borrowing are generally used to increase flexibility and provide incentives for participants to accurately report catch and comply with their share allocation. In non-transferable catch share systems, borrowing from future years may be even more important because it allows a way for participants to cover their catch and may also help deter participants from discarding share overages.

While carryover and borrowing of shares may provide flexibility for participants, they can be very challenging to administer and may impact stock assessments and allowable catch limits (Grafton et al., 2006). Fisheries that employ carryover or borrowing provisions will often limit the amount permissible to transfer between years and/or create a differential counting scheme where shares borrowed from the following year are discounted (e.g., 10 pounds of 2010 shares are equivalent to five pounds of 2009 shares) (Grafton et al., 2006). This essentially is a penalty to prevent chronic borrowing.

zones. Often these zones are based on clear biological stock or sub-stock structure which was in place prior to the implementation of the catch share (see **Step 2.2** and **2.3**).

A few fisheries, such as the Bering Sea and Aleutian Islands Crab Rationalization Program, have experimented with regional landing requirements, in which some shares are tied directly to a port or geographic area (NMFS Alaska Regional Office, 2010).

Fleet-based limitations

Limiting trades based on fleet characteristics may be useful when it is desirable to promote or maintain certain groups within a catch share fishery. This can be directly achieved by implementing a group-allocated catch share, as discussed in **Step 3.1**, but may also be supported through trading restrictions. For example, there may be pre-existing management divisions such as different gear sectors and a goal to maintain each sector.

Additional fleet-based divisions could include limiting trades based on income levels, shareholding amounts, equivalent monitoring systems, licenses and more. This may preserve the historical make-up of the fleet and maintain differences in the fleet. For example, a fishery that has a variety of different vessel sizes may allocate shares based on a specific vessel size and restrict their use to that category. For example, the Alaska halibut and sablefish fisheries restrict use of quota based on vessel length and vessel type to promote both size classes (Pautzke and Oliver, 1997) (see **Catch Shares in Practice: Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program**).

Administratively-based limitations

Some management authorities have chosen to limit trading in order to facilitate tracking of trades and catch accounting. For example, some fisheries have limited the size of the transfer unit, the number of trades allowed by year or by holder, or the time in which trading can occur.

Many of these administrative considerations may not be as important today since technological and information systems have improved.

Another administrative limitation is the use of a "transition period" in which certain features of a catch share program, such as permanent transferability, are limited for a period of time. This may help participants better understand a program before allowing permanent transfers of shares.

In the British Columbia Halibut IVQ Program, shareholders were not able to lease or sell shares for the first two years. During the next two years, they were allowed limited transferability (Wilen, 2002). This approach seems to have helped participants understand the system and ease into a new way of management.

A transition period that prohibits trading could be an important feature of a new catch share especially when there has not been significant stakeholder participation in the design process or when it is suspected that many participants do not have a good understanding of how catch shares work. However, if a fishery has significant problems with overcapitalization or bycatch concerns in a multi-species fishery, then introducing a transition period will delay the system's intended results.

Trade-offs

Restricting transferability in any way will come with costs and will limit fleet-wide profitability. You should implement trading stipulations when they can address your clearly identified goal. Otherwise, decreasing flexibility unnecessarily limits participants' ability to make good business decisions.

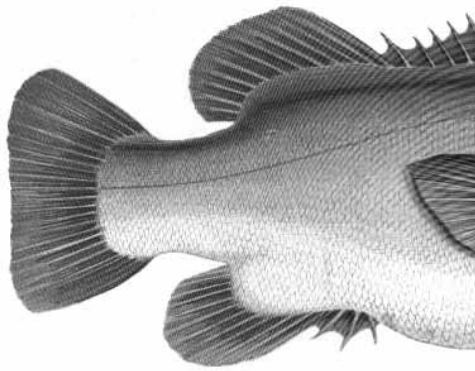
Decisions about trading restrictions will also inform the initial allocation process, discussed in **Step 6 – Develop Administrative Systems**.

Step 4 – Define the Privilege

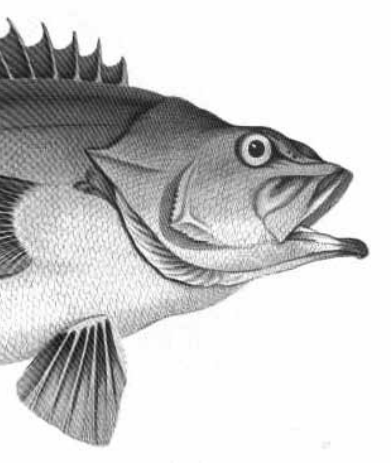
This chart provides a brief summary of the Step 4 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

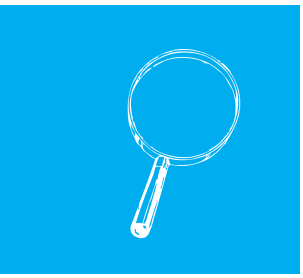
	4.1 SPECIES-BASED OR SPECIES AND AREA-BASED	4.2 TENURE LENGTH	4.3 LONG-TERM SHARE	4.4 ANNUAL ALLOCATION UNIT
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Species-based	Indefinitely	Percentage shares, called "quota shares"	Weight-based, called IFQ permit weight
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	Species-based	Granted annually with strong presumption of renewal	Percentage shares, called "IVQ holdings"	Weight-based, called IVQ pounds
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	Species and area-based for main species, including loco Some additional species are area-based only	4 years Groups can re-apply	Exclusive use areas	Number of individual organisms
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Species-based	No expiration date Can be revoked with 8 years' notice	Percentage shares, called "ITQ shares"	Weight-based

4.5 PERMANENTLY AND/ OR TEMPORARILY TRANSFERABLE	4.6 RESTRICTIONS ON TRADING AND USE OF SHARES
Permanently and temporarily transferable with restrictions	Yes Based on vessel class, vessel operation modes, regions and more No leasing except for initial shareholders
Permanently and temporarily transferable with restrictions	Yes Based on gear sector, target species and more Initial transition period
Transfers not allowed between groups Transferability unclear within groups	n/a
Permanently and temporarily transferable with restrictions	Yes Voluntary entrance into the “coastal fishery” restricts permanent transfers



5 Assign the Privilege





At a Glance

Assigning the privilege has often been the most difficult and controversial Step of implementing a catch share program. Participants feel that much is at stake in the distribution of catch share privileges and initial allocation sets up the starting point for the program.

KEY PRINCIPLES

Develop a transparent, independent allocation process that is functionally separate from the rest of the design process. Allocations that retain the relative equity positions of stakeholders are the least contentious. | 70

Employ an allocation appeals process that allows eligible participants to refute allocated amounts with verifiable data. | 72

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5 Assign the Privilege

Initial allocation is a key Step in transitioning to a catch share program. Allocation will determine who receives initial shares of the catch and in what quantity, effectively setting up the starting point for a catch share fishery. Because the number of shares that can be allocated in any fishery are of limited supply, and therefore valuable, much is at stake in the distribution of shares. Furthermore, catch share programs have often been introduced in fisheries that are overcapitalized and/or overfished with the goal of reducing capitalization and sometimes catch limits.

Allocation within a catch share program is separate from allocation between the recreational and commercial sectors, often called inter-sector allocation. Allocation of catch shares within the commercial sector generally occurs on a percentage basis and the relative catch limit for each sector can still be changed.

PRINCIPLE 8

Develop a transparent, independent allocation process that is functionally separate from the rest of the design process. Allocations that retain the relative equity positions of stakeholders are the least contentious.

Allocation has often been the most difficult and controversial Step along the path toward a catch share program, and it warrants extra attention. The good news is that initial allocation usually only happens once and many catch share fisheries have successfully navigated the process. Furthermore, while there is no perfect process, common practices that highlight fairness have emerged and will be discussed throughout this Step.

By successfully assigning the privilege you will ensure that shares have been **Exclusively** allocated to participants in order to end the race for fish. This Step may also ensure that **All sources** of mortality are included as part of the catch share program.

5.1 WHAT DECISION-MAKING BODY WILL DETERMINE INITIAL ALLOCATION?

Different countries have used various decision-makers to determine allocations, including fishery managers, fishery stakeholders and independent third parties. First and foremost, allocation processes must comply with existing law and many countries already have legal requirements or legal precedents regarding the allocation of catch shares. For example, U.S. federal processes must comply with the Magnuson-Stevens Fishery Conservation and Management Act, the Administrative Procedures Act, and the National Environmental Policy Act, among other policies. However, within the defined legal process there is generally some flexibility regarding who can participate, so you can be creative in your approach.

Fishery managers

Managers are generally responsible for developing policy, analyzing options and implementing decisions, and therefore hold the ultimate responsibility for developing and implementing the catch share program including allocation. Managers have played a central role in many allocation decisions. For example, New Zealand's national fisheries management body, the Ministry of Fisheries, led the allocation and implementation process for catch shares in 1986 when they created the Quota Management System (QMS) and 27 species came under catch share management. The Ministry has continued to oversee allocation as more species enter the QMS (New Zealand Ministry of Fisheries, 2007). In the U.S., Regional Fishery Management Councils have largely presided over the process, with input and assistance from NOAA and final approval by the U.S. Secretary of Commerce.

Fishery stakeholders

Stakeholders, particularly fishermen, have participated substantially in the allocation process. Stakeholder participation in the allocation process is expected, and even advisable, because of fishery participants' extensive knowledge about the fishery. However, allocation decisions also directly impact stakeholders' businesses and livelihoods and it may be challenging for fishermen with a financial stake to remain neutral decision-makers. In order to ensure fairness, likely catch share recipients should not have disproportional representation and influence over the allocation decisions.

Independent, third party panels

Independent panels have also been used for catch share allocation decisions. For example, Australia has used independent panels almost exclusively to develop allocation processes and formulas. These panels have generally been comprised of three participants: a retired judge, a fisherman with no direct stake in the fishery and an economist or policymaker (Shotton, 2001). Panels are directed by managers and receive guidance about the goals and objectives for a catch share program. They are then directed to solicit input from a variety of sources to develop a fair and equitable process. Participants have generally viewed the approach as favorable, and the results have held up in court (Shotton, 2001).

In the case of group-based catch shares, managers need to determine overall allocations to the various associations, sectors, communities or companies (assuming there are multiple groups within one fishery), and then each group can decide on the appropriate way to divide and hold catch shares among themselves. This may be one benefit of a group-allocated catch share. However, the group must have a process and structure that is able to handle such a contentious process or it is also likely to run into fairness issues (Anderson and Holliday, 2007).

5.2 WHEN WILL ALLOCATION OCCUR?

Initial allocation can occur at any point in the catch share design process, and in reality, decisions impacting allocation will occur at multiple stages of the process. Often, managers and stakeholders are comfortable with the concept of catch share management, and perhaps even eager to pursue a program, but stakeholders may have specific concerns about their personal outcome under a catch share. In this case, it may be advisable to focus on allocation upfront to reduce uncertainty and bolster support. For example, when managers in the Gulf of Mexico calculated fishermen's projected initial shares, fishermen were more supportive of a catch share for red snapper. In addition, calculating different allocation scenarios upfront can shed light on the appropriateness of different design options. For example, general category sea scallop *(Placopecten magellanicus)* fishermen on the U.S. Atlantic coast could see clearly that any catch share plan that provided equal access would eliminate many businesses, making the allocation of catch shares based on individual catch histories the most viable option.

On the other hand, some fisheries have found it beneficial to wait until the end of the design process to make allocation decisions. Knowing the design features of a catch share – such as whether it will be group or individually-allocated, whether it is transferable, whether there is a cost recovery mechanism and more – may be important considerations during the allocation process.

5.3 WILL THERE BE AN APPEALS PROCESS?

An appeals process can help ensure fairness in allocation. While it is not, and should not be, a substitute for transparent allocation decisions, an appeals process can address certain issues. Appeals processes have commonly been used to address factual issues such as interpretations of regulations or corrections of accounting errors. Managers may find it helpful to determine upfront that there will be an established process to handle complaints in order to earn buy-in from participants early on. Some countries already have established appeals processes that should be followed.

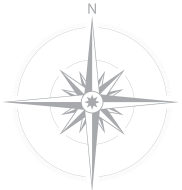
Generally, appeals processes hear cases in which fishermen claim data on their landings or income reports were inaccurate or missing. If fishermen can make a compelling case by showing corroborating data, then appeals processes are likely to change their initial allocation share.

Appeals processes are likely to be more effective if they are conducted by professionals and removed from the political process. And importantly, appeals should not result in a change in the other design features of a program. For example, in the New Zealand abalone fishery, participants were granted additional shares without a recalculation of the total. As a result, the shares exceeded the originally identified catch limit by 10%, on average (Lock and Leslie, 2007). The appeals process should have recalculated shares appropriately in order to stay within the catch limit.

While an appeals process is important for fairness, it should not be used as an excuse to delay difficult decisions about allocation. Rather, those issues should be worked out through the identified initial allocation process and appeals should be reserved for extreme or unordinary cases.

PRINCIPLE 9

Employ an allocation appeals process that allows eligible participants to refute allocated amounts with verifiable data.



5.4 WHO IS ELIGIBLE TO RECEIVE SHARES?

Determining eligibility is an important Step for your fishery's initial catch share allocation. Decisions made in previous Steps will certainly influence this determination. Identifying the target fishing sectors in the **Before You Begin** section is a natural starting place to understand who might be eligible, and going through the process described in **Step 3 – Define Eligible Participants** will also provide input. For example, individual catch share programs such as Individual Transferable Quotas (ITQs) or Individual Fishing Quotas (IFQs) must distribute initial shares to individuals, whereas group catch shares, such as Cooperatives, will allocate shares to a group. If shares are allocated via auction, you can require participants to meet eligibility requirements in order to bid in the auction.

Eligibility can be thought of as consisting of two different layers. The first, often a political decision, is determining what categories of stakeholders will be eligible to receive allocation of shares. This is generally driven by social and economic characteristics of your fishery as well as by available data. Catch shares are commonly granted to the same entities that hold licenses to participate in the fishery, but it is possible to identify other eligible recipients. For example, the U.S. federal law (16 U.S.C. 1853a) requires consideration of nine distinct factors of eligibility:

1. Current and historical harvests
2. Employment in the harvesting and processing sectors
3. Investments in, and dependence on, the fishery
4. Current and historical participation of fishing communities
5. Small-vessel owner-operators
6. Captains
7. Crew
8. Entry-level participants
9. Fishing communities

The second layer of eligibility is determining who within those stakeholder sectors will actually receive shares. Not every participant in an eligible group may be allocated shares (see **Step 5.6**).

Additional considerations

Your fishery's goals will help drive eligibility decisions. If your goal is to limit disruption to the existing fleet structure, then current and historical harvest levels will be important criteria. Whereas if your goal is to ensure that those most dependent on the fishery receive shares, then income generated by fishing activity may be the most important information. You may have multiple goals, as defined in **Step 1 – Define Program Goals**, to which you have assigned relative importance.

While focus tends to be on allocation to individuals, there is precedent in the U.S. for groups to receive allocation. Community Development Quotas in Alaska and the Northeast Multispecies Sector Management Program are good examples. While group catch shares, in which allocation is to a group as a whole, differ from an individual catch share program, in which shares will be distributed to eligible individual entities (people, vessels or companies), at some point in nearly all catch share fisheries allocation to an individual is considered. Within a group-allocated catch share, members of the group often choose to allocate specific shares among themselves down to the individual level. Recognizing this, the rest of this chapter will focus on allocation down to the individual level.

The Magnuson-Stevens Fishery Conservation and Management Act identifies Fishing Communities (FCs) and Regional Fishing Associations (RFAs) as eligible entities to hold shares. However, Fishing Communities are allowed to receive an initial allocation of shares, whereas RFAs cannot. RFAs can be formed after a catch share is in place and participants within them can pool, purchase or lease shares. FCs and RFAs are new and untested entities, but hold

significant promise for addressing some of the community concerns around catch shares (Anderson and Holliday, 2007). For further information on RFAs and FCs, please see the Magnuson-Stevens Fishery Management and Conservation Act and NOAA's Technical Memo, *The Design and Use of Limited Access Privilege Programs* (2007).

Finally, it is possible to identify other eligible recipients, such as citizens who have not participated in the fishery, non-profit organizations or more. Allocations to non-participants would raise important issues that would need to address concerns from existing fishery participants and stakeholders. See Table 5.2 for a list of eligibility requirements from select catch share fisheries.

SNAPSHOT 5.1 | Allocating to Numerous Stakeholders

Bering Sea and Aleutian Islands Crab Rationalization Program

The Bering Sea and Aleutian Islands Crab Rationalization Program was implemented in 2005. The program included a relatively complex allocation process resulting in a variety of participants holding harvesting quota.[6] Shares were granted to participants based on eligibility requirements including historical participation in the fishery as a captain and/or crew, community dependence and more. The program includes four types of harvesting quota – catcher vessel, catcher-processor, crew or "skipper," and community quota (NOAA Fisheries Services, 2009j). While allocating shares to crew has been challenging in other fisheries due to a lack of good data, the Crab Rationalization Program managers were able to access landings records with the names of crew and thus were able to allocate shares.

5.5 WILL INITIAL SHARES BE AUCTIONED OR GRANTED?

There are two main forms of initial share distribution: auctioning and granting. Auctions require participants to pay for the shares, whereas granting gives the shares free of charge to an identified set of participants at program initiation (although following initial allocation, shares are generally traded). Participants could also be granted a share and be required to pay a set fee. There are a number of policy and political reasons to consider all approaches.

It may be helpful to look at other allocations of other public resources to inform your fishery allocation decisions. Both auctioning and granting of shares have been used to allocate public resources in the U.S. For the allocation of resources with a strong tradition of local users, such as fields for grazing or water, granting has been more common. Resources that are newly "discovered" or without a strong history of use, such as the electromagnetic spectrum, have been allocated through auctions (White, 2006). To date, fisheries have used granting to allocate initial shares almost exclusively.

Auctioning

Under auctions, eligible recipients pay upfront for the privilege to use a public resource. The revenues generated through auction can be distributed back to the public, used to cover management costs, such as the cost of research or enforcement, or used to meet other objectives. If shares are initially allocated via auction, it should occur at the end of the catch share design process so that bidders know the attributes of the privileges. Auctions have rarely been used in fisheries. Looking to other public resources, such as the electromagnetic spectrum or other arenas, may provide some helpful insight into the use of auctions.

6 The program also allocated processing shares to processors and provided for binding arbitration between harvesters and processors. This is a rare design feature that required special legislation in the U.S. to create.

Granting

Under a granting system, eligible recipients receive allocations of catch shares without payment. Granting is the most common method for distributing shares initially. Many catch share programs may still require an annual participation fee, such as a license fee, but the catch shares are granted without fee. Fishermen and fishing communities with a long history of reliance on, and participation in, a fishery favor granting as the most fair and equitable approach (Le Gallic, 2003). Furthermore, granting does not require capital upfront and therefore likely accommodates more participants.

Granting of initial allocations does require developing a formula or method for distribution among participants. Formulas are often highly contentious and may require significant data.

Fee

Allocating shares for a required, standard fee is another approach to consider. This approach may achieve some of the benefits of both auctions and grants. However, we have not yet encountered a fishery in which this has been used for the initial allocation of shares. Fees can be one-time or ongoing and the purpose can be to pay for management costs or to recover resource rents. Generally, cost-recovery fees are charged to participants on an ongoing basis and cover the administrative costs of managing a fishery, such as monitoring systems, trading systems, science and more. For a full treatment of cost-recovery and resource rents, see **Step 6.4**.

Combination

It is possible to combine auctions and grants. Fisheries can allocate a certain percentage of shares for free while holding a portion back for auction. Many fisheries have contemplated holding back some shares for adaptive management or to make it available to a specific group, such as new entrants or fishermen who meet certain conservation objectives. The government could thereby generate some revenue through the auction, while also winning support among existing fishermen, and achieving specific program goals.

TABLE 5.1 | COMMON FEATURES OF ALLOCATION FORMULAS

	DEFINITION	GOAL
CATCH HISTORY	Calculation of a fisherman's historical participation in the fishery based on his/her landings as a percentage of the fishery's total landings	To ensure a fair and equitable distribution of shares that is based on past patterns of participation
CONTROL DATE	A fixed date, after which landings are not counted toward an individual's standing. A date is often set for a period prior to discussions about catch shares	To prevent fishermen from increasing effort to improve their landings in the period leading up to catch share implementation, which can exacerbate existing management problems
BASE YEARS	Years used to calculate landings. It is generally a three to five year period	To accurately represent participation in the fishery over a sustained period of time
EXCLUDED YEARS	The year(s) that may be discarded from the calculation. These are often the years of lowest individual landings	To include the best representative years of participation and account for years of non-participation

TABLE 5.2 | ALLOCATION FORMULAS FOR SELECT PROGRAMS

		GEAR	START YEAR	ELIGIBILITY INFORMATION	INITIAL ALLOCATION FORMULA	
UNITED STATES	ATLANTIC SURFCLAM AND OCEAN QUAHOG INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Dredge	1990	Vessel owners who reported landings at anytime from 1979 to 1988 About 150 entities were eligible	Surfclam	80% catch history from 1979 to 1988 where the last 4 years counted twice and the 2 worst years were excluded 20% vessel cubic capacity (length x breadth x depth)
					Quahog	100% catch history from 1979 to 1988, excluding the worst year
	SOUTH ATLANTIC WRECKFISH INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Hook and Line	1992	Vessel owners who fished in 1989 or 1990 90 entities were eligible	50% catch history from 1987 to 1990 and 50% equal shares	
	WESTERN ALASKA COMMUNITY DEVELOPMENT QUOTA PROGRAM	Trawl and Hook and Line	1992	Native Alaska Claims Communities (1) within 50 miles of the Bering Sea, (2) with residents that conduct 50% of their subsistence or commercial activities in Bering Sea and (3) that did not already have significant pollock activity 65 eligible communities organized into 6 groups	The State of Alaska recommended how to share among the 6 groups, largely based on population considerations Each CDQ group had to identify a partner to fish the allocation	
	ALASKA SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM*	Longline	1995	Vessel owners who were active at least 1 year from 1988 to 1990 4,816 entities were eligible	100% catch history based on the best 5 of 7 years from 1984 to 1990	
	ALASKA HALIBUT FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM*	Longline	1995	Vessel owners who were active at least 1 year from 1988 to 1990 1,052 entities were eligible	100% catch history based on the best 5 of 6 years from 1985 to 1990	
	BERING SEA POLLOCK CONSERVATION COOPERATIVE	Trawl	1998	Involvement in the Bering Sea and Aleutian Islands catcher-processor fishery 9 companies form the Cooperative	Negotiated among member companies	
	BERING SEA ALEUTIAN ISLANDS CRAB RATIONALIZATION PROGRAM	Pots	2005	Vessel owners and skippers involved in the 9 fisheries, with up to 5 seasons of qualifying years received Quota Shares Processors received processor shares	100% catch history based on the average of the percentage of catch limit caught over 5 qualifying years	

*also had "set-asides" for CDQs

TABLE 5.2 | CONTINUED

		GEAR	START YEAR	ELIGIBILITY INFORMATION	INITIAL ALLOCATION FORMULA	
CANADA	LAKE WINNIPEG INDIVIDUAL QUOTA PROGRAM	Gillnet	1972	Individuals who met one of two criteria: (1) held a license in 1968 or 1969 or (2) held a license in 6 of the 7 years prior to 1968 690 entities were eligible	Equal share of each area/ season catch limit	
	ATLANTIC OFFSHORE GROUNDFISH ENTERPRISE ALLOCATION PROGRAM	Trawl	1984	Vertically integrated harvester-processor companies 18 entities were eligible	Northern cod	Arbitration
					Other	Judgmental process largely based on catch history between 1977 and 1980
	BRITISH COLUMBIA GEODUCK INDIVIDUAL VESSEL QUOTA PROGRAM	Dive	1989	"G" vessel license holders at time of implementation 55 entities were eligible	Equal shares	
	BRITISH COLUMBIA SABLEFISH INDIVIDUAL VESSEL QUOTA PROGRAM	Longline and Trap	1990	"K" vessel license holders at time of implementation 48 entities were eligible	70% catch history based on the best 1 year catch between 1988 and 1989 30% vessel length	
	BRITISH COLUMBIA HALIBUT INDIVIDUAL VESSEL QUOTA PROGRAM	Longline	1991	"L" vessel license holders at time of implementation 435 entities were eligible	70% catch history based on the best 1 year catch between 1986 and 1989 30% vessel length	
	BRITISH COLUMBIA GROUNDFISH TRAWL INDIVIDUAL VESSEL QUOTA PROGRAM	Trawl	1997	"T" vessel license holders at time of implementation 142 entities were eligible	80% catch history 10% Groundfish Development Shares (by application judged on community benefits) 10% Code of Conduct (same allocation as the initial 80% unless a complaint is received as to unfair treatment of crews)	

TABLE 5.2 | CONTINUED

		GEAR	START YEAR	ELIGIBILITY INFORMATION	INITIAL ALLOCATION FORMULA
ICELAND	PELAGIC HERRING INDIVIDUAL TRANSFERABLE QUOTA SYSTEM	Purse Seine and Trawl	1975		Equal shares
	PELAGIC CAPELIN INDIVIDUAL TRANSFERABLE QUOTA SYSTEM	Purse Seine and Trawl	1980	52 vessel owners were eligible	Equal shares
	DEMERSAL FISHERIES INDIVIDUAL TRANSFERABLE QUOTA SYSTEM	Trawl	1984		100% catch history based on 1981 to 1983 (upward adjustment if vessel had major repairs or entered fishery after 1981)
	INDIVIDUAL TRANSFERABLE QUOTA SYSTEM—VESSELS OVER 6 GROSS REGISTER TONS IN ALL	Multiple	1991	1,265 vessels were eligible	100% catch history with some exceptions, such as for herring, capelin, etc., or for historical reasons
NEW ZEALAND	INSHORE QUOTA MANAGEMENT SYSTEM	Multiple	1986	Permitted vessel owners with a combined total of at least five metric tons of shares for all species under the allocation formula About 2,560 entities were eligible	100% catch history based on the best 2 of 3 years from 1982 to 1984
	OFFSHORE QUOTA MANAGEMENT SYSTEM	Multiple	1986	Companies and consortia that had large "commitment" in the fishery 9 entities were eligible	100% "commitment" based on either catch history, investment in onshore processing employment or fishing capital (provided company "commitment" level exceeded 2,000 metric tons per year)

TABLE 5.2 | CONTINUED

		GEAR	START YEAR	ELIGIBILITY INFORMATION	INITIAL ALLOCATION FORMULA
AUSTRALIA	SOUTHERN BLUEFIN TUNA INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Troll	1984	Vessel owner who met one of three criteria: (1) landed at least 15 metric tons in any of the three years from 1980/81 to 1982/83, (2) people who would have qualified above and who could demonstrate that they bought another boat before September 1984 or (3) people who purchased a boat before July 1984 and worked at least two complete fishing seasons on a boat that harvested 15 metric tons 143 entities were eligible	75% catch history based on the highest catch in three years from 1980/81 to 1982/83 25% capital investment or the value of individual's boat as estimated by contracted independent marine surveyor
	SOUTH AUSTRALIA ABALONE INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Dive	late 1980s	35 existing operators were eligible	Equal shares
	SOUTHEAST TRAWL INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Trawl	1992	About 140 existing operators were eligible	Varied by species 50% - 80% catch history based on the best 4 years from 1984 to 1989 20% - 50% investment based on vessel's length, breadth, depth and engine power
	SOUTH AUSTRALIA SOUTHERN ZONE ROCK LOBSTER INDIVIDUAL TRANSFERABLE QUOTA PROGRAM	Pots	1994	187 existing operators were eligible	Operator chose 1 of 3 formulas: (1) 100% catch history in the previous 3 years, (2) current pot entitlement or (3) 50:50 catch history and pot entitlement

5.6 HOW MANY SHARES WILL ELIGIBLE RECIPIENTS RECEIVE?

If your fishery decides to grant catch shares, then you must develop a protocol for distributing the shares. Fisheries that have opted to grant without a fee have used a variety of formulas to determine share holdings. Formulas usually use data on catch history, and/or level of investment, or use equal sharing to divide shares. Within a formula, you can also give variables different weights. Auction systems can also set parameters for participation such as creating classes of eligible participants. The parameters outlined below can apply to auctions as well.

Historical landings

Overwhelmingly, the most common initial allocation criterion has been historical landings. Historical landings are often the most complete data set available and the best representation of recent fishing patterns (Huppert et al., 1996). To calculate historical landings, an individual fisherman's landings are identified for a specified period of time and compared to the total of all eligible recipients' landings. Each participant's catch history is expressed as a share or percentage of the total. This identifies the individual's "catch share" or percentage share.

Some jurisdictions have allowed participants to select specific years from an overall time frame as the basis for calculating historical landings, e.g., select the three best years from a time window of five years. This helps to accommodate participants who may not have landed fish in a particular year due to "unavoidable circumstances."

A common regime has emerged for initial allocation processes with regard to using landings data. See Table 5.1 for further description.

Level of investment

You may choose to use fishermen's level of investment as an indication of an individual's potential catch capacity and commitment to a fishery. Factors indicating investment might include vessel length or size or value of other capital investments. Investment may be an especially important factor if participants in your fishery have recently made investments in new boats or if landings are not an accurate account of participation due to constraining trip limits or other regulatory measures. In the case of a new fishery, the founders of the fishery may merit special consideration because of their disproportional investment to other participants; in the Namibian orange roughy fishery a larger share of the allowable catch was rewarded to the company that invested its capital to find a viable stock (Oelofsen and Staby, 2005).

Equal shares

Alternatively, it is possible to simply divide the shares evenly among all participants. For example, if there are 300 participants in a fishery, and the fishery will allocate 100% of the catch limit, each participant would get 0.33% of the catch. Administratively, this is very simple to determine and to carry out.

Auction caps

If an auction is used to allocate initial shares, it may also be important to set a limit on how many shares eligible participants can purchase in the auction. See **Step 3.3** for a more in-depth discussion of concentration limits.

Additional considerations

While catch history and investment are the most commonly used formula components, they are by no means your only options. Theory allows for consideration of any number of variables including overall environmental performance of individuals, performance of different gear, dependence of individuals on the fishery and more.

See Table 5.2 for a description of allocation formulas for select fisheries.

5.7 WHAT DATA ARE AVAILABLE FOR ALLOCATION DECISIONS?

What data are available will impact the method of your fishery's initial allocation. If data are very robust, then it will be possible to develop an allocation system that depends heavily on existing, retrievable information. However, if there are few data or the data are inaccurate, alternative methods should be developed.

Most fisheries transitioning to catch shares have been under some form of permitting or licensing program and the management body usually has administrative records on participants and their key characteristics. These are:

- License holder characteristics (e.g., length of tenure and number of licenses held)
- Vessel characteristics (e.g., length or type of vessel)
- Participation characteristics (e.g., number of years with landings and landing history)

Any and all of these can be important factors for determining initial share allocation. The more accurate the data, the less contentious the process will be.

In most jurisdictions, managers have used predetermined criteria to calculate eligibility and initial shares, and then dispersed information to participants. In some fisheries, participants have been responsible for calculating their own allocation and submitting an application to managers. Managers then compare the application to existing administrative records and have final determination on eligibility and share holdings. In either case, some data were required to generate or verify the allocation process.

Additional considerations

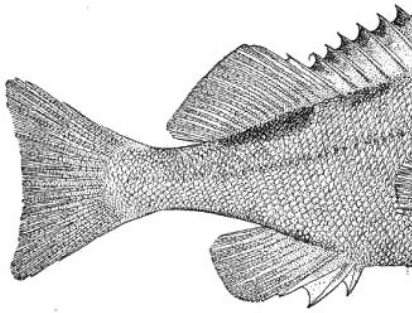
Available records can also influence participant eligibility. For example, one challenge with the allocation of catch shares to crews is that in most cases there is not adequate administrative information on the identity of crew members on particular vessels or on particular trips. The Bering Sea and Aleutian Islands Crab Rationalization Program was able to allocate shares to crab skippers because there were legal documents – fish tickets – identifying the vessel skipper (NMFS Alaska Regional Office, 2009j). Many fisheries do not have such data available.

Step 5 – Assign the Privilege

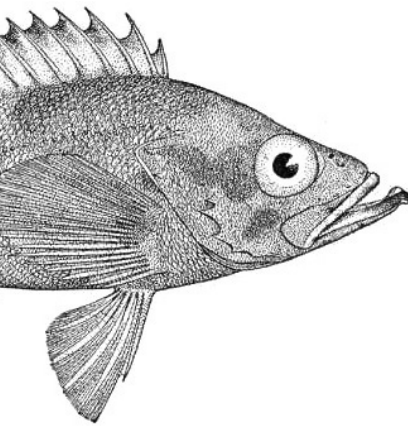
This chart provides a brief summary of the Step 5 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

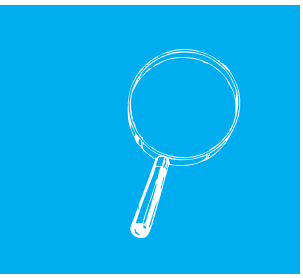
	5.1 DECISION-MAKING BODY	5.2 WHEN ALLOCATION OCCURRED	5.3 APPEALS PROCESS	5.4 ELIGIBILITY REQUIREMENTS
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Restricted Access Management Division of National Marine Fisheries Service	After program design	Yes Multi-leveled	Vessel owners or lease holders who made at least one landing in 1988,1989 or 1990
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	Fisheries and Oceans Canada with input from industry advisory bodies Retired Supreme Court Justice for Trawl sector	After program design	Yes	Sector-specific license holder Some sectors required minimum landings amount
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	National Fishing Service oversees allocation of areas to organizations Organizations manage membership	Ongoing Via application process	If denied, may re-submit application	Fishing organization made up of registered artisanal fishermen Application with required information including list of members
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Ministry of Food, Agriculture, and Fisheries Danish Directorate of Fisheries	During program design	Yes	Operators with 60% or more of income derived from fishing Non-eligible operators accommodated under alternative regulations

5.5 AUCTIONED OR GRANTED	5.6 SHARES RECEIVED	5.7 AVAILABLE DATA
Granted	100% catch history based on the best 5 of 7 years (halibut) or 5 of 6 years (sablefish) from qualifying period	Reported landings data
Granted	Various formulas based on license category Catch history and vessel length during specified time period, catch history only, or equal shares	Reported landings data and licensing information
Granted	One TURF per application Organizations determine allocation within group via equal sharing of catch limit, equal sharing of profits, or competition, etc.	Verification via National Register of Artisanal Fishermen
Granted	Formula based on weighted catch history from 2003, 2004, and 2005 Weights used were 20%, 30% and 50%, respectively	Vessel catch history



6 Develop Administrative Systems





At a Glance

Administrative systems are an important component of a catch share program. By developing and implementing effective administrative systems, you will ensure that participants can successfully participate in the program and are held accountable for their privileges.

KEY PRINCIPLES

Encourage cost-effective, transparent trading that is easy for all participants. | 87

Employ transparent catch accounting completed regularly enough to ensure the catch limit is not exceeded. | 88

Design and implement a fishery information system that keeps costs low and is effective for conducting catch accounting, collecting scientific data and enforcing the law. | 90

SUB-STEPS

6.1 How will trading occur? | 86

6.2 How will catch accounting work? | 88

6.3 How will fishery information required for science, catch accounting and enforcement be collected? | 89

6.4 Who covers the program cost? | 92

SPECIAL FEATURES

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Paying for the Program: Namibian Rights-based Management System | 93

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6 Develop Administrative Systems

As with any fishery management system, the catch share program must be implemented and administered. Most jurisdictions have existing systems in place to track fishing participants, monitor and enforce fishing activity, conduct science and more. Managers should determine how a catch share program will work within existing systems and what administrative changes may be necessary or beneficial for creating an easier, more cost-effective system.

Because this Design Manual is focused on the design of catch share programs, it will not provide a full treatment of fishery administration and enforcement. Instead, this Step will highlight some of the necessary administrative systems for catch share programs and some of the key issues that arise during catch share program development. The four components outlined here are integral to the design of a catch share and should be considered during the design phase and prior to system implementation.

Just like any fishery management program, performance of catch share programs will depend on good information, compliance and the ability for the program to be cost-effective. When participants have a secure, long-term stake in the fishery, as in a well-designed catch share program, the potential for improved information, compliance and cost-effectiveness is increased. Tracking the performance of a catch share over time, just as managers would for any management approach, will help improve systems.

By developing and implementing effective administrative systems, you will ensure that participants are **Accountable** to the program and their allocations.

Appendix A: Monitoring and Data Collection Approaches has additional information on specific monitoring approaches. Monitoring of catch is an important aspect of fisheries management and often discussed in the creation of a catch share program. It will be beneficial to develop a monitoring program that can support all the information requirements for the fishery in a cohesive way.

6.1 HOW WILL TRADING OCCUR?

Most catch share fisheries allow trading of shares, either through permanent or temporary transfers, in order to achieve biological and economic goals (Anderson and Holliday, 2007). When a catch share is transferable, there must be a mechanism for trades to occur. Different approaches may be employed for permanent transfers than for temporary transfers.

The purpose of trading is generally to create a system that allows participants to adjust to management changes, such as increases or decreases in the catch limit. Therefore, the success of the management system is inextricably linked to the success of the trading system. A good trading system will give participants access to reliable information about availability and prices of shares and will allow shares to be freely traded. These concepts should inform the development of an appropriate trading system.

The trading system must also connect to the catch accounting system (described in **Step 6.2** below) to accurately track catch

PRINCIPLE 10

Encourage cost-effective, transparent trading that is easy for all participants.

and landings against share holdings. Note also that it is not necessary for the government to develop and administer the system. There may be places that require government oversight, but often third party service providers have fulfilled this function.

Catch share fisheries have used a number of different approaches to facilitate trades:

Self-identified

It may be possible for participants to generate their own methods of identifying others interested in trades. This may be a natural extension of a tight-knit community or a fishery in which fishermen are continually in contact. The Internet may provide good opportunities for fishermen to converse as well.

Brokerages

In many instances, communication among fishermen has not been sufficient and professional share brokers and brokerages have emerged to provide these services (Sanchirico and Newell, 2003). Share brokers match up willing buyers and sellers and conduct trades for a fee.

Trading platforms

Many fisheries have created open trading platforms, either government-run or privately-run, for participants to connect. For example, NMFS records, monitors and approves all share transactions for the Gulf of Mexico Red Snapper Individual Fishing Quota Program. In other fisheries, private companies have stepped into the roles. For example, participants in the New Zealand Quota Management System use FishServe, which is owned by the national fishing organization, for administrative trading support. Competition within the private sector has often yielded highly effective companies that are adding significant value to privilege holders and their businesses (see **Catch Shares in Practice: British Columbia Integrated Groundfish Program**). In programs with eligibility standards for participating in the trading of shares, there needs to be some way to ensure that buyers are eligible to purchase shares.

Trading platforms help participants know the market price of shares and may make the system more flexible. This is especially important for multi-species programs where participants may need to regularly trade shares to cover their catch.

Additional considerations

Most of the experience with trading systems is in the context of individually-allocated systems. Therefore, these trading approaches have developed to connect individuals who may be separated and not know each other. In the case of group-allocated catch shares, trading may also be desirable, either between groups or within a group. Groups may be able to more easily identify other shareholders for trades, but still may find it useful and beneficial to employ one or more of the approaches described above.

6.2 HOW WILL CATCH ACCOUNTING WORK?

Accountability of shareholders to their allocated share is one of the most important aspects of a catch share. Importantly, catch share fisheries consistently stay within their catch limits and rarely exceed limits (NMFS Southeast Regional Office, 2009; NMFS Alaska Regional Office, 2009a; NMFS Alaska Regional Office, 2009b; NMFS Alaska Regional Office, 2009c). One of the keys to catch share management is to continually track fishermen's catch, including landings and discards, against their share holdings. This is called "catch accounting," "catch balancing" or "share balancing." Essentially, this requires deducting catch (including landings and other mortality such as discards) from the holder's available shares.

Similar to a bank account, catch accounting systems must track the shareholders' initial balance, i.e., their annual allocation, against their catch and landings, and in the case of a transferable system, any increases or decreases in shares due to trades. Some form of catch accounting system is necessary for all catch shares. Group-allocated catch shares may do the accounting internally and report back to the government, but they still need a mechanism to track all participants. Territorial Use Rights for Fishing (TURFs) may require less sophisticated systems because they tend to be small.

Catch accounting systems will be linked to fishery information and monitoring systems. **Appendix A: Monitoring and Data Collection Approaches** identifies some of these options in fuller detail. Generally, catch accounting is completed through self-reporting, reporting by authorized buyers or processors, or by independent third parties. In addition, share sales, leases and purchases must also be linked to catch accounting to give the holder an accurate understanding of their holdings.

Timing of accounting

Catch accounting systems can require real-time accounting of trades and landings, or they can use retrospective balancing at various set points throughout the season. For example, under the British Columbia Integrated Groundfish Program, catch accounting takes place upon the landing of a vessel and participants must account for any overages prior to engaging in any further fishing activity. Many shareholders conduct trades at-sea in order to effectively balance their catch against shareholdings. This system ensures that the catch limit is never exceeded and has proven especially useful in multi-species fisheries where certain species have low catch limits. Real-time catch accounting does require more technologically advanced systems.

Other catch share fisheries employ retrospective balancing in which they must balance their catch and holdings on a monthly or quarterly basis. Many Australian fisheries require quarterly balancing. The benefit of this approach is that it requires less technologically advanced systems and provides a lag time for participants to obtain shares. This flexibility may be especially helpful for participants in a multi-species fishery where it is difficult to predict the exact species ratio of the catch. There are also drawbacks. When shareholders are not required to track their catch in real-time it is more likely that the fleet could exceed catch limits. Also, some shareholders may choose to manipulate the market by holding shares for sale or lease until the end of the balancing period when participants are required to balance their catch, thereby driving up prices.

PRINCIPLE 11

Employ transparent catch accounting completed regularly enough to ensure the catch limit is not exceeded.

Deemed values

Fees may be another component of a catch accounting system. New Zealand has a system of "deemed values" in which fishermen who land species for which they do not have shares pay a fee to the government. The goal is to make the fee high enough that people are not encouraged to fish for that species but low enough that they do not dump fish overboard or otherwise fish illegally. And importantly, the fee is refunded if they subsequently buy or lease shares to cover their catch. The deemed values system has proven particularly useful for multi-species fisheries in which it has been challenging for shareholders to always have the right mix of shares for their catch (Newell, 2004). However, it does require additional administrative work to gather enough information to set and adjust deemed values and then collect the fees, especially because deemed value could vary as much as daily due to changing market conditions. It can also be difficult to set deemed values at levels that both discourage fishing for that stock by those who do not have shares and discourage discarding. Furthermore, by allowing participants to land catch for a fee rather than based on their annual allocation holdings, it becomes more likely that the fleet will exceed its catch limit. Managers must carefully track this and consider whether there are certain stocks, such as highly vulnerable stocks, that should not employ deemed values as an approach.

Weight or tags

As discussed in **Step 4 – Define the Privilege**, it is possible to create a weight-based system or a tag-based system. If using a weight-based system, catch must be weighed and verified either on the vessel, at the delivery point, or both. Often the fisherman and the dealer weigh the catch and these reports are checked against each other to verify the correct amount.

Tag-based systems work similarly to hunting tags. A certain number of tags are allocated in the beginning of the year based on an individual's holdings and every fish or standardized delivery weight must be tagged to be accepted for delivery. For example, the surfclam and ocean quahog shareholders are allocated a certain number of cage tags at the beginning of each year, based on the size of the cage and an individual's holdings. Each cage that is delivered is required to have one of these tags (McCay, 2001). Tag-based systems are often lower cost, but they may be infeasible depending on how the product is caught and delivered.

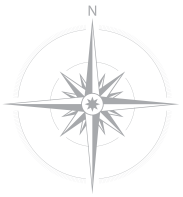
6.3 HOW WILL FISHERY INFORMATION REQUIRED FOR SCIENCE, CATCH ACCOUNTING AND ENFORCEMENT BE COLLECTED?

The key to sustainability for any fishery is to ensure the catch does not exceed the appropriate science-based catch limit. As with all fisheries management, catch share programs also require good information to function well. Information systems should be designed and used to conduct catch accounting, collect scientific data and enforce the laws. Many jurisdictions use the implementation of a catch share program as a time to implement more comprehensive fishery information and monitoring approaches. This often leads to the perception that catch shares require more monitoring. In fact, any catch limit-based management system will require a certain amount of monitoring to track catch and landings. There are numerous benefits to a robust information system, irrespective of the management approach. Strong information systems build trust among fishery participants and between managers and fishermen, improve science and knowledge of the stocks, and can lead to a higher level of compliance.

Fishery information is important for both individually-allocated and group-allocated systems, but the way in which it is reported for each might be different. In an individually-allocated system, each participant will be required to report information to the management authority, whereas a group-allocated system will require each group to report information to the management authority. The group must

PRINCIPLE 12

Design and implement a fishery information system that keeps costs low and is effective for conducting catch accounting, collecting scientific data and enforcing the law.



employ a system that will provide an accurate representation of its members' activities. TURFs are likely to employ different approaches often focused on a system of self-monitoring to verify landings and protect their borders from non-members.

Fishery information can be collected through a broad array of methods, from at-sea to dockside data collection and self-reported to independently-collected methods. See Figure 6.1 for more detail. The fishery's resource, fleet, operational and market characteristics are important determinants in your choice of approach for gathering and verifying information. Furthermore, the appropriate systems will depend on your program goals. Some programs will require spatial or temporal information, while others may require information on prohibited species or bycatch. In general, the least cost, most effective approach should be used for a fishery.

Credibility of information systems is important; if the system is credible, the focus will be on the meaning of the data, whereas if the information system is not credible, the focus will be on the collection of the data. Many fisheries rely on self-reported information systems, such as fishermen logbooks and dealer reports. Self-reported systems are low cost but may have lower-quality, inconsistent data. Therefore, accuracy and authenticity are often a key concern and additional incentives, such as random checks and strong penalties for misreporting data, will help improve data. Independent monitoring systems, such as 100% observer coverage or non-tamperable camera systems tend to be more objective and better trusted. They generally have higher data quality, and are deemed more credible, especially when the data collection is independent from the business operations of the fishery and data collectors are specifically trained for their role.

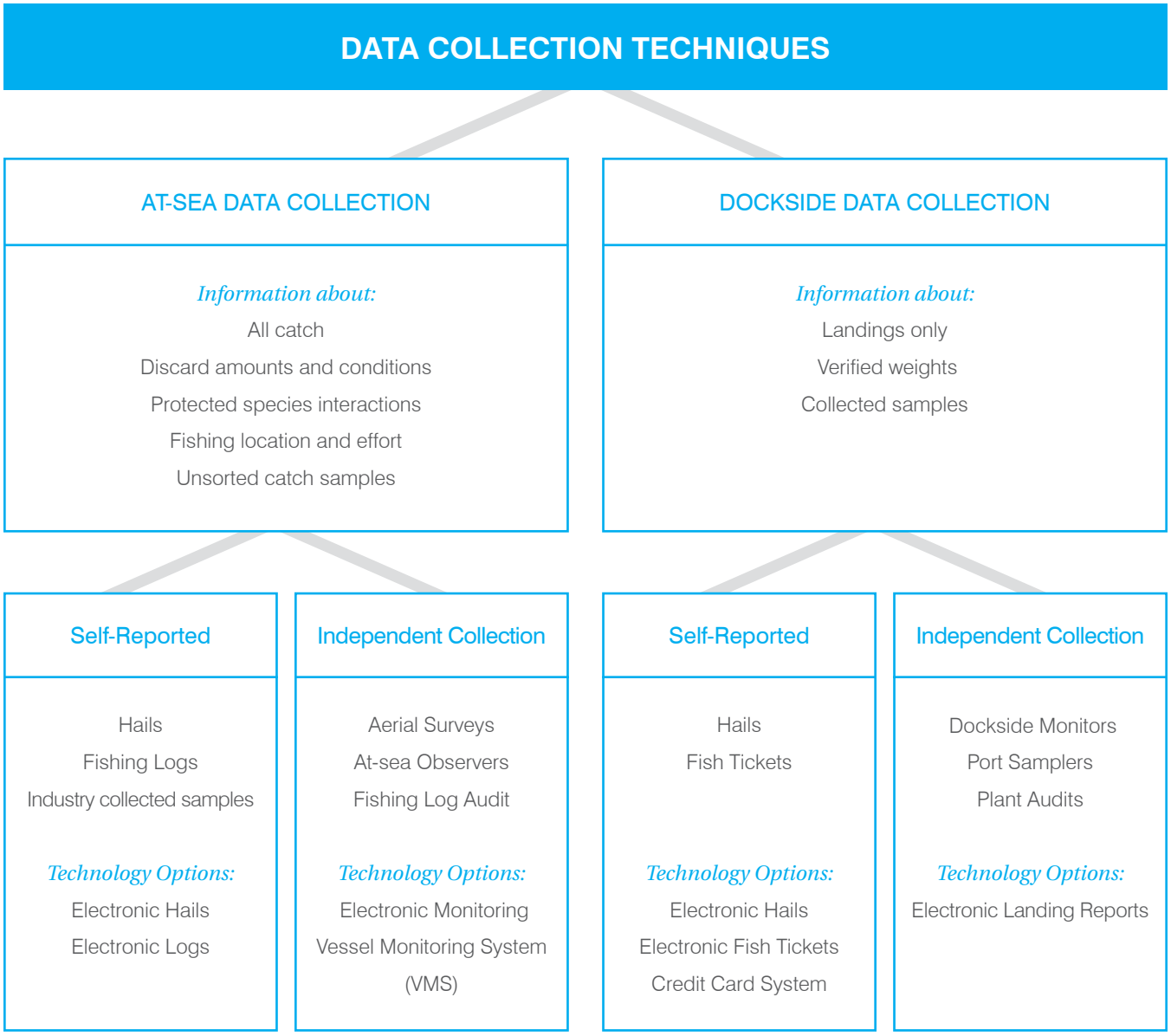
It may be possible to combine self-reported and independent information systems via a verification approach based on sampling, in which only a percentage of information is collected, verified, or both. A sampling approach will provide less robust data (Babcock et al., 2003), but it can be designed to have a high level of confidence for monitoring, verification and scientific purposes. One such method is to pair self-reporting with partial observer coverage or electronic monitoring with audits. If inaccuracy is detected for specific shareholders, then you can increase auditing and/or onboard observer frequency. Importantly, you can charge shareholders for the cost of additional monitoring as an incentive to increase accuracy of self-reporting.

The British Columbia Integrated Groundfish Program has achieved a good balance between full coverage and the time and cost savings of random sampling. Each vessel has 100% electronic monitoring and footage is randomly sampled from each vessel trip for review against participant's logbooks. If cheating behavior is detected all the footage is reviewed. In any system, when a high degree of uncertainty around data exists, then a more precautionary approach to setting caps should be employed. See **Catch Shares in Practice: British Columbia Integrated Groundfish Program** for more information.

Furthermore, developing a good chain of custody system so that products can be tracked from vessel through processing and wholesaling should be a key part of the overall compliance system and can reduce costs of at-sea and dockside monitoring. This will not work as well for products that are sold into local markets.

For a further discussion of specific monitoring and information approaches and how they might work for your fishery, please see **Appendix A: Monitoring and Data Collection Approaches**.

FIGURE 6.1 | *Fishery Information Strategies*



6.4 WHO COVERS THE PROGRAM COST?

Fish are public resources held in common by all citizens and managed on their behalf by the government. By accessing and selling fish, fishermen are inherently benefitting from a public good. There are management costs to this activity that must be paid for somehow. This is true for any fishery, whether it is open access, limited access or a catch share program. Often, governments have underwritten the costs of management, essentially providing a subsidy to fishing fleets. Governments are increasingly interested in limiting subsidies and shifting the cost of management to the participants who benefit. When participants and government share the costs, there is an incentive for participants to work with the regulators to improve management and cut costs (Gislason, 1999; Yandle, 2003).

Fisheries under catch shares are generally more profitable than traditionally managed fisheries (Fujita et al., 2004; World Bank and FAO, 2008) and thus better able to afford at least some cost of management. Furthermore, even though all fishery management programs should achieve robust monitoring for compliance, management authorities often use the transition to catch shares as an opportunity to implement more sophisticated, and potentially more costly, monitoring and/or scientific approaches. The benefits of this investment include more accurate information and a level playing field for participants. However, there is a question of how to pay for science, monitoring and compliance. Fishermen under catch share programs have an increased incentive to invest in monitoring and science in order to have better information that may lead to more sustainable stocks and higher catch limits (Festa et al., 2008).

There are two general cost-related issues to consider: how the transition will be paid for and whether the ongoing cost will be recovered from industry. In addition, you should consider whether to collect rents from industry for their use of a public resource.

Financing the transition

Some governments have made the public policy decision to provide financial aid to fishing fleets in order to fund the transition to catch shares. Catch shares are often implemented in fisheries that are overcapitalized and overfished, generally as a result of ineffective management. Providing some transition funding can help move a fishery more easily toward a catch share program. For example, New Zealand financed the transition by buying back catch history (which was the basis for share allocation) and by injecting capital and ongoing operating money into the management authority. The rationale for this investment was based on the expected long-term stock and financial benefits of the catch share program (Sissenwine and Mace, 1992). In fact, most New Zealand fisheries now cover their own management costs.

Cost recovery

Cost recovery refers to a variety of mechanisms by which fishing participants pay for some or all of the costs of management. Costs may include science for setting catch limits, monitoring costs, administrative costs and more. Cost recovery fees can be collected in a variety of different ways including direct payment to the government through a fee or tax on the annual landings and/or direct contracting by shareholders with service providers.

Fishery participants and the government will often split costs according to which are traditional government services and which are better suited for industry to pay. For example, the government may pay for maintenance of administrative systems, while participants may cover the costs of monitoring systems.

Catch share fisheries have taken a variety of different approaches to this. For example, all Australian fisheries are required (or are transitioning) to pay 100% of the

"attributable costs" of the fishery. Shareholders pay a yearly levy based on each year's budget and each individual fisherman's share holdings. New Zealand recovers costs from participants to pay for research and compliance. In addition, New Zealand shareholders have purchased additional science services directly from third party vendors to improve the understanding of their stocks and the accuracy of the catch limits (Lock and Leslie, 2007).

In the U.S., the Magnuson-Stevens Fishery Conservation and Management Act requires that catch share participants pay up to 3% of the ex-vessel value of the fishery to cover additional management costs incurred as a result of shifting from conventional management to catch shares (16 U.S.C. 1854). While some U.S. catch share programs use revenues from cost recovery fees to pay for monitoring, it is not required for programs to do so. Monitoring costs generally fall outside of the 3% cost recovery fee and have historically been paid for by the government or by industry.

Resource rents

Resource rent is the value of extracting the resource in excess of the costs of extraction (including management). Resource rents are a fee charged to shareholders for the benefit of accessing a public resource. While resource rents are not as common as cost-recovery fees, some governments do collect rents on behalf of the public.

It is possible to collect resource rents from a fishery either via auctioning of the allocation or through charging royalties. In some countries, rent recovery is of prime importance to national economies, and the opportunity cost of failing to extract rent is very high. For example, income from fishing royalties accounts for over 40% of the Falkland Islands gross domestic product, and provides the government with over half its annual income (Harte and Barton, 2007). A resource rent will impact the catch share. If it is set too high, then it may hamper the flexibility of the system or reduce participants' conservation incentives (Libecap and Anderson, 2009). On the other hand, setting a low fee may not return as much value to the public. Appropriate analysis will help determine the best level.

Catch share fisheries tend to be more profitable than traditionally managed fisheries and better equipped to cover all or a portion of the costs of management. Achieving the transition to catch shares may require an up-front investment by the government, but as the fishery becomes more efficient under a catch share program and as stocks recover, those costs can comfortably be shifted to industry.

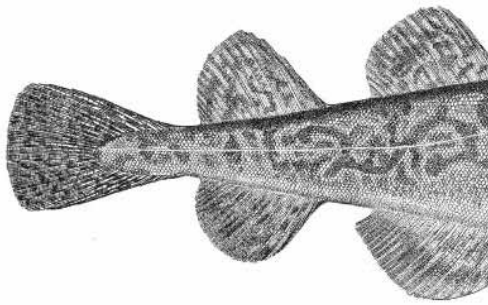
SNAPSHOT 6.1 | Paying for the Program
Namibian Rights-based Management System

The Namibian government provides an interesting case of both categories of fees in catch shares: cost recovery and rent capture (i.e., resource rents). Cost recovery refers to the cost of managing the fishery, while resource rents attempt to capture some of the value fishermen receive from using the public fishery resource. Namibia recovers all the management costs by charging catch share holders cost recovery fees, which are established by taking into account the value of landings, operating costs and the profitability of industry. On average, these fees total 5% – 15% of the total landed value in Namibia (Namibian Ministry of Fisheries and Marine Resources [MFMR], 2004). In addition, the government collects a portion of economic rents through charging resource rents.

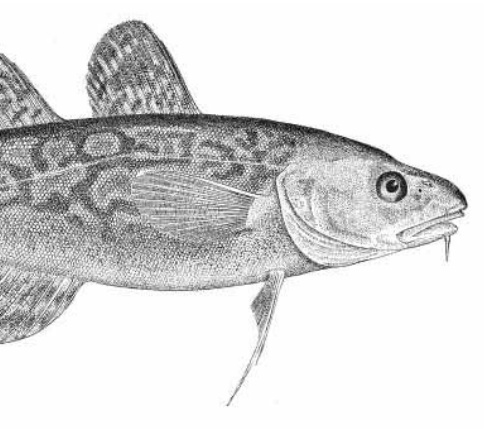
Step 6 – Develop Administrative Systems

This chart provides a brief summary of the Step 6 design decisions for the four case studies featured in this Design Manual. For an in-depth discussion of each fishery, please see the full case studies in the **Catch Shares in Practice** section starting on page 103.

	6.1 TRADING MECHANISM	6.2 CATCH ACCOUNTING	6.3 FISHERY INFORMATION	6.4 WHO PAYS
ALASKA HALIBUT & SABLEFISH FIXED GEAR INDIVIDUAL FISHING QUOTA PROGRAM 	Government-maintained, web-based trading platform Independent brokers	Shareholders and dealers report landings for each trip via web-based system maintained by government	Logbooks Dockside monitoring: 100% at main ports, random checks at smaller ports Onboard observer coverage: 30% for certain vessel classes, 100% for certain vessel classes	Participants pay incremental costs of catch share management via cost recovery ~1%-2% of ex-vessel revenues
BRITISH COLUMBIA INTEGRATED GROUNDFISH PROGRAM 	Mostly through independent brokers	Catch and landings reported for every trip and deducted from IVQ pounds Any overage must be covered by next trip	Logbooks 100% at-sea monitoring (onboard observers or electronic monitoring) 100% dockside monitoring	Participants pay all direct costs of monitoring ~5% of fishery value
CHILEAN NATIONAL BENTHIC RESOURCES TERRITORIAL USE RIGHTS FOR FISHING PROGRAMME 	Trading not authorized	Each group collects, aggregates and reports landings data to government Verified with sampling data	Landings data reported to government by groups For some species, also record harvester name and depth of harvest	Groups pay for application fees, baseline studies, stock assessment and some monitoring and enforcement Also pay tax based on hectares
DANISH PELAGIC & DEMERSAL INDIVIDUAL TRANSFERABLE QUOTA PROGRAMS 	Primarily via voluntary cooperatives that use an online transfer system Independent brokers	All landings are reported and managed via online transfer system Pilot program on reporting all catch	Dockside monitoring At-sea monitoring using EM	Participants pay for at-sea monitoring (currently a voluntary program)

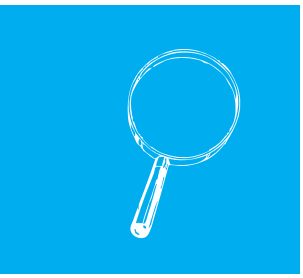


7 Assess Performance and Innovate



SEASALT

- Secure
- All sources
- Scaled
- Accountable
- Limited



At a Glance

The final Step of catch share design is to ensure the program is functioning well and achieving the identified program goals. You should conduct regular assessments and modify the program as necessary to meet existing and new goals. In addition to formal program changes, participants should also be encouraged to innovate in order to improve the program.

KEY PRINCIPLES

Assess performance against goals and encourage innovation to improve the program over time. | 100

SUB-STEPS

7.1 Conduct regular program reviews. | 98

7.2 Assess performance against goals. | 98

7.3 Encourage innovation. | 99

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7 Assess Performance and Innovate

The final Step of catch share design and implementation is to assess program performance and innovate to address emerging opportunities and challenges. Flexibility is a key aspect of catch shares and programs must be dynamic in order to meet the changing needs and conditions of the fishery.

Completing this Step is a key part of ensuring all key attributes of the catch share program are being met. In particular, program assessment can determine whether privileges are **Secure** enough to realize benefits and if the **Scale** of the program is working well biologically and socially. In addition, information and feedback over time can help track whether **All sources** of mortality are included in the program and if catch is appropriately **Limited**. Finally, regular review can assess whether the program is **Accountable**.

7.1 CONDUCT REGULAR PROGRAM REVIEWS

As with any fishery management program, regular reviews of the catch share program will provide important information. It may be helpful during the design process to identify a review schedule, as well as the specific topics to include in a regular review. In the U.S., the LAPP provision of the Magnuson-Stevens Fishery Conservation and Management Act requires new programs to be reviewed five years after implementation and then at least every seven years thereafter.

Reviews should include an assessment of biological conditions, especially in regard to ending overfishing and restoring and maintaining healthy stocks. Assessing other conditions, such as the economic status of the fishery may also be important. Remember that it may take a few years for the full effects of the catch share program to be evident.

7.2 ASSESS PERFORMANCE AGAINST GOALS

As you will recall, the purpose of **Step 1 – Define Program Goals** was to identify the biological/ecological, economic and social goals for the catch share program. **Steps 2 – 6** focused on designing the program to meet those goals. Once the catch share is underway, it is important to assess program performance against the originally defined goals.

Some goals may be easier to assess than others due to available data. As you plan the program, you may need to collect baseline data, especially economic and social data, in order to provide a meaningful reference point. Assessing performance is a regular practice of most catch share fisheries. Program design should be modified as needed based on performance against goals and changing conditions in the fishery.

7.3 ENCOURAGE INNOVATION

Flexibility and innovation are key aspects of catch share programs. Under catch shares, fishermen are allowed flexibility while being held accountable for their share of the catch, which often leads to new, innovative solutions to challenges that may arise. For example, fishermen in many catch share programs have substantially reduced bycatch and habitat impacts by reducing and modifying the gear used, carefully planning fishing activities, cooperating with other fishermen and more.

Many catch share programs have also undergone expansion or integration of existing programs. The British Columbia Integrated Groundfish Program began as separate gear and species-specific catch share programs and is now

SNAPSHOT 7.1 | Innovations to Enhance Performance

Japan's Community-based Cooperatives

Community-based Cooperative catch share programs are the foundation of nearshore coastal fisheries in Japan and have evolved from traditional organizations dating back to the feudal era. These exclusive fishing rights are available only to community members, and there are over 1,600 cooperatives in Japan with exclusive fishing rights recognized by the Japanese government (Uchida and Makino, 2008).

The fisheries are co-managed by two types of organizations: Fishery Cooperative Associations (FCAs) and Fishery Management Organizations (FMOs). FCAs are comprised of all the communities that partake in fishing in the coastal fisheries and have been granted exclusive access by the government. The FCA management areas are defined by geo-political backgrounds rather than stock boundaries (Uchida and Makino, 2008). An FCA is comprised of specific communities and all of the fisheries within those boundaries; therefore FCAs manage multiple species, gears and sectors at once (Uchida and Makino, 2008). Additionally, FCAs are required to maintain catch records of all members.

Fishery management organizations (FMOs) are an innovative program organized by fishermen. They are specific to a single fishery and/or species and are comprised of fishermen who fish at the same fishing grounds, fish the same species stocks and/or employ the same type of fishing gear (Uchida and Makino, 2008). Fishermen have formed FMOs in order to coordinate harvest and manage resources on mutually agreed rules. The responsibilities of a FMO can include fishery resource management, fishing ground management, and fishing effort control. FMOs are legitimately recognized by the FCAs, and together they help manage Japan's coastal fishing grounds.

PRINCIPLE 13

Assess performance against goals and encourage innovation to improve the program over time.

integrated into a comprehensive overarching program for all commercial fishermen targeting groundfish. The New Zealand Quota Management System began with a few dozen species in 1986 and now incorporates approximately 100 species. The Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program has been officially modified 39 times since initial implementation (NMFS Alaska Regional Office, 2010b).

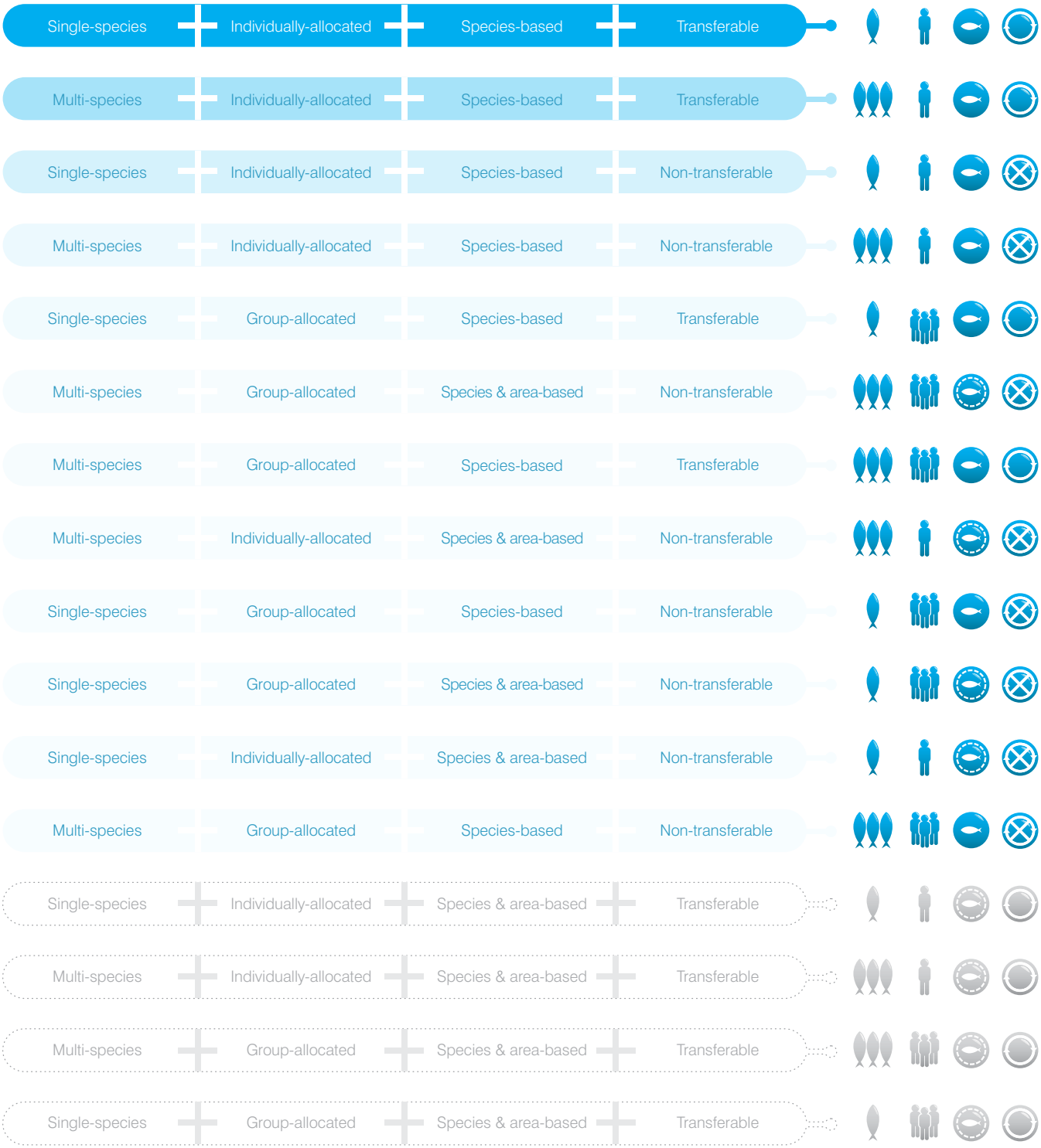
Many programs have made changes following initial implementation to rules regarding trading, eligibility, new entrants and more. Innovations allow programs to meet new and/or changing demands, although managers should carefully select and introduce innovations in order to maintain program stability and improve performance relative to goals.

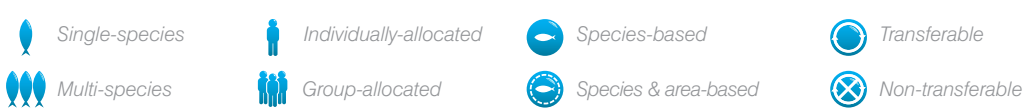
Innovations frequently occur in the private sector as well. When catch share fishermen have a secure share in the fishery and are no longer forced to race, they are able to put their creativity toward solving problems or improving conditions that help the resource and their profitability. Fishermen may increase the value of their catch through activities such as value-added processing, better marketing, developing new markets and more. Fishermen and managers may develop more effective fishery information systems that improve science, catch accounting and more.

When designed well, catch shares can successfully meet program goals. By assessing performance and encouraging innovation a catch share program can be effective well into the future.

FIGURE 7.1 | *Combinations of Catch Share Design Features*

IN ORDER OF MOST COMMONLY USED WORLDWIDE





Catch Shares in Practice

Keith Bell and Buck Laukitis pull aboard a pacific halibut while commercial longline fishing in the Aleutian Islands, Alaska.

PHOTO: SCOTT DICKERSON

SEASALT
- Secure
- Exclusive
- Scaled
- Accountable
- Limited
- Transferable

CATCH SHARES IN PRACTICE

Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program

SPECIAL DESIGN FEATURES

MULTI-SPECIES, INDIVIDUALLY-ALLOCATED AND GROUP-ALLOCATED, SPECIES-BASED, TRANSFERABLE

The Alaska Halibut and Sablefish Fixed Gear Individual Fishing Quota Program (IFQ Program) was one of the first to include a variety of design elements to meet key social goals while also contributing to decreasing overcapitalization and increasing the value of the fishery. Some of the key design elements include low concentration limits, restrictions on trading, strict shareholder eligibility requirements and more. The program also allocates a percentage of the shares to the Community Development Quota (CDQ) program, which includes 65 eligible communities organized into six groups and was designed to ensure fishing access, support economic development, alleviate poverty, and provide economic and social benefits to residents of western Alaska communities (North Pacific Fishery Management Council, n.d, A).

SYNOPSIS

In 1995, managers implemented an IFQ Program for the Alaska halibut *(Hippoglossus stenolepis)* and sablefish *(Anoplopoma fimbria)* fixed gear fishery. The IFQ Program has received significant attention as it was among the first catch share programs to design for explicit social goals in addition to biological and economic goals. Fifteen years after implementation, the catch share program is meeting its goals.

The fishery occurs in federal waters off Alaska in the Bering Sea, Aleutian Islands and Gulf of Alaska. Fishermen use fixed gear vessels ranging in length from less than 35 feet to over 60 feet, including longline catcher vessels and catcher-processor vessels. In 2008, fishermen landed approximately 74 million pounds worth U.S. $245 million (NOAA Fisheries Service, 2009f).

The fishery is managed by the National Marine Fishery Service (NMFS), with consultation by the North Pacific Fishery Management Council (NPFMC), and the International Pacific Halibut Commission (IPHC), which sets the catch limit and coordinates the management of the Pacific halibut fish stocks for Canada and the U.S. (Hartley and Fina, 2001).

Road to a Catch Share

The commercial hook and line fishery for halibut began on a small scale in the 1880s. It grew greatly in the 1920s with the introduction of diesel-powered engines and mechanical longline equipment (Hartley and Fina, 2001), and soon after landings increased and stocks began to decline. From the 1920s through the 1980s, more and more vessels entered the fishery (many vessels entering part-time due to declining crab and salmon stocks) and effort continued to increase. Managers responded with various regulations and Canada and the U.S. coordinated efforts through the International Pacific Halibut Commission.

By the 1980s, overcapitalization had hit an extreme. The high number of vessels in the fishery led managers to implement stricter and stricter regulations causing an Olympic race for fish. In the final years before the catch share program, the halibut season was only open for a few days out of the calendar year, in which the commercial sector landed their entire catch limit, approximately 43 million pounds of fish (Pautzke and Oliver, 1997). While the stocks were not overfished, fishermen consistently exceeded the catch limits. Gear conflicts, ghost fishing (due to gear that is cut loose during the race for fish and left in the water continuing to kill fish), concerns regarding safety including deaths at-sea, low catch per unit of effort, declining product quality, and low ex-vessel prices were the norm (NOAA Fisheries Service, 2009f). In addition, regulations prohibited sablefish fishermen from landing halibut and vice versa, leading to significant discards of marketable fish.

In response to the severe failures of traditional management, managers and fishermen implemented a catch share program. The British Columbia halibut and sablefish fisheries had recently implemented a successful IVQ Program that provided a model for Alaska (see **Catch Shares in Practice: British Columbia Integrated Groundfish Program**). Alaska fishermen and managers identified a variety of goals that were important for their fishery, including biological goals outlined in the National Standards of the Magnuson-Stevens Fishery Conservation and Management Act and additional economic and social goals.

Performance

Fifteen years later, the program is successfully meeting its goals. Since fishing under the IFQ Program, fishermen rarely exceed their catch limits: No stocks are overfished and overfishing is not occurring. Bycatch has declined and ghost fishing has decreased substantially. Due to longline gear, seabird bycatch (including short-tailed albatross, Laysan albatross, northern fulmars, and shearwaters) had historically been a big problem in the fishery. However, with the slower seasons fishermen have been able to innovate, and the introduction of seabird excluder devices, such as streamer lines, has significantly improved the rate of seabird bycatch.

Dockside revenues have also increased under the IFQ Program. Under race conditions, fishermen would deliver the entire year's catch in very short windows of time, creating a glut and requiring processors to freeze most of the fish. Under the IFQ Program, fish are now landed over eight months and processors can deliver a fresh product to customers. By avoiding a glut and delivering a higher quality product, fishermen's dockside revenues have increased. In combination with decreased costs, fishermen now have more stable, profitable jobs.

Safety has also improved substantially since fishermen have more flexibility around when to go fishing. Just prior to the catch share program, search and rescue cases numbered in the 20s and 30s. By 2007, there were only five search and rescue cases, and in 2008, only three cases occurred (NOAA Fisheries Service, 2009f).

While some fishermen and crew have left the fishery following the IFQ Program, this outcome was expected due to the extreme overcapitalization under traditional management. Importantly, overcapitalization has been reduced while still meeting the program's goals in regard to maintaining historic fleet and participant structure (NOAA Fisheries Service, 2009f). Low concentration limits have prevented corporate ownership of the fleet and owner-on-board provisions for new participants have encouraged owner-operators (NOAA Fisheries Service, 2009f). Short-term, unstable, often low-paying jobs have been replaced with more stable, long-term, better-paying jobs. And, if the fishery had not transitioned to a catch share, it would have continued to face shorter and shorter seasons and potentially closures.

STEP 1 IN PRACTICE

Define Program Goals

Alaska fishermen and managers identified a variety of catch share program goals. These included meeting legal requirements of the Magnuson-Stevens Fishery Conservation and Management Act regarding stock sustainability and additional ecological, economic and social goals.

Biological goals prescribed in the National Standards (NS) One, Three and Nine of the Magnuson Stevens Fishery Conservation and Management Act (16 U.S.C. 1851):

NS1 - Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

NS3 - To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

NS9 - Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

The final ruling on the program said "The IFQ program is intended to resolve various conservation and management problems that stem from the current 'open access' regulatory regime, which allows free access to the common property fishery resources and has resulted in excess capital investment in the fisheries" (National Marine Fisheries Service, 1992). Additional goals of the IFQ Program were to keep the historic fleet structure of the fishery, limit and discourage corporate ownership, limit windfall profits to participants granted quota, discourage speculative entry, and reward participants who invested in the fishery (long-time participants and active participants) (Hartley and Fina, 2001). Furthermore, the NPFMC wanted to prevent quota from being owned strictly by large vessels that could possibly harm the smaller communities dominated by small boats (Pautzke and Oliver, 1997).

STEP 2 IN PRACTICE

Define and Quantify the Available Resource

Defining and quantifying the available resource was largely driven by pre-existing management structures, as laid out by the International Pacific Halibut Commission and the previously established Fishery Management Plan.

Halibut *(Hippoglossus stenolepis)* and sablefish *(Anoplopoma fimbria)* are the target species of this multi-species program. Both of the species are long lived (50 years for halibut and 90 years for sablefish), demersal species that live near the seafloor. Fishermen tend to target either halibut or sablefish in a trip, but can frequently encounter both species. Prior to the IFQ Program, fishermen targeting halibut were not allowed to land sablefish and vice versa. Since the species habitats do overlap, fishermen were discarding significant amounts of each species. In particular, halibut was the main discard species for sablefish fishermen. Grenadier, spiny dogfish and skates are also caught as bycatch in the sablefish fishery (Danner, 2008). What little bycatch there is in the halibut fishery consists mostly of groundfish species.

Managers designed the multi-species IFQ Program with an eye toward reducing bycatch. Most importantly, sablefish fishermen are permitted to hold halibut shares and keep the halibut they encounter; halibut discards have been substantially reduced under the IFQ Program (Pautzke and Oliver, 1997). In both fisheries, participants are allowed to retain certain amounts of groundfish species as bycatch (Smith, 2004). Community Development Quota (CDQ) fishermen are required to keep all sablefish and legal-sized halibut that they catch. Catcher-processor vessels may discard halibut if they do not have quota shares for it, however the proportion of halibut discarded to sablefish quota shares caught is relatively small and therefore bycatch rates have not been a concern.

The Fishery Management Plan identifies eight halibut zones and six sablefish zones based on biological stocks. Managers set a separate catch limit for each zone based on scientific advice, and the IFQ Program identified and allocated shares based on each zone. Fishermen are only allowed to use stock-specific shares to cover their landed catch in that area (Pautzke and Oliver, 1997).

STEP 3 IN PRACTICE

Define Eligible Participants

Defining eligible participants was an important part of meeting the program goals, including retaining the historical character of the fleet. There are many detailed provisions about who is permitted to participate in the program, and these stipulations informed initial allocation (discussed in more detail below), as well as requirements for new participants.

The program allocates privileges to both individuals and groups. The majority of shares are individually-allocated, but a portion of both halibut and sablefish shares were allocated to groups via the CDQ program, which was established in 1992 to provide western Alaska communities the opportunity to participate in the Bering Sea and Aleutian Islands fisheries. There are six regional organizations of CDQs comprising 65 communities. Every federal catch share program in the Bering Sea and Aleutian Islands is required to allocate shares to the CDQs.

One hallmark of the IFQ Program is the "owner-on-board provision" that requires shareholders to be aboard the vessel during fishing operations. It was designed to promote the owner-operator model prevalent in the fishery prior to the IFQ Program. Recognizing the different business models that existed at the time of implementation, initial shareholders are exempted from the provision and exempted owners may hire skippers to fish the IFQ shares if the skipper owns 20% of the vessel. Individual share owners are also required to be a U.S. citizen and sign the fish ticket (documentation of landings) upon landing (Pautzke and Oliver, 1997).

There are specific rules pertaining to corporations and partnerships. Notably, they can purchase catcher vessel shares only if they received shares during the initial allocation (Pautzke and Oliver, 1997). If new owners join a corporation or partnership, the entity must separate from its catcher vessel quota shares and sell those shares to a eligible individual (Smith, 2004).

Concentration limits are also an important design feature of this program. Many catch share fisheries use concentration limits, but the IFQ Program has identified particularly low caps. Vessels are subject to two different caps: the vessel IFQ cap, which limits how many pounds a vessel may land in a season, and the quota share use cap, which limits how many long-term shares a participant may hold. Some shares are designated as "blocked," meaning they cannot be subdivided for trading. Participants are not permitted to hold more than two blocked quota shares in a single management area (Smith, 2004).

Each management zone has limits on how much quota an individual is permitted to own, ranging from 0.5% – 1.5% of the total quota shares. Participants who exceeded the concentration cap at the time of implementation were grandfathered in at the levels indicated by their landing history during the eligible years (Pautzke and Oliver, 1997).

New participants can enter the fishery by buying or leasing shares. To be eligible to purchase shares, new participants must apply for and obtain a Transferable Eligibility Certificate issued by the North Pacific Region of National Marine Fisheries Service (NMFS). An applicant must be a U.S. citizen and show documentation of 150 days of commercial fishing experience in the U.S.

There are currently two special programs in support of new entrants: The North Pacific Loan Program, which helps finance new participants and shareholders with low quota holdings (Hartley and Fina, 2001, NOAA Fisheries Service, 2009f), and the Community Quota Entity (CQE) program, which helps select communities acquire shares.

Define the Privilege

The privilege was defined largely to maintain the relative structure of the fleet at the time of program implementation. The program includes numerous classes of shares, each with specified uses. The privilege is species-based, meaning participants are allocated secure shares of the catch limit for halibut and sablefish.

The long-term privileges, "quota shares," were granted indefinitely to initial shareholders and can be sold to eligible participants. Quota shares may be revoked as a penalty for non-compliance with regulations, and as with any management program, managers may change or end the program through the normal processes set out for management changes. If this occurs, shareholders will receive no compensation.

Participants' annual allocations are calculated at the beginning of each season. For each zone, the catch limit is multiplied by the participant's quota shares (both permanent and temporary holdings) and then divided by the total amount of quota shares held by all participants (Pautzke and Oliver, 1997). From this, shareholders are alerted of the IFQ permit weight, the annual allocation unit, that they are allowed to land during the season.

There are two main types of vessels in the fishery: catcher-processor vessels (also called freezer longliners) and catcher vessels, each with specified quota share categories (Pautzke and Oliver, 1997). Catcher vessels are further divided into size categories.

There are four vessel categories for halibut, including:

1. Catcher vessels less than 35 feet in length
2. Catcher vessels between 35 and 60 feet in length
3. Catcher vessels greater than 60 feet in length
4. Catcher-processor vessels

There are three vessel categories for sablefish, including:

1. Catcher vessels less than 60 feet in length
2. Catcher vessels greater than 60 feet in length
3. Catcher-processor vessels

The catch share program allows both permanent and temporary transfer of shares, but leasing in the fishery has been "very restricted" (NOAA Fisheries Service, 2009f). Quota shares can only be traded within their respective vessel class size, vessel operation mode and region. Each vessel class has particular rules on trading:

- Catcher vessels can only permanently transfer (i.e., sell) quota to "eligible buyers," which includes participants who received quota shares during initial allocation or people who obtain a Transferable Eligibility Certificate by

documentation of 150 days of commercial fishing experience in the U.S. Temporary leasing is not allowed in the catcher vessel class. Corporations and partnerships can buy catcher boat shares only if they received shares during the initial allocation (Pautzke and Oliver, 1997).

- Catcher-processor vessel quota shares can be temporarily leased and permanently transferred to any U.S. citizen.
- CDQ quota is not transferable; however CDQ quota holders can hire fishermen to fish their quota.
- All quota can be inherited by heirs upon the passing of the owner.

Furthermore, some shares are "blocked," meaning they cannot be subdivided during transfers. Blocked quota was developed, in part, to keep the price lower and more affordable for smaller shareholders and new entrants, and 15 years after the program, price per unit of blocked quota is slightly lower than unblocked quota (Dock Street Brokers, 2010).

Minimal inter-season trading is also permitted. Participants are not allowed to carry over unused quota, but in the event of overage, they are allowed to borrow up to 10% of the following year's share.

During the first three years of the program, catcher vessel shareholders were only allowed to lease 10% of their shares per year, and were not allowed to permanently sell shares (Pautzke and Oliver 1997). This was intended to prevent major changes to the fleet characteristics while participants began to understand how the program worked.

STEP 5 IN PRACTICE

Assign the Privilege

Initial allocation is often one of the most contentious parts of the catch share design process and requires careful attention. Following a thoughtful design process, in 1991 the North Pacific Fishery Management Council voted to implement the IFQ Program for the Alaska halibut and sablefish fishery. Upon approval, NMFS created the Restricted Access Management Division (RAM), comprised of approximately nine staff members, to determine the initial allocations for eligible participants and to administer the IFQ Program (Hartley and Fina, 2001). The allocation process took about one year to complete and occurred in 1994, a year prior to program implementation.

Vessel owners or leaseholders who made at least one commercial landing in 1988, 1989 or 1990 were eligible to receive initial share allocations (multiple years were chosen to accommodate disruption due to the Exxon Valdez oil spill). Eligible participants were granted shares based on catch history. Halibut share allocations were calculated based on participants' highest landings in five of seven years from 1984 to 1990; sablefish share allocations were calculated based on the best five of six years from 1985 to 1990.

RAM used landings data from existing NMFS records to calculate each eligible participant's share and mailed eligible recipients his/her estimated initial allocation and a quota application. The eligible participants were required to confirm the recorded data, complete the application, and send it back to RAM.

Eligible participants were allowed to appeal their estimated quota allocations by supplying RAM with proper documentation of the data in question. Acceptable documentation included fish tickets, leases or ownership papers (Hartley and Fina, 2001). Once RAM received the documentation, it went under technical review and the owner would be alerted of any changes in quota allocation within 45 days. If the RAM technical review did not result in any changes, participants could request a hearing with a NOAA officer in which they presented documentation in support of their cause. If the participant was still dissatisfied with the NOAA decision, they had the option to appeal to the federal court within 30 days.

Out of 9,000 applications for quota, about 8,000 were allocated shares (Hartley and Fina, 2001). Six hundred and fifty appealed their allocation calculation citing errors such as improper vessel category determination, basic eligibility to receive quota, size of allocation, etc. (Hartley and Fina, 2001). Following the technical review by RAM, 179 further appealed their cases and ultimately only 10 cases went to the federal court system for a final decision.

STEP 6 IN PRACTICE

Develop Administrative Systems

The RAM Division of NMFS administers the IFQ Program. RAM responsibilities include: determining eligibility and issuing permits, processing transfers, collecting landing fees and related activities. The systems used to administer the catch share program have evolved over time, especially as technology and access to the internet have improved.

Participants are held accountable for their landings and fishery information is largely collected via dockside monitoring. Shareholders are required to hail in/out and complete logbooks for each trip. At 16 main ports, NMFS agents perform comprehensive dockside monitoring of all landings, checking the actual landings against the shareholders' logbooks. At smaller ports, NMFS agents perform random checks. Fish buyers are required to have a permit and to report all purchases made from IFQ and CDQ vessels.

On average, the monitoring program requires 30% onboard observer coverage. Vessels smaller than 60 feet and halibut vessels do not require observer coverage. Coverage levels for other vessels vary by vessel size, type and gear. Vessels larger than 125 feet are required to have observer coverage 100% of the time (North Pacific Fishery Management Council, n.d., B.)

Participants use eLandings (landings.alaska.gov), an interagency electronic reporting system for all commercial fishery landings in Alaska, to record and track halibut and sablefish landings. The website is the preferred system for administration and will soon replace the landing reporting function on the NMFS web application. The website is managed by Alaska Department of Fish and Game, the International Pacific Halibut Commission

and NOAA fisheries. Access to both of the systems is free and available to any vessel owner with an IFQ permit. Websites are housed in the NMFS Alaska Regional Office website.

Throughout the year, participants enter information on the NMFS web application, which deducts the trip landings from their annual quota pounds. The system is also used to track vessel quota balances, print receipts for past landings, create an ex-vessel value and volume report, renew buyer permits, check permit balances, pay cost recovery fees, review IFQ landing ledger reports, review registered buyer landing ledger reports, and produce a quota share holdings report (NMFS Alaska Regional Office, n.d.B).

If a participant exceeds his/her shares by 10% or less, they may "borrow" shares from the following year to cover their overage. If a shareholder exceeds his/her quota by more than 10% on the last trip of the season, they may be subject to fines and suspensions. In severe cases, the government may revoke a participant's shares.

Design and implementation of the IFQ Program cost approximately $2 million and was paid for by the NMFS budget (Hartley and Fina, 2001). In 2001, a cost recovery fee program was implemented as authorized by the Magnuson-Stevens Fishery Conservation and Management Act. The program requires shareholders to pay a maximum of 3% of the ex-vessel value of IFQ landings to cover the incremental administrative management costs due to the catch share program, such as facilitating transfers, enhanced enforcement, etc. Cost recovery fees are calculated annually, and fishermen have never paid more than 2% of the ex-vessel value of the landings. Enforcement for the fishery costs about $2.3 million per year and in 2008, $1.1 million was spent on administration of the fishery (NOAA Fisheries Service, 2009f; Hartley and Fina 2001). When the cost recovery program was initially implemented, some collected revenues funded the North Pacific Loan Program; however, all collected fees now pay for management costs. Fishermen who are required to have an onboard observer pay those costs directly.

STEP 7 IN PRACTICE

Assess Performance and Innovate

The program has gone through numerous innovations over the years. In fact, the program has been officially modified 39 times since initial implementation (NMFS Alaska Regional Office, 2010b). These have included modifications to trading restrictions, eligibility rules, administrative catch accounting systems and more.

One notable innovation occurred in 2004, 13 years after program implementation. The Council created the Community Quota Entity (CQE) program, which authorizes non-profit organizations to purchase and use annual IFQ for a council-approved list of 42 communities, including Old Harbor, Craig, and Sand Point (Smith, 2004). This program is designed to provide these communities with secure access to the fishery and a valuable asset (North Pacific Fishery Management Council, 2010). CQEs must comply with specific rules including restrictions on concentration. For example, CQE is not subject to vessel class sizes, but there are limitations on how much quota they can hold. Each CQE is responsible for determining the use of their quota shares including eligible fishing participants. It is still too early to assess the performance of this special program, but it shows how managers and fishermen were able to innovate over time.

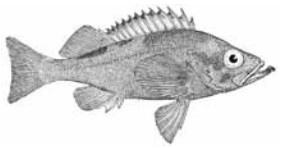
PHOTO: WES ERIKSON

SEASALT

- Secure
- Exclusive
- All sources
- Scaled
- Accountable
- Limited
- Transferable

CATCH SHARES IN PRACTICE

British Columbia Integrated Groundfish Program



SPECIAL DESIGN FEATURES

MULTI-SPECIES, INDIVIDUALLY-ALLOCATED, SPECIES-BASED, TRANSFERABLE

The British Columbia Integrated Groundfish Program (Integrated Program) is one of the most comprehensive catch share programs in the world. The multi-species program includes over 70 species, 30 of which are managed via quota, and includes all commercial fishermen targeting groundfish, regardless of gear type. The program includes a number of innovative design features such as quota set-asides, which are meant to encourage community development and incentivize positive treatment of crew. Additionally, the program requires 100% individual accountability of all catch and uses an innovative monitoring and catch accounting system to support accountability.

SYNOPSIS

The British Columbia groundfish fishery has a 20-year history with catch shares: The first catch share program was implemented in 1990 for the sablefish *(Anoplopoma fimbria)* fishery, followed one year later by the halibut *(Hippoglossus stenolepis)* fishery. In 1997, the groundfish trawl fishery implemented an IVQ Program, and in 2006, managers implemented the Integrated Groundfish Pilot Program that combined the halibut, sablefish and groundfish trawl programs and incorporated all commercial hook and line caught rockfish, lingcod *(Ophiodon elongates)* and dogfish *(Squalus acanthias)* into one overarching program. The overarching program was made permanent at the start of the 2010/2011 season and is what we refer to in this case study as the Integrated Program.

The fishery occurs off Canada's west coast and is managed by Fisheries and Oceans Canada (DFO), with joint management of halibut stocks by the International Pacific Fisheries Commission. Fishermen use hook and line, traps and trawls to harvest over 60 stocks of groundfish. The total value of groundfish landings was $124 million in 2007 (Fisheries and Oceans Canada, 2009a).

Road to a Catch Share

Until the late 1970s, there was little management of marine resources in the waters off British Columbia. The groundfish fishery was open to domestic and foreign fleets, and by the mid-70s, stocks had started to decline (e.g., in 1974 halibut landings were just one third of the averages in the 1960s). In response, managers began implementing a variety of traditional management measures including limited entry licensing, annual catch limits, fishery closures, and gear and vessel restrictions.

Fishing licenses were largely based on the vessels' target species. For example, fishermen targeting halibut were required to have a halibut license while fishermen targeting sablefish were required to have a sablefish license. Fishermen who did not hold the appropriate license were not permitted to land those species. In actuality, fishermen were encountering multiple species and were therefore required to discard large amounts of marketable species.

From 1980 to the early 1990s, the capacity and ability of the fleet to catch fish increased dramatically. In 1980, the commercial halibut fleet harvested 5.7 million pounds of halibut in 65 days; in 1990, fishermen harvested 8.5 million pounds in six days (Sporer, 2001). In every year from 1979 to 1990 (except 1980), the halibut catch limit was exceeded and a race for fish resulted in shorter seasons, unsafe fishing conditions, large quantities of discards, poor quality of fish and inconsistent supply of fresh fish (and corresponding low dockside prices).

The experience was similar in the sablefish and groundfish trawl fisheries. In fact, the groundfish trawl fishery was closed in 1995 due to severe overharvesting of the catch limit and the inability of managers to ensure compliance with catch limits (Sporer, 2001). The system failed to ensure sustainability leading to depletion of fish stocks, and the economic viability of the fleets and communities that depended upon them was decreasing.

The 1990s marked a time of widespread change. In response to the failures of traditional management, and often upon request of the fishermen, catch share programs were implemented in the sablefish, halibut and groundfish fisheries in 1990, 1991 and 1997, respectively. The halibut and sablefish programs were initially implemented as trial programs, but they were formalized shortly thereafter, upon meeting identified conservation and economic goals (Sporer, 2001). In 2006, the remaining groundfish fleet (mostly hook and line vessels) were introduced into the program and all commercial fisherman targeting groundfish (including halibut and sablefish) were integrated into a single catch share program.

Conservation and protection of fish and fish habitat is the first goal of Canada's fishery management. Following this mandate, additional goals include compliance with regulations, secure and stable access for fishermen, fairness to individuals and groups, promotion of historical participation, economic viability, best use of the fish for economics, social and cultural needs, and assuring public access.

Performance

The catch share program is successfully meeting its goals. Fleet-wide catch limits are rarely exceeded, bycatch rates have been substantially reduced, revenues and profits have increased, season length has increased and jobs are more stable (Munro et al., 2009; GSGislason and Associates, Ltd., 2008). The catch share program has a robust system of individual accountability which has ensured catch limits are not exceeded and stocks are doing well. No species in the groundfish complex are designated under the Species at Risk Act, meaning no species require special management attention (Fisheries and Oceans Canada, 2009a).

Bycatch had previously been a substantial problem in the groundfish fishery, especially because fishermen were often required to discard perfectly marketable species that were caught as bycatch, i.e., directed sablefish fishermen discarded halibut due to regulations. One primary impetus for integrating all groundfish species under one management plan was to reduce discards, and the system has been largely successful in accomplishing this goal.

As of 2007, there were over 300 active licenses in the British Columbia Groundfish fisheries. Close to 200 of these were used to operate in the halibut fishery with the remainder spread out fairly evenly over the other fisheries (Turris, 2009). Most vessels are multi-licensed and can participate in several fisheries (i.e., a vessel will have all the necessary licenses to fish halibut, sablefish, rockfish, lingcod and dogfish by hook and line gear).

STEP 1 IN PRACTICE

Define Program Goals

General objectives of management for the groundfish fishery are to ensure sustainability, economic development and equity. More specific objectives have been outlined for the management of some groundfish species in each management plan.

Overarching goals for the Integrated Program included conservation of fish stocks, increased benefits from the groundfish fishery, and a fair distribution of benefits arising from the Integrated Program. Specifically, the management objectives outlined prior to development of the Integrated Program are:

- Maintain the existing processing capacity
- Stabilize employment in the fishery
- Encourage economic development in coastal communities
- Ensure the fair treatment of crew
- Allow for controlled rationalization of the fleet
- Minimize the negative consequences associated with the leasing and concentration of quota shares (Sporer, 2001)

DFO developed five additional objectives prior to the integration of all stocks into IVQs in 2006 (Fraser, 2008):

1. Account for all rockfish catch
2. Manage rockfish catch according to established rockfish management areas
3. Require fish harvesters to be individually accountable for their catch
4. Implement new monitoring to ensure above objectives
5. Examine species and stocks of concern and take action for precautionary management

STEP 2 IN PRACTICE

Define and Quantify the Available Resource

One important design feature of the Integrated Program is the coordinated management of all species and fishermen. There are over 70 marine species under management in the groundfish fishery, 30 of which are managed through the allocation of quota shares.

Many of the species in this fishery have multiple biological stocks, which were reflected in previous management plans as eight designated Groundfish Management Areas (Fisheries and Oceans Canada, 2009b). These were maintained in the Integrated Program and there are 60 species and area combinations with distinct catch limits and quota allocations for each. Catch limits are set annually by each species-area combination and are based on scientific advice provided to managers at the Department of Fisheries and Oceans. Where available, stock assessments are used to set catch limits consistent with government policy on precautionary management. Compliance with catch limits is extremely high.

Fishermen do catch some species that are not included in the Integrated Program, mostly traditionally un-marketable species, and there is some concern regarding the discards of unmanaged species and other species of concern (Driscoll et al., 2009). For example, prior to 2004, fishermen in the groundfish trawl fishery were allowed to land and sell bocaccio (*Sebastes paucispinis*) (a species with no catch limit), resulting in high catches. In 2004, DFO and industry agreed that all bocaccio landings would be relinquished and the proceeds from sales would be used to conduct research on the species. This policy resulted in little economic incentive to target, catch and retain the species: Total catch, which includes landings and discards, has declined by more than 50% but there has been an increase in discards (Driscoll et al., 2009). The program is expected to continue to evolve and further improve management. This highlights the importance of having a catch limit and allocating quota for encountered species.

Define Eligible Participants

Eligibility to participate in the catch share program has been primarily driven by historical participation in the fishery. Shares in the Integrated Program can be held by individual participants owning licensed vessels in one or more of the seven directed groundfish fisheries. Only licensed commercial groundfish vessels and/or fishermen are permitted to hold and fish shares.

The Integrated Program includes a number of concentration limits to prevent over-consolidation in the fishery. Concentration caps vary based on the needs of the participants for each fishery. Some are set lower to protect sectors that may be more vulnerable to extensive leasing or sale outside of the sector, while others are set higher to ensure that participants can operate at levels that are profitable. There are caps on trades between individuals and separate caps on trades between sectors (e.g., halibut trading to groundfish). Furthermore, there are identified limits for the long-term share, IVQ, and the annual allocation units for a number of species, areas and sectors.

The majority of individual concentration caps are based on percentage of holdings, although some caps limit weight. Individual species concentration caps in the groundfish trawl fishery are based exclusively on a percent of the catch limit and range from 4% – 15% depending on the species. Caps on directed dogfish are set on a weight basis, while directed dogfish shareholders are also subject to caps on all other species, determined as a percent of dogfish IVQ holdings (the caps range from 0.04% – 5.80%). Weight-based caps are also used in the directed rockfish fishery, for non-halibut species in the halibut fishery, and for non-sablefish species in the sablefish fishery. In the sablefish fishery, there is no concentration cap on temporary or permanent transfers, so a single participant could technically own or lease 100% of the quota, although this has never happened and the average quota holdings are around 3.22% (Fisheries and Oceans Canada, 2010b).

Individuals who were not initially allocated shares generally lease or purchase shares to enter the groundfish fishery. Special programs also exist to provide access for members of First Nations communities. Under one program, existing shareholders can offer licenses and quota to DFO for a self-identified price and DFO can choose to purchase or not. If DFO purchases the license from commercial operators, they issue equivalent community-held communal licenses to First Nations. From 2007 to 2009, the government spent 50.3 million Canadian dollars (U.S. $47.55 million) to acquire 6.43% of the commercial halibut catch limit, 4.77% of the sablefish catch limit, 0.24% of the groundfish trawl catch limit and 44 commercial licenses for groundfish (31 of which were halibut licenses) (Fisheries and Oceans Canada, 2009c). In addition, the recreational fishery has leased some quota from commercial halibut shareholders on an annual basis to address increasing harvests in the recreational fishery.

Define the Privilege

In order to meet the myriad program goals, managers carefully defined the privilege. At its most basic, the program uses a species-based privilege that allocates secure shares of the total catch for a number of species. However, there are a number of unique rules on trading that vary by gear type and target species. Some of the complexity relates to how the different fisheries were integrated over time.

The sablefish, halibut and groundfish trawl privileges are granted annually with a very strong presumption of renewal. The newly integrated sectors including rockfish, lingcod and dogfish began management under a three-year Integrated Groundfish Pilot Program in 2006, a program that was made permanent starting in 2010.

The Integrated Program allocated long-term shares, IVQ holdings, which are a percentage share of the total catch limit for each species-area designation. At the beginning of each season, shareholders' annual allocation units, or IVQ pounds, are calculated by multiplying the yearly catch limits by participants' IVQ holdings.

Participants are allowed to permanently and temporarily transfer shares, but there are numerous limitations. Under full integration, regulations regarding transfers between sectors were developed and established and complexity of the rules regarding transferability of quota has increased.

The trading rules are mainly focused on maintaining sector-specific allocations and limiting concentration of quota into one sector. Within the halibut, sablefish and groundfish trawl sectors, permanent transfers are allowed (i.e., halibut within halibut sector, sablefish within sablefish sector, and groundfish within groundfish trawl sector).

Shareholders are allowed to carry over and borrow limited amounts of quota pounds from adjacent fishing years for select species. The permitted amounts are specific to each species. For example, for some species a shareholder may carry over 30% of his/her quota pounds; whereas other species are limited to 10%. Participants are allowed to "borrow" a limited amount of quota from the following year if they exceed their IVQ pounds and are unable to purchase additional quota pounds.

Transfers between the recreational and commercial sectors have also occurred in the halibut fishery. Prior to the 2004 and 2005 seasons, the recreational industry was not catching all of the recreational halibut catch limit, and the commercial industry wanted to access that fish. The government allowed the commercial industry to create a non-profit organization that could lease recreational catch limits. Through this arrangement, the commercial sector leased close to 320 metric tons, generating 1.8 million Canadian dollars (U.S. $1.7 million) for a fund set up on behalf of recreational fishermen. More recently, the recreational sector has been interested in leasing shares from the commercial sector. In 2009, a letter was issued by the Sport Fishing Advisory Board soliciting commercial fishermen who might be willing to lease quota to the recreational sector. The recreational sector has 1.8 million Canadian (U.S. $1.7 million) dollars from the previous deals to use toward leasing commercial quota.

All four programs limited quota transfers during a transition period. Initially, no halibut shares could be transferred to another halibut vessel, essentially prohibiting any consolidation of quota. By 1999, quota was freely transferable (temporarily and permanently) as long as no single halibut vessel held more than 1% of the catch limit (certain vessels with higher historical harvests were grandfathered in and exempted from the limit) (GSGislason and Associates, Ltd., 2008). Both permanent and temporary transfers are allowed within each sector, subject to concentration caps (GSGislason and Associates, Ltd., 2008). The Integration Program only allows temporary transfers between sectors and prohibits permanent reallocations of IVQ holdings. Over time, less stringent restrictions on quota transfers within and between sectors may be considered.

STEP 5 IN PRACTICE

Assign the Privilege

There have been four cases in which quota shares have been allocated in the British Columbia groundfish fisheries: sablefish (1990), halibut (1991), groundfish trawl (1997), and during the integration process for rockfish, lingcod, and dogfish (2006). Initial allocation of shares varied for each sector, but many common approaches were used. Both fishermen and managers played a role in the allocation process and all allocations have occurred after program development. All initial allocation privileges have been granted, rather than auctioned, to eligible participants.

Sablefish was the first fishery to implement IVQs. DFO originally proposed IVQs in 1984, but fishermen rejected the idea. In anticipation of the 1990 fishing season, which was projected to last just eight days, an industry group asked DFO for a quota program. Throughout 1989 DFO consulted with an industry advisory body, the Sablefish Advisory Committee (SAC), and after several meetings DFO distributed a survey with an outline of the trial catch share program and proposed allocations for each license-holder. Ninety-five percent of respondents supported the proposal and an IVQ Program was introduced in 1990, nine months after the initial request by industry (Sporer, 2001).

The halibut fishery followed a similar approach, except DFO established the Halibut Advisory Board (HAB) comprised of license holders, processors, First Nations and union representatives to determine initial allocation of quota shares. Many proposals were put forward, including equal shares, pounds based on vessel length, auctions and shares based on the number of crew employed. After a four-day deliberation, the HAB nearly unanimously agreed on an initial allocation formula (Sporer, 2001). The allocation formula was voted on by halibut license holders as part of an overall IVQ proposal. Seventy percent of respondents voted in favor of the IVQ proposal.

In late 1995, industry representatives and DFO began discussing changes to the management of the groundfish trawl fishery and developed a paper outlining six management options. Participants agreed on pursuing the IVQ approach. Following these discussions, DFO hired a retired Supreme Court justice as an independent arbitrator to recommend the initial allocation formula. Following a public process including hundreds of comments, the judge

submitted recommendations that were ultimately approved. After 14 months of negotiations, the IVQ Program was introduced in 1997.

The primary eligibility requirement for initial share allocations was a groundfish-specific license. All initial grantees were required to have a license and eligibility was limited to licenses that directly targeted species within each fishery (e.g., sablefish license holders were eligible for sablefish IVQ, halibut license holders were eligible for halibut IVQ, and groundfish trawl license holders were eligible for groundfish IVQ species).

Under the integration program, certain license holders were eligible for lingcod and dogfish IVQ allocations if they had landed a total of 1,000 and 3,000 pounds, respectively, from 1996 to 2003. To receive rockfish allocation, eligible participants were required to hold Inside or Outside Rockfish licenses. In addition, halibut license holders were eligible for allocation of rockfish quota.

The initial allocation formulas were largely based on catch history or catch history and vessel length. Some shares were also allocated based on equal sharing (e.g., to certain license categories). In the sablefish, halibut and groundfish trawl fisheries, initial share allocation was based 70% on catch history and 30% on vessel length. These data were easily available through fish slips, dockside landings report data and license information.

The sablefish allocations were calculated on the license holder's best annual catch from 1988 or 1989. Both halibut and groundfish trawl allocations were based on catch history from 1986 to 1989. To accommodate all of the species in the groundfish trawl fishery, the allocation formula applied to hake *(Merluccius productus)* landings and separately to an aggregate of non-hake landings. Individual holdings were then calculated into groundfish equivalents. The resulting percentage for hake landings is applied to the annual catch limit for hake, while the non-hake IVQ percentage is applied to all species-area combinations to determine specific quota pounds for each species-area.

Lingcod and dogfish were allocated to eligible license holders based on catch history from 1996 to 2003. Rockfish species were allocated to eligible license holders in different manners, dependent on the license. Fishermen targeting species under an Inside or Outside Rockfish license were allocated equal shares of the numerous species annually. Halibut license holders were allocated rockfish IVQ as a percentage of their halibut holdings. This is calculated for each rockfish species-area combination (Fisheries and Oceans Canada, 2009b).

In addition, both groundfish trawl and dogfish implemented hold-back programs: 80% of the total groundfish trawl shares were allocated to eligible participants and the remaining 20% is held by the government and the IVQ pounds from these quota shares are allocated annually based on recommendations by the Groundfish Development Authority (GDA), which consists of representatives from communities, crew and shoreworkers, processors, groundfish trawl license holders, First Nations, and a non-licensed individual. The GDA oversees Groundfish Development Quota (GDQ) and Code of Conduct Quota (CCQ), each equaling 10% of total shares. These shares are allocated annually based on certain criteria, including treatment of crew and co-applications by processors and harvesters (Sporer, 2001).

GDQ allocation is intended to aid in regional development of coastal communities, attain employment objectives, and encourage sustainable fishing practices. CCQ was developed to ensure fair treatment of crew and safe vessel operation. CCQ is allocated to each vessel according to its particular quota holdings unless a complaint has been made and confirmed regarding treatment of crew. In such cases, the offending vessel would not receive any or a portion of its CCQ (Groundfish Development Authority, 2007). While the CCQ program has provided some benefits, critics worry that crew have little incentive to report poor treatment because it reduces the amount of quota for the vessel, therefore impacting the crew members' earnings, and some crew fear being blacklisted. As of 2005, there had been no formal complaints filed affecting CCQ for the groundfish trawl fleet (Grafton et al., 2005).

Similar to the Groundfish Development Quota, 10% of dogfish shares are held back for Dogfish Development Quota. Processors and licensed vessels are allowed to submit annual applications for this quota, and the Dogfish Development Committee makes recommendations for how to allocate the shares.

DFO established an official appeals process for all IVQ fisheries in regard to allocation. For halibut and groundfish trawl, specific review boards were established. The halibut board recommended changes to 30 participants' allocations based on their findings. The allocation for the entire fleet was then recalculated. A similar process for appealing data errors was conducted for the groundfish trawl fishery and the integration of the other sectors.

STEP 6 IN PRACTICE

Develop Administrative Systems

Individual accountability of all catch, landed or discarded, is a primary goal of the catch share program. The administrative systems are designed to account for all fishing mortality, ensure compliance and collect scientific data. All groundfish fisheries are subject to a robust monitoring program that includes logbooks, a hail system, 100% dockside monitoring and 100% at-sea monitoring. Catch accounting occurs at the end of each fishing trip.

Electronic monitoring, onboard observer, and dockside monitoring services are provided by private companies that are contracted by individual vessel operators, specific fleets or the government (McElderry, 2008a). Vessels are required to hail in/out at the beginning and end of every trip, primarily to coordinate the at-sea and dockside monitoring personnel.

The 100% at-sea monitoring requirement is fulfilled differently for various sectors. The majority of the groundfish trawl fleet uses onboard observers to observe all fishing events including landings and discards. The hook and line, trap, mid-water trawl for hake, and the small inshore groundfish trawl fishery use an audit-based electronic monitoring system that includes two or more cameras, a GPS system, a winch sensor, and a hydraulic pressure sensor that monitors the use of fishing gear. Fishermen are required to keep accurate logs of all trips and 100% of the fishing events are recorded, but only 10% of the fishing events for each trip are audited at random. Auditors

compare the logbooks to the video for accuracy. The data analysis is used to reconcile all catch information against the vessels' IVQ pounds. Within seven days, a quota status report is then sent to each vessel's contact.

Dockside monitors observe all offloads to verify the weight of all landed fish on a species-specific basis. This is then deducted from the vessel's annual IVQ pounds. Every landed halibut must be tagged by an observer at the offloading location to reduce illegally caught halibut from entering the market and to facilitate marketing British Columbia halibut as a distinct, high quality product. If a quota owner exceeds the allocated annual quota pounds for a species, they are prohibited from fishing until they either purchase additional quota pounds or borrow from the next year's allocation.

The "overage level" varies by target species and licenses being used. Directed and non-directed IVQ species have different "overage levels," and the level is either a set percentage of an individual IVQ holding or an absolute weight limit. For example, a shareholder in the lingcod fishery has incurred an overage if he/she exceeds his/her total directed lingcod IVQ pounds by more than 10% or 100 pounds. An overage can also occur if a shareholder exceeds his/her annual IVQ species cap. Any vessels that have landings in excess of the IVQ pounds for any species are given a Quota Status Verification Number (QSVN) that is then used during the hail-out for their next trip. Vessels are allowed one trip to clear excess overages on non-directed species.

Following integration of the groundfish sectors, there has been an increase in the complexity around trading quota. Potential buyers, sellers, leassors and leasees have to be cognizant of the prices, supply and demand within their sector, and of the rules on trading of species between sectors. The complexity of the restrictions has also increased, with inter-sector caps on quota, and some prohibitions on permanent transfers. To help facilitate this market, some privately-operated quota brokers have developed. They help facilitate voluntary trades by identifying willing buyers and sellers and matching them up. Some brokers also provide services for trip planning, quota status updates and fishing logs (Integrated Quota Management, Inc., 2009).

Industry and government share the costs of management. Private companies serve as designated service providers for at-sea, electronic, and dockside monitoring, while the government takes on the majority of the roles for catch accounting and management. IVQ holders arrange and pay for all direct costs of monitoring including at-sea and dockside monitoring services.

The aggregate monitoring costs for groundfish fisheries are around 5% of the fishery value every year (McElderry, 2008b), but costs vary by fishery and fleet. Costs are around 3% of the total landed value for the hook and line fleet and slightly higher for the groundfish trawl sectors. The costs are lower for the hook and line fleet mostly due to the use of electronic monitoring (EM) instead of onboard observers; daily cost of EM is approximately 154 Canadian dollars (U.S. $146) versus 558 Canadian dollars (U.S. $527) for onboard observers (McElderry, 2008b). Fishermen also pay minimal annual license fees.

In the sablefish fishery, the Joint Project Agreement between DFO and Wild Canadian Sablefish (an industry group) dictates the financial responsibilities of industry and management. The 2009/2010 plan specifies that industry will pay 1.5 million Canadian dollars (U.S. $1.42 million) for fishery monitoring, science and stock

assessment, and some management costs. Costs for administration, salaries of government employees, and patrol vessels and aircraft are covered by DFO.

STEP 7 IN PRACTICE

Assess Performance and Innovate

There have been two major innovations in the catch share program used in the British Columbia groundfish fisheries. First, integrating all sectors into one overarching catch share program ensured total accountability for the entire BC commercial groundfish fisheries. Second, managers and fishermen were able to develop a flexible, innovative system that accounts for different species and different fishing business models. Along with this innovation, partners were also able to develop a comprehensive monitoring program that would work for a variety of different vessels. This included new technology and applications to provide a variety of solutions to meet the needs of vessels. Managers and fishermen continue to innovate in order to enhance biological, economic and social outcomes.

PHOTO: SCOTT EDWARDS

SEASALT
Secure
Exclusive
Scaled
Accountable
Limited

CATCH SHARES IN PRACTICE

Chilean National Benthic Resources Territorial Use Rights for Fishing Programme

SPECIAL DESIGN FEATURES

MULTI-SPECIES, GROUP-ALLOCATED, SPECIES AND AREA-BASED, NON-TRANSFERABLE

Among the largest species and area-based catch share programs in the world, the Chilean National Benthic Resources Territorial Use Rights for Fishing Programme (TURF Programme) includes over 17,000 artisanal fishermen co-managing over 550 distinct areas along the coast. The voluntary system primarily manages loco, Chile's most valuable mollusc, and provides secure access to benthic resources to groups of artisanal fishermen. Management is built on science performed by universities and consultants, resulting in co-management by the government, industry and the private sector.

SYNOPSIS

In 1991, Chile began implementing one of the largest species and area-based catch share programs in the world. The program focuses on managing the artisanal small-boat fishermen targeting nearshore benthic resources, specifically loco, the Chilean abalone. Through the program, established groups of fishermen from sanctioned "caletas," or coves, are granted exclusive access to publicly owned benthic resources via an area concession called Management and Exploitation Areas of Benthic Resources, commonly referred to as Territorial Use Rights for Fishing (TURFs) (Gallardo Fernández, 2008). Loco must be managed within a TURF and numerous other species are also eligible for exclusive use rights within the system.

Chile's TURF Programme currently includes over 550 uniquely managed TURFs spanning Chile's 2,500+ mile coastline.[7] Not all portions of the marine area are currently managed via TURFs, but much of the coast is eligible to participate in the TURF Programme. In 2004, around 5,000 metric tonnes of loco were landed under the TURF Programme and the export value for loco was U.S. $55 million. A number of government agencies oversee management of the TURF Programme including the Undersecretary of Fisheries, or Subsecretaria de Pesca (SUBPESCA), the National Fishing Service, or Servicio Nacional de Pesca (SERNAPESCA) and 13 regional fishing councils and five Zone Fishing Councils, or Consejos Zonales de Pesca.

7 Each TURF is managed independently, but must abide by the regulations set forth by the government. Collectively, they are referred to as the TURF Programme.

Road to a Catch Share

The loco *(Concholepas concholepas)*, a sea snail also known as the "Chilean Abalone," is Chile's highest value mollusc species and important for artisanal fishermen, who have been harvesting loco for decades. In the mid 1970s, a loco export market developed and shortly thereafter stocks began to rapidly decline. From 1981 to 1992, managers implemented numerous traditional management approaches, including season limits and catch limits, with little success. Catch limits were continually exceeded by large amounts, and seasons became shorter and shorter. In 1990, managers implemented a total closure on the loco fishery for two years.

In response to localized loco stock depletion, some fishermen and marine ecologists instituted informal TURFs as early as 1988. They rotated exploitation through experimental no-take zones and open areas and called the program Natural Shellfish Restocking or Repopulation via Rotational Exploited Areas. These fishermen regulated the areas themselves and were exempted from the loco total closure of 1990 to 1992.

Primarily to address the rapid decline in loco, the government implemented a General Fishing Law in 1991 that requires fishermen to harvest loco within an established MEABR or TURF. Rather than implementing TURFs from the top down, the law created a voluntary application-based system with three main components. First, the government identified a series of eligible land-based caletas or coves. Second, groups of fishermen, mostly residing in these caletas, are eligible to apply to the government to manage the adjacent benthic resources via exclusive access. The application process requires, among other things, an independent scientific assessment of the resources in the area, with particular attention to loco. Finally, upon review, the government grants a TURF to the fishing group for their exclusive use and requires them to co-manage the resources with the government, consultants and/or universities. The ban on loco fishing outside of TURFs provides a strong incentive for fishermen to form or join organizations and apply for official recognition.

Performance

More than 10 years after implementation, the catch share program is meeting many of its goals. Importantly, the TURF Programme has also been successful in assuring access for the artisanal sector and improving knowledge of the resources. Over 17,000 artisanal fishermen participate in the catch share program and every TURF is required to conduct regular stock assessments. Furthermore, landings have increased as much as five-fold, the mean sizes of individual organisms has increased, catch per unit effort is up (Castilla and Gelcich, 2008), and some fishing organizations have established no-take areas (areas in which fishing is prohibited) to enhance spawning within their TURF.

The program has challenges and managers are fine-tuning certain aspects. For example, some overharvesting and illegal harvesting does still occur, especially in open access areas and by fishermen who are not within the established caleta and TURF. There have also been instances where fishermen modify their TURF to obtain the maximum revenue possible, including systematically removing predators (Castilla and Fernandez, 1998),

seeding the area with target species taken from other locations and intentionally leaving loco prey species within the system (Castilla and Gelcich, 2006). In response, the government has clarified that resources may only be brought into the TURF once, during its formation (Castilla and Gelcich, 2006), and issued a Regulatory Decree that states that predators should not be removed so as "not [to] inflict negative impacts on [the] environment" (Castilla and Fernandez, 1998).

STEP 1 IN PRACTICE

Define Program Goals

Managers and legislators identified a variety of goals – biological and ecological, economic and social – when developing and implementing the TURF Programme. The Undersecretary of Fisheries (SUBPESCA) identified the following key program goals (Gallardo Fernández, 2008):

- Contribute to the conservation of benthic resources
- Contribute to the sustainability of artisan economic activity
- Maintain or increase biological productivity of benthic resources
- Increase knowledge of the functioning of benthic eco-system
- Generate useful information for management
- Promote participative management

The goals were informed by the experimental no-take zones and marine preserves, which resulted in natural restocking of benthic resources. Furthermore, managers recognized the need to alleviate the pressure of migrating fishermen on localized productive benthos (Castilla and Gelcich, 2006; Gelcich et al., 2009) and from an administrative point of view, desired to decentralize fisheries management (Gallardo Fernández, 2008).

STEP 2 IN PRACTICE

Define and Quantify the Available Resource

The catch share program was developed primarily to manage loco, Chile's most economically important benthic artisanal resource. Loco are required to be managed via the TURF Programme and most TURFs target loco. However, all species found within a TURF can be included in the official management plan and extracted by members of the associated fishermen's organization (Castilla and Fernandez, 1998).

Most of the TURFs are multi-species, in which the management plan identifies more than one species that fishermen are able to harvest. At least 63 species including molluscs, algaes, crustaceans, finfish and other invertebrates are landed under the TURF Programme. Other than loco, the most common species in the catch

share program are "lapas," several species of key-hole limpets; the "erizo," or red sea urchin *(Loxechinus albus)*; and a sea snail species. Of the officially sanctioned management plans, 80% include loco, 70% include lapas and 30% include erizo (Castilla and Gelcich, 2008). While 100% of legally caught locos are under the catch share program, only 5% of the lapas and 1% of the erizo landings come from TURFs.

The TURF and caleta system occurs intermittently along the entire coast of Chile and has already granted exclusive access to over 100,000 hectares through a series of area concessions (Castilla and Gelcich, 2008). In 1998, the government established an official list of permanent coves or caletas. Any fishing association within one of the official caletas is eligible to establish a TURF. There are already over 550 TURFs from 453 different permanent coves (some coves have more than one TURF and others are only "temporary coves"). Each TURF averages about 100 hectares in size and encompasses all or part of geologically delineated caletas (small bays). Most TURFs occur on state property, which makes up 56% of the Chilean coast, primarily in the northernmost and southernmost regions in Chile.

Most artisanal fishing activities occur outside the catch share program, although all loco, Chile's most valuable benthic species, must be caught within the system. Some official coves have not yet started or completed the application process, and there are areas that have purposefully been left as open access and are fished by fishermen who are members of organizations managing nearby TURFs and by fishermen who do not participate in the catch share program.

When a fishing organization from a sanctioned caleta applies for a TURF, they are required to submit an initial baseline study of the claimed area, including population assessments for species requested for harvesting. This study is conducted by an external consultant and used to establish the catch limit, when possible, for requested benthic species. A catch limit is required for loco and the Undersecretary of Fisheries confers final approval of the TURF only after scientific recommendations are made. Every fishing organization granted a TURF is required to conduct yearly follow-up assessments of stocks in the management area to assess the species' health, adjust catch limits and determine if species without catch limits are still open for fishing. Indicators such as declining catch per unit effort, disappearance of an indicator species and social cues such as amount of infighting amongst members (Molyneaux, 2007) are used to manage species in the TURF that do not have an established catch limit.

STEP 3 IN PRACTICE

Define Eligible Participants

Defining eligible participants was an important aspect for meeting the goals of the catch share program. The program is exclusively designed to manage artisanal fishermen in the nearshore waters, and there are many provisions outlining participation. First, the program allocates secure access to groups, rather than to individual fishermen. The government outlines specific requirements for groups that are eligible to apply. Second, in order to meet the goal of encouraging artisanal fishermen, the program also outlines clear rules regarding membership within groups.

Only cooperatives, unions, or guild associations can apply for a TURF. As of 2006, approximately 42,000 registered artisanal fishermen (over 75% of all registered artisanal fishermen) were organized into about 680 fishing organizations. This includes 500 unions, 120 guild associations and 30 cooperatives. Three hundred and twenty of these organizations, including 17,000 fishermen, have been granted TURFs. These range in size from 25 to nearly 900 fishermen (Cancino, et al., 2007).

Organizations that are granted TURFs can only be comprised of licensed artisanal fishermen. The law distinguishes four types of artisanal fishermen:

1. Shellfish divers, who extract molluscs, crustaceans or echinoderms and must complete formalized training including theoretical and practical instruction
2. Seaweed collectors, who collect seaweed
3. Fishermen, who are captains or crew of an artisanal boat
4. Ship owners, who are limited to one or two artisanal boats, defined as 18 meters or less in length and 50 tonnes or less; if the ship owner has two registered boats, they together must not exceed a combined 50 tonnes

All fishermen within the catch share program must belong to a fishing organization, and reside, at least part-time, in the caleta adjacent to the defined benthic area. A fisherman may belong to multiple categories, e.g., shellfish diver and fisher, but is not permitted to be registered in more than one region (Castilla and Gelcich, 2008). The main purpose of this regulation is to prevent migration pressures on productive benthic areas. If an artisanal fisherman moves, he must resign his rights to the original region and request permission for the new one (Bernal et al., 1999).

While there are rules against excluding members who meet these initial requirements, the fishing organizations can create additional requirements such as an initiation fee and an apprenticeship, perhaps unpaid, including harvesting and/or assisting with monitoring and enforcement (Cancino, et al., 2007). Indigenous peoples in Chile fall under the same laws and must apply for licenses within one of the above artisanal categories (Castilla and Gelcich, 2008).

STEP 4 IN PRACTICE

Define the Privilege

The TURF Programme allocates species and area-based privileges to eligible participants. The primary target species, loco, is required to have a catch limit. In some TURFs, additional species are extracted, which may or may not have identified catch limits. As science and information improve, more and more TURFs have species for which scientifically-determined catch limits are established.

Successful applicants are granted a TURF for four years and groups can renew the area concession by submitting another application. Fishing organizations can lose their access if the organization fails to pay yearly taxes or if the members use the resources in a non-approved fashion, including introducing exotic species, extracting organisms during banned periods, capturing species under the minimum size, or using forbidden techniques for capture.

The program is non-transferable: Organizations in sanctioned caletas are not allowed to transfer their secure TURF allocation to another group or area (Castilla and Fernandez, 1998). If an individual fisherman leaves an area or an organization, he surrenders any access to the TURF. It is unclear, and likely variable, how organizations manage their areas and quotas. It is possible that an organization may divvy up the catch limit and allocate it to individuals, in which case they may allow transferability among their own members.

STEP 5 IN PRACTICE

Assign the Privilege

Initial share allocation has been an ongoing process due to the voluntary, application-based nature of the program. Rather than implementing a comprehensive program at one time, eligible organizations are allowed to apply on a rolling basis.

There are two "allocation events" for establishing and fishing within a TURF. First, the government allocates a TURF, or specific benthic area, to an eligible group of fishermen upon review and approval of an application. Then, the group must determine how to manage fishing among its members.

Any fishing organization made up of artisanal fisherman can apply for a TURF. Fishing organizations must create a "Management Plan and Exploitation of Area" application to apply for exclusive spatial privileges and rights to harvest certain species within these areas. First and foremost, the requested area must include the natural habitat of the main targeted species, be on the list of official caletas, and must not overlap with previously established exclusive areas (Gonzalez, 1996). Additional application requirements include:

- An initial baseline study of the requested area conducted by an external scientist
- Population assessments and background information for each requested species, i.e., species the association plans to target
- Proposed exploitation strategy for each requested species
- Proposed conservation measures
- Market information
- Proposed research methods to meet conservation and management data requirements
- Description of the geographic area, including coordinates

- A list of all members, including the inscription number and the fishermen's classification as listed in the National Register of Artisanal Fishermen

If modifications to the application are required, the fishing organization must make the necessary changes and reinitiate the project from the beginning. If more than one fishing organization applies for a TURF in the same cove, priority goes to those located nearest the resource, followed by those with the most members, followed by the oldest. SUBPESCA reviews and approves applications and SERNAPESCA generates a written agreement granting exclusive, area-based rights to the fishing organization.

Once the application is approved and the TURF is granted, fishing organizations choose how to administer their own fishing activities. For species with a catch limit, there are a number of basic approaches that have been used. Some organizations evenly distribute the catch limit among fishermen or among diving teams (divers and crew members). Others allow fishermen to fish as they choose until the catch limit is reached; in these cases the fishermen pay a percentage of catch profits to the fishing organization, which then divides this among members who participated in organization-wide duties. Sometimes fishermen pool all profits and then evenly distribute the profits to active fishermen and inactive fishermen who take part in other activities required for running the program.

STEP 6 IN PRACTICE

Develop Administrative Systems

The administrative systems for the catch share program are largely decentralized and conducted by each fishing organization that has been granted a TURF. Participants are required to collect landings data for all managed species including the number of individual organisms extracted, size and location. This information, along with the yearly stock assessments and extraction plan, are submitted to the government for review. The National Fisheries Service verifies the information against sampling data gathered by inspectors. For some species, organizations also issue tickets which record the diver's name and the depth at which the species was collected, and track the species to the markets (Molyneaux, 2007). Each organization hires independent scientists to conduct stock assessments and determine the annual catch limits.

Fishermen that illegally fish loco outside of TURFs, poach within TURFs, or break fishing organization rules are subject to penalties ranging from exclusion from fishing for a specified time period, banishment from the TURF Programme or prosecution (Molyneaux, 2007). Despite these penalties, theft has been a problem and some fisheries organizations feel they have inadequate resources to monitor and enforce against illegal activities (Gelcich et al., 2009). This may be an area that needs future attention.

The cost of the catch share program is shared by the government and participants. Fishing organizations are required to pay application fees and fund baseline studies, annual stock assessments, and often monitoring and enforcement of the TURF. With each renewal (every two or four years) a tax is imposed on the fishing

association based on hectares under the TURF. Some organizations feel the cost burden is too high and have proposed basing the fees on amount of extracted resource, market prices and revenue, instead of a hectare-based flat rate. Additionally, some fishing organizations would prefer to conduct their own scientific assessments rather than pay consultants (Castilla and Gelcich, 2006; Gelcich et al., 2009).

STEP 7 IN PRACTICE

Assess Performance and Innovate

The program has undergone a number of innovations. Interestingly, from 1993 to 1997, Chile experimented with a global loco quota, administered through "tickets" equivalent to a specific amount of loco. This system was not very successful because it was too easy for divers to forge the tickets and too costly to administer this program along Chile's long coastline. Upon assessment, managers replaced the global species-based quota system with the current TURF or area-based system.

Fishermen have also innovated within the program. Some fishing organizations have combined into larger marketing cooperatives in order to sell resources between their organizations and create economies of scale for exportation. For example, in central Chile, fifteen fishing organizations created the PACIFICOOP to form strategic alliances with exporters and generate better prices. In Southern Chile, five fishing groups created a private company called TERPESCAR, which has gained rights to administer landing ports, thereby generating further income (Castilla and Gelcich, 2008). Near some wealthier urban areas, fishermen have further enhanced their profits by creating and supplying "live" fish markets and developed dive tourism within the TURF (Cancino et al., 2007).

SEASALT
Secure
Exclusive
Accountable
Limited
Transferable

CATCH SHARES IN PRACTICE

Danish Pelagic and Demersal Individual Transferable Quota Programs

SPECIAL DESIGN FEATURES

MULTI-SPECIES, INDIVIDUALLY-ALLOCATED, SPECIES-BASED, TRANSFERABLE

The Danish Pelagic and Demersal Individual Transferable Quota Programs (ITQ Programs) include a number of thoughtful design decisions in order to meet the programs' goals, including promoting economic growth in the fisheries sector by balancing the capacity of the fishing fleet with the available resource, and addressing social concerns. Important features of the catch share program include quota set-asides for small vessels and new entrants; Fishpools, which promote cooperation and coordination among participants; and programs to reduce discards. Denmark's catch share programs demonstrate how innovative design features can be used to promote social goals within a system introduced for economic and biological reasons.

SYNOPSIS

In 2003, the Danish government introduced an ITQ Program for the Danish herring *(Clupea harengus)* fishery. In 2007, the system was extended to cover additional pelagic species including mackerel *(Scomber scombrus)*, horse mackerel *(Trachurus trachurus)*, sprat *(Sprattus sprattus)*, pout *(Trisopterus esmarki)*, sandeel *(Ammodytes marinus)* and blue whiting *(Micromesistius poutassou)*. At the same time, managers introduced an ITQ Program for the Danish demersal fisheries.

The major Danish fisheries occur in the North Sea, the Skagerrak, the Kattegat and the Baltic Sea. In 2009, over 2,800 Danish commercial fishing vessels and over 2,500 people were engaged in fish harvesting (Danish Directorate of Fisheries, 2009). The pelagic and demersal fisheries are comprised of a variety of vessels, most of which operate in many locations and use multiple gear types. Vessels vary in size, with the largest vessels operating in the pelagic fishery and the industrial reduction fisheries for sprat, sandeel, pout and blue whiting. The smallest vessels, skiffs, target nearshore demersal species with gillnets. In 2007, the value of Danish landings was over $450 million, 90% of which were under catch share programs (55% in the ITQ-Pelagic Program and 35% in ITQ-Demersal Program) (MRAG et al., 2009).

Road to a Catch Share

Denmark has a long fishing tradition. With over 400 islands and close proximity to productive fishing grounds, the Danish fisheries have historically been one of the top producers within European Union member states (FAO, 2009). The contribution of fisheries to the Danish economy is relatively low, around 0.5% of gross domestic product (Christensen, 2009), yet many coastal communities depend on commercial fishing, especially those located in northern and northwestern regions (Christensen, 2009).

Danish fisheries have experienced periods of booms and busts in landings and revenue. During the two decades preceding the ITQ management, Danish fisheries' policies attempted to reduce capacity and curb overfishing through vessel decommissioning, and through policies limiting vessel entry and investments in vessels. Denmark's vessel decommissioning used public funding to remove vessels permanently from the commercial fleet. From 1989 to 2006, 1,272 vessels were removed at a total cost of 1.4 billion Danish kroner (U.S. $245.3 million) (Danish Directorate of Fisheries, 2009). While a reduction in gross tonnage has been achieved with this program, efficiency has not increased and biological goals have not been met. From 1994 to 2002, overall catch and catch rates steadily declined, showing no evidence that the fleet reduction program led to increased catch opportunities (Lindebo, 2005). Perhaps most importantly, vessel decommissioning does not change the underlying incentives that lead to overcapacity, which often makes it a short-term solution for overcapacity in fisheries (Beddington et al., 2007).

The Danish Ministry of Fisheries developed the ITQ Programs in the pelagic and demersal fisheries to achieve the following goals: ensure that fleet capacity is in line with fishing opportunities, create a viable fishing economy, and benefit the coastal fisheries (Schou, 2010). While the ITQ Programs were designed primarily to promote economic efficiency, they were also designed to support the coastal fishery (and those communities dependent on it), provide young fishermen with the ability to participate, and indirectly reduce discards by removing excess capacity.

Performance

Under the ITQ Programs, the capacity in Danish fisheries has been reduced by 25% without the use of public funds for decommissioning. Profits have increased from 9% – 20% and fishermen have doubled new investments in value-added efforts, rather than in catch maximization technology, which fuels the race for fish (Schou, 2010). The coastal fishery has increased its shares of the catch, indicating success for coastal communities.

Before introducing the ITQ Programs, the Danish government clearly stated that a necessary consequence of removing overcapacity would be a reduction in the number of vessels and participants in the fishing industry. However, the government also said the fleets would have newer vessels that are able to carry high-quality fish and be more attractive for young fishermen to work on. The ITQ Programs have achieved all of these goals at a surprising speed.

By using innovative approaches such as Fishpools (voluntary cooperatives that facilitate trades between fishermen), managers and fishermen have successfully balanced fleet capacity with fishing opportunities. Importantly, overcapacity has been reduced without compromising social goals.

STEP 1 IN PRACTICE

Define Program Goals

Traditional fishery management approaches have resulted in overfished stocks and left coastal communities suffering from underperforming economies (Schou, 2010). Over the last two decades, there has been a concerted push in the Danish fisheries to create sustainable harvests with balanced, profitable fishing fleets. Policies have mostly focused on reducing capacity (by using public funds to decommission fishing vessels) and implementing effort controls to regulate fishing mortality (such as limiting days-at-sea and total kilowatt days per year). These two policies have been ineffective, yet the goals for the fisheries have remained the same.

ITQ management was adopted in 2007 as a means to achieve economic, biological and social goals. Economic goals were a focal point of the ITQ Programs, with objectives to balance fleet capacity with fishing opportunities, create economic growth in the fishery sector, and allow fishermen to create long-term value-added investments in fishing operations. Biological goals focused on reducing discards in the fisheries. Specific design features were added to meet the social goals of the fishery, which included maintaining a competitive coastal fishery and improving entrance for young fishermen (Schou, 2010).

STEP 2 IN PRACTICE

Define and Quantify the Available Resource

The ITQ-Pelagic Program includes the pelagic fisheries and industrial reduction fisheries, including herring, mackerel, horse mackerel, sprat, pout, sandeel and blue whiting. The ITQ-Demersal Program includes the lobster fishery and the demersal fish stocks – cod *(Gadus morhua)*, saithe *(Pollachius virens)*, plaice *(Pleuronectes platessa)*, haddock *(Melanogrammus aeglefinus)*, hake *(Merluccius merluccius)*, whiting *(Merlangius merlangus)*, sole *(Solea solea)*, turbot *(Psetta maxima)*, and monkfish *(Lophius piscatorius)*. A number of fishing areas are further subdivided into zones based on designations determined by the International Council for the Exploration of the Sea (ICES).

Through the authority of the Common Fisheries Policy (CFP) of the EU, the European Commission (EC) sets a catch limit for each species and area combination and allocates these to EU member states according to a fixed percentage. Country-level quota can be transferred between EU member states so long as the EC is given

advanced notice. The catch limits set by the Commission reflect the goal of achieving maximum sustainable yield for European fisheries (European Commission, 2010). Member states measure and report landings. To account for discards, the EC normally sets the catch limits lower than the advised maximum.

Effort is also restricted in a number of different areas, mainly the North Sea, the Skaggerak, the Kattegat and the Baltic Sea. In these areas, days-at-sea and total kilowatt hours per year are capped by the European Commission.

STEP 3 IN PRACTICE

Define Eligible Participants

The two ITQ Programs follow general principles regarding who can hold and fish shares, but each program has some unique features. In both, allocations are made to individual registered fishermen to use on a registered fishing vessel. Thus, only active fishermen can use the quotas on active vessels ensuring that benefits from operation accrue to those in fishing communities (Schou, 2010). To be eligible for allocation, fishermen must have had more than 60% of their earnings come from fishing.

Concentration limits are also in place to avoid excessive consolidation of shares. Concentration limits are higher for the industrial and the pelagic fishery where efficiency and large holdings are important, and they are lower in the demersal fishery, where operations are smaller and tied to local communities.

The coastal fishery, a sector comprised of vessels under 17 meters, has additional requirements for quota holders. Vessels can voluntarily enter this sector and in return receive additional quota shares of cod and sole, two of the most important demersal species. The quota set-aside is fixed at 10%, so the amount each operator receives depends on the number of vessels that join (Danish Ministry of Food, Agriculture and Fisheries, 2010). Quota cannot be sold out of the coastal fishery, but operators in this sector can purchase additional shares from both coastal fishermen and non-coastal fishermen. Operators in this sector must stay in the sector for a minimum of three years, and the majority of their fishing trips must be fewer than three days in length. In every year since this feature was introduced, the coastal segment has experienced landings higher than their historical average (Danish Ministry of Food, Agriculture and Fisheries, 2010).

Providing opportunities for new entrants was an important program goal and there are three main ways in which the program accomplishes this. First, the shares are transferable and new entrants may purchase shares in order to participate in the fishery. Second, the Fishfund is an initial set-aside of quota shares for new entrants who demonstrate an investment in the fishery, such as by purchasing a new vessel. Participants are allowed to access Fishfund quota annually. Finally, new entrants are allowed to join one Fishpool (Fishpools are described in more detail below) and can access the pooled quota for a fee. These programs have all supported the participation of younger fishermen and fishermen who did not receive initial allocations.

STEP 4 IN PRACTICE

Define the Privilege

The ITQ Programs issue species-based privileges that allocate secure shares for specific species and area combinations. Shares are allocated with no expiration date, but can be revoked by the government with eight years' notice. Each year, the shares are converted into actual weights that fishermen can land based on the fishermen's holdings and the species-area catch limits.

Managers also formed a system of quota set-asides to promote specific social goals including access for small vessels and new entrants. For the coastal fishery, shares of the most important demersal species, sole and cod, were set aside for use by vessels under 17 meters. Vessels meeting this requirement can opt into the coastal fishery and will receive additional shares provided they stay in the coastal segment for three consecutive years at a time. In this period they may buy or lease quota shares from vessels outside the segment but are not allowed to sell any out of the segment. The quota set-aside is fixed, so the amount individual operators receive depends on the number of vessels that opt in.

Additionally, shares were set aside for a program called the Fishfund. These shares are allocated to fishermen to support new entrants, data collection and innovation, but have, to date, been mainly used to allocate quota to new entrants who make investments in vessels.

The Fishfund and the ability for the government to revoke shares with eight years' notice help ensure that fish are recognized as a public resource, while still providing fishermen with stability and security.

Both permanent and temporary transfers are allowed to support changes in industry structure, such as reduction in overcapitalization, and adjustments to variations within the quota year (Schou, 2010). Industry has developed a series of Fishpools, cooperatives that facilitate trading, especially annual leases within the season.

STEP 5 IN PRACTICE

Assign the Privilege

Allocation is often the most contentious issue in the development of a catch share program, and this was no different in the case of the Danish fisheries. Industry was initially skeptical of ITQ management and thus a driving principle of the program was to ensure fishermen broadly accepted the initial allocation of shares as being fair and a true picture of their historic performance.

Allocation was based on weighted catch history from 2003, 2004 and 2005: Weights used were 20%, 30% and 50%, respectively. While this was fairly straightforward, fishermen were allowed to appeal allocations to accommodate

non-typical cases, such as those where the operator was unable to fish during the years used to determine catch history (e.g., due to sickness, damage to vessel, sale of vessel, etc.) (Eurofish, 2009). A thorough appeals process was fundamental to the system. Overall, fishermen seemed satisfied with allocation process and outcomes.

STEP 6 IN PRACTICE

Develop Administrative Systems

The ITQ Programs have a number of interesting administrative systems, driven both by the government and by fishermen. Transparency is an important aspect of the system, so all allocations and trading are open to see for the public on the Danish Directorate of Fisheries' webpage.

The system allows both permanent and temporary transfers. Permanent transfers are handled by the government. Fishermen register and obtain approval for the transfer from the Danish Directorate of Fisheries. Within the quota year, extensive swapping and leasing takes place. This is done almost entirely through Fishpools, voluntary, privately-established groups of fishermen that promote cooperation and coordination between quota holders. Fishpools are managed by a "pool master," who must gain approval from the Danish Directorate of Fisheries, and each Fishpool is responsible for ensuring that aggregate member landings do not exceed total quota shares.

Eleven pools are currently in operation and around 80% of all quota has been brought into Fishpools (MRAG et al., 2009). Fishpools facilitate temporary transfers between members and nearly all leasing is done through Fishpools. A main feature of the Fishpools is that members are not allowed to discard fish due to lack of quota as long as the pool has quota for that species. Fishermen who exceed their quota can lease quota to cover their catch upon return to the harbor. The result has been a substantial reduction in discards (Schou, 2010).

Fishpools use an online system (www.puljefiskeri.dk) to conduct trades. The government does not actively participate in the trading market, but the Fishpool system and private brokerages have combined to promote a well-functioning quota market. While fishermen are provided yearly allocations based on quota holds, participation in a Fishpool is one quota year plus one month. This is used to ensure that any overfishing can be accounted for in the following year.

The ITQ Programs require all landed fish to be deducted from participants' shares. Denmark has also conducted a pilot program on full accounting of all catch and landings, called Catch Quota Management (CQM). The 2008/2009 pilot program showed that fishermen will fish selectively to reduce discards and improve earnings rather than maximize profits by catching and then releasing lower value fish.

In 2010, Denmark, the U.K., Sweden, Holland and Germany have planned, and partially implemented, a CQM program for nearly 70 vessels. The CQM program requires all catches, including discards, to be registered by weight in an electronic logbook and counted against the vessel quota. In return, operators receive additional

quota to reflect the decrease in uncertainty surrounding catch. To participate in the program all catches including discards are monitored by cameras and sensor systems through an electronic monitoring system.

The British and Danish CQM trials in 2010 dictate a mixed fishery to stop when one species in a multi-species fishery is exhausted. The effect is that biological targets for the individual stock are not overshot – as may be the case in the quota basket and the weighted transfer models. The result has been that fishermen will plan, choose and innovate fishing methods to fish selectively to optimize catches on each species in the mixed fishery. To the extent they cannot decide on the precise catch composition, the flexible ITQ Programs will allow swapping or leasing of quota to cover their needs.

STEP 7 IN PRACTICE

Assess Performance and Innovate

The ITQ Programs are designed to align economic investment with the available catch. The basic features of the system work well and no fundamental changes are expected. Future program innovations will continue to focus on accounting for all catch, landed and discarded, and providing incentives for fishermen to fish selectively and improve fishermen's management of their shares.

In addition, the Danish government supports the development of improved market access, especially among big retailers. As such, they are investing in fish traceability technology and full documentation of total catches through camera and sensor monitoring and establishing a database for anybody to extract required and well-documented data, e.g., for the purposes of certification or to supply retailers with all relevant and documented data.

Denmark is also focused on driving the 2012 revision of the EU common fisheries policy (CFP). Denmark's goals are to enhance output management of all catches, reduce effort-based regulations dictating fishing methods and move toward true catch-based management in which all caught and landed fish are deducted from quota holdings. Danish, German and U.K./Scottish ministers made a joint declaration in 2009 toward full accounting of catch and landings and implemented it on a limited scale in EU legislation in 2010.

FIGURE B | *Use of Catch Share Design Features*

BY COUNTRY | AS OF 2010

There are over 275 catch share programs within 35 countries worldwide. Managers make four main design choices based on underlying fishery characteristics and program goals. Below are the design options countries have used for their catch share program or programs.

Country	● Single-species ○ Multi-species	● Individually-allocated ○ Group-allocated	● Species-based ○ Species & area-based	● Transferable ○ Non-transferable
Argentina	●	●	●	unknown
Australia	● ○	●	●	● ○
Bangladesh	○	○	○	○
Belgium	unknown	●	●	unknown
Canada	● ○	●	●	● ○
Chile	● ○	● ○	● ○	● ○
Cook Islands	●	●	●	●
Denmark	● ○	●	●	●
Estonia	● ○	●	●	●
Fiji	unknown	○	○	unknown
Finland	unknown	○	○	unknown
Germany	unknown	●	●	unknown
Grenada	○	○	○	unknown
Iceland	○	●	●	●
Italy	●	○	○	○
Japan	unknown	○	○	unknown
Latvia	unknown	●	●	unknown
Lithuania	○	●	●	unknown
Malta	●	●	○	○
Mexico	● ○	● ○	● ○	○
Namibia	● ○	●	● ○	● ○
Netherlands	● ○	●	●	●
New Zealand	○	●	●	●
Norway	●	●	●	●
Papua New Guinea	unknown	○	○	unknown
Peru	●	●	●	unknown
Philippines	●	●	○	unknown
Poland	●	●	●	○
Portugal	unknown	●	●	●
Solomon Islands	unknown	○	○	○
South Africa	● ○	●	●	● ○
Sweden	●	●	● ○	unknown
United Kingdom	●	●	●	● ○
United States	● ○	● ○	●	● ○
Vanuatu	unknown	○	○	unknown

Appendices

APPENDIX A

Monitoring and Data Collection Approaches

Monitoring of catch and landings provides fishery managers with vital information for science, enforcement and catch accounting and is a key component of effective fisheries management. There are a variety of data collection and monitoring approaches that have been successfully used for managing fisheries and choosing the appropriate method or methods will help ensure the effectiveness of a catch share program.

This Appendix provides a basic overview of different monitoring approaches, including a discussion of their pros and cons, as well as commonly used combinations based on different gear types. Future addenda to the Design Manual will provide more detailed information and recommendations on monitoring, and numerous companies (including Archipelago Marine Research Ltd., OLRAC, MRAG Americas and more) are available for consultation, development, testing and implementation of monitoring approaches.

To begin developing your monitoring system, you must first think about the specific goals of your catch share program and the attributes of your fishery. Your answers to the questions below will help guide you through the various monitoring options that are laid out in this Appendix.

Resource characteristics

- Is the fishery (and catch share program) multi-species or single-species?
- Are there high rates or amounts of discards and bycatch?
- Are there encounters with protected species, i.e., seabirds, mammals, turtles, etc.?
- Are there significant at-sea releases?
- Are there limits by species, stock or area that must be tracked?
- Are there any closed areas?
- What is the geography of the area?

Fleet characteristics

- What is the size/composition of the fleet?
- What are the vessel sizes?
- What type of gear is used?

Operational characteristics

- What is the value of the fishery?
- What are the characteristics of the catch?
- What is the geographic range of fishing activity?
- What are the landing characteristics of the fishery?
- How much illegal, unreported or underreported catch occurs?
- What is the trip length?
- How is the catch processed and/or stored?
- When does fishing occur? Is it year-round or seasonal?

Governance characteristics

- Is authority centralized or dispersed?
- What is the history of regulation?
- What is the culture around compliance?
- Is there strong political will for specific methods?
- What is the current management regime?

Data collection and monitoring programs can rely on self-reported data or independently collected data and can be conducted at-sea or dockside. Below is a discussion of these approaches.

HAIL PROGRAM

A hail program allows a vessel operator to communicate their fishing activity to a central clearinghouse. They may report activities such as commencement and completion of a fishing trip, fishing location, scheduled landings, and offloadings of fish.

Hail programs are often used by the enforcement agency to facilitate the logistics and planning associated with at-sea or dockside monitoring and surveillance. Departure hails, the notification of trip commencement, generally include identification of the vessel and skipper as well as the intended fishing plan, including target species, fishing location and time period. Landing hails generally include all of the details regarding landing location and time and may include information about what species are to be offloaded.

Pros – Hail programs help facilitate appropriate coverage and enforcement of fleet-wide fishing trips, monitoring processes and may help facilitate product delivery and offloading.

Cons – Hail programs require fishermen to have communications capabilities on the boat. They also require a system on the backend for collecting the data pertinent to the call.

VESSEL MONITORING SYSTEMS (VMS)

Vessel Monitoring Systems (VMS) transmit vessel identity, speed and location via satellite to a central database (Anderson and Holliday, 2007). They are commonly found on commercial fishing vessels participating in federally regulated fisheries, especially where there is a need to track vessel location. Some fisheries also use VMS to increase safety or to provide vessel hail information. The Certified Vessel Monitoring System includes a computer, a Global Positioning System (GPS) unit attached to a vessel, and backend software that receives the data and information from the vessel transponder. The VMS program also requires centralized data management on the backend.

Pros – VMS provides independent, accurate and timely information on location and can be used effectively as an enforcement tool to monitor encroachment on areas closed to fishing. When integrated with other data collection tools, VMS could be a key piece of an effective monitoring strategy. Some VMS also incorporate email capabilities thereby providing boats with enhanced modes of communication.

Cons – VMS generally contains no detail regarding vessel activity, catch or gear and thus cannot be used to verify vessel activity, such as when the vessel is actively fishing or traveling to fishing grounds. VMS data, by itself, may be of limited value for management purposes due to the lack of information regarding catch, discard and effort data.

AT-SEA OBSERVER PROGRAM

At-sea Observer Programs have independent human observers onboard vessels to record vessel and fishing location, fishing activity, catch (retained and released) estimates, compliance with fishing rules (closed areas, mandatory retention, gear restrictions) and to collect biological samples and information.

Pros – At-sea Observer Programs are one of the most effective approaches to independently and systematically collect accurate, unbiased data on catch and effort from an active commercial fishery. Observers can ensure individual accountability given a high enough level of coverage, without which it is difficult to bring about the behavioral changes required to reduce bycatch levels and accurately account for total catch by area for each fisherman and the fishery as a whole.

Cons – At-sea Observer Programs are one of the most expensive and logistically complex monitoring solutions. Managers can determine the level of at-sea observer coverage for a fishery and each vessel, but the utility for fishery management purposes of the data collected will depend on the level chosen. In many programs, catch is sampled, rather than fully accounted for. Data obtained in this manner will not be adequate to assess individual accountability. Furthermore, when vessels are selected as part of a sampling strategy, vessel operators may modify their fishing behavior, sometimes significantly, as a result of having an observer onboard. This is commonly referred to as the "observer effect" (Babcock et al., 2003). Random fleet coverage, as opposed to 100%, limits the value of the data. The relatively high cost of at-sea observers often prevents fishery managers from being able to implement full coverage, or the high sampling levels that will lead to high data confidence. In addition, these systems may not be suitable for very small vessels.

ELECTRONIC MONITORING PROGRAM

Electronic Monitoring (EM) Programs use cameras, sensors and Global Positioning System units onboard vessels to record vessel and fishing location, fishing activity, images of catch (retained and released) and compliance with fishing rules (closed areas, mandatory retention, gear restrictions) (McElderry, 2008a). EM has been developed largely as an alternative to onboard observers, but it may also be used in conjunction with observers, particularly on large factory vessels and 24-hour operations. EM also requires onshore labor to analyze the data.

EM is a system of cameras and sensors that detect fishing activities and collect video records of fishing events. EM supports industry data collection activities by providing a tool to audit self-reported data. An audit involves comparing a sample of vessel logbook data with the EM coverage. Given proper incentive structures, an EM audit functions as a 'radar trap' and can improve the quality of self reported data. The audit results provide several products: a measure of logbook data quality, an independent sample of fishing activity and an avenue for providing feedback on logbook data quality (McElderry, 2008a).

Pros – When properly employed, EM can be extremely effective. EM-based monitoring solutions are a lower cost and more convenient alternative to onboard observers. The cost of EM monitoring will vary widely by application, but experience has shown that EM technology-based monitoring programs can be expected to cost half, or less, of an equivalent At-sea Observer Program (Bonney and McGauley, 2008). Furthermore, EM can be combined with an audit approach to check the accuracy of self-reported logbooks or dealer reports. Fewer audits are required when accuracy is consistently high.

Cons – Given its fixed expenses, EM is not always viable for small-boat fishermen or for others whose landed values are low. It is possible for vessel operators to tamper with the system. However, such incidents are tamper-evident, and there are generally program rules in place to prevent or discourage tampering (McElderry, 2008a). In addition, the system requires expert installation and periodic calibration to function well.

LOGBOOKS

A logbook is a report completed by vessel personnel that provides a record of fishing activity including fishing time and location, fishing gear used and composition of catch. The logbook can be either paper or electronic. Logbooks are most useful when combined with other monitoring approaches, such as dealer reports and electronic monitoring, to increase accuracy of the data.

Pros – Logbooks can be relatively low in cost to fishermen and managers. Many fisheries are experimenting with electronic logbooks that can significantly reduce data turnaround time, recording errors, and inconvenience to fishermen.

Cons – The effectiveness of logbooks as a data-gathering tool and the reliability of the data is completely dependent on the circumstances of the fishery and the individual motivations

and abilities of the skippers completing them. Where an individual is highly motivated to record the best data possible, the results can be good. However, there may be incentives for skippers to inaccurately report catch amount and location. Timely and accurate completion of the logbook may not be among the top priorities of a skipper. In addition, discarded fish are rarely well-documented unless they become a detriment to catching the target species.

DOCKSIDE MONITORING PROGRAM

Dockside Monitoring Programs use independent observers at landing ports to monitor and report on the sorting and weighing of catch offloaded from fishing vessels (also referred to as a weigh master program).

Pros – Dockside Monitoring Programs create an independent record of the offload event, which the management authority can use with confidence. Dockside monitoring is one of the most powerful tools available to fishery managers for the collection of accurate, complete and credible records of fishery landing data. It produces verified data records that are usually available within a few days or less. When dockside monitoring is implemented with 100% coverage, every offloading event is independently witnessed and a data record is completed at the time.

Having a dockside monitor at offloading events also provides the opportunity to carry out other activities such as reviewing product quality and marketing initiatives, collecting and checking fishing logbooks, collecting biological samples and providing general outreach and communication.

Cons – Dockside Monitoring Programs require the cooperation of the buyer, vessel skipper and the offloader, which can be challenging to coordinate. In addition, dockside monitoring activity must be carried out in a way that minimizes impact on the offloading process. In addition, it can be complicated to count live, frozen and/or pre-packed product without disturbing packaging or damaging the product.

Dockside Monitoring Programs require staff trained in standardized data collection procedures and enough monitors to cover all required offloading events. They also require coordination between fishermen, offloaders and monitors, such as through a notification system, so monitors are available at the appropriate time.

DEALER REPORTS

Landings and sales slips are reports completed by the purchaser of landed fish. They provide a record of the vessel, landing location, buyer, species, product type, product value (usually) and amount offloaded. Product type and value are two data pieces that are rarely, if ever, collected elsewhere. Experience has shown that timeliness and quality of dealer data is dependent on the level of feedback and interaction by the fisheries agency. Where little feedback is given from managers, data quality is likely to be poor. In cases where interaction is high or there are consequences for poor quality or untimely data, the resulting data quality will improve.

Pros – Electronic filing of dealer reports significantly reduces the labor requirement of the fisheries agency and the turnaround time for the data. Electronic reports are also likely to reduce data-recording errors.

Cons – Recording timely and accurate data is dependent on requiring compliance through a licensing system or other incentives for dealers to participate. An easier process will increase compliance.

TABLE B | MONITORING AND DATA COLLECTION APPROACHES - *How they accommodate fishing characteristics*

	GEAR TYPES	LANDED/ DISCARDED CATCH	VOLUME OF CATCH/ LANDINGS	FLEET AND VESSEL SIZE	EQUIPMENT NEEDED	INDUSTRY REQUIREMENTS	GEOGRAPHIC RANGE AND PROCESSING LOCATIONS	RELATIVE COST
HAIL PROGRAM	All	Does not account for catch or discards	Any	Any Larger fleets will require more coordination	Mode of communication	Report sail and landing events	Any More dispersed areas or a greater number of processing locations may increase costs and require additional coordination	Low
VESSEL MONITORING SYSTEMS (VMS)	All	Does not account for catch or discards		Any	GPS units, computers and software	Install and maintain system		Mid
AT-SEA OBSERVERS	All	All	Any	Vessel must be able to accommodate additional person	Trained observers	Coordinate and accommodate observers on vessel		High
ELECTRONIC MONITORING PROGRAM	Works best for gears that do not bring catch aboard in mass. Full retention can be used with such gears to verify species information		Any	Any	Cameras, sensors and software	Maintain system		Mid to High
LOGBOOKS	All	All Self-reported	Any Self-reported	Any	Standardized paper forms or electronic logbooks	Keep and report accounts of catch		Low
DOCKSIDE MONITORING PROGRAM	All	Landed catch only Some catch may be discarded	Any	Any	Trained monitors and a database	Notify of trips and offloads		Mid
DEALER REPORTS	All	Landed catch only Some catch may be discarded	Any	Any	Dealer slips	Dealer to regularly submit reports		Low

APPENDIX B

Managing Without a Catch Limit

As stated in the Introduction, this Design Manual is focused only on catch share programs that set clear, appropriate limits on catch. There are programs worldwide that provide some amount of secure, dedicated access to fish resources but do not include a catch limit. Namely, area-based approaches without a catch limit, in which an individual or group is allocated secure access to an area but no catch limit is defined, and tradable effort-based approaches in which there is a cap on effort but not on catch.

The effectiveness of these approaches is less clear than of catch shares with a catch limit, due to limited experience with these programs and/or a lack of empirical research. While they may be viable approaches in some cases, they are outside the scope of this Design Manual and likely require additional research to understand the conditions under which they work well. Furthermore, it is likely that these approaches will require different design elements than those discussed in this Design Manual.

AREA-BASED APPROACHES WITHOUT A CATCH LIMIT

Area-based approaches, generally called Territorial Use Rights for Fishing (TURFs), specify and assign an area to an individual or a group (including an association, community, local government, etc.). Formal and informal TURFs have been used in many countries for centuries and are garnering more attention as a viable approach to managing marine resources. Many TURFs set a formal catch limit for one or more species, including the Chilean National Benthic Resources Territorial Use Rights for Fishing Programme, one of the largest in the world (See **Catch Shares in Practice: Chilean National Benthic Resources Territorial Use Rights for Fishing Programme** for more information). TURFs with a catch limit are discussed in more detail in **Step 3 – Define Eligible Participants** and throughout the Design Manual.

However, it is also possible to allocate a secure area to participants without setting a catch limit. In these instances, participants may develop their own methods for controlling catch. While some of these TURFs may be sustainable, even over a long period of time, it is also quite possible for participants to overharvest in the absence of sufficient controls or information. The overall effectiveness of these approaches, and why they are effective, remains an area for further research.

TRADABLE EFFORT-BASED APPROACHES

Tradable effort-based approaches place a maximum cap on the total number of effort units available, such as days, pots, trawl tows, etc. Shares of the effort units are then allocated to participants either as a finite number or as a percentage of the effort cap and participants are allowed to trade effort units. Managers adjust the effort cap up and down as required for stock sustainability

Rather than directly controlling the amount of catch, effort-based approaches control the catch as a function of the allowed effort. As the stock decreases, the gear becomes less efficient and effective, thereby leaving a certain amount of stock in the water. There are some distinct drawbacks to effort-based approaches. First, it may be challenging to effectively predict the appropriate level of effort to ensure stock sustainability. And second, fishermen are often able to innovate and develop methods to catch more fish while complying with the total effort units. Managers must continually assess the level of effort and its impact on the stock and change the caps on effort as appropriate. The link

and feedback loop between effort caps and catch is not as tight as the connection between catch limits and catch.

The benefit of tradable effort systems is that they do not require a robust stock assessment to set a science-based catch limit. Tradable effort shares may be an appropriate approach for fisheries where it is challenging to set a catch limit, due to either lack of data or the characteristics of the species, such as a species with variable annual recruitment. Generally, these fisheries have low bycatch mortality and very weak stock recruitment relationships.

Tradable effort share programs have most often been used in fisheries targeting crustaceans, such as Australia's West Coast Rock Lobster Individual Transferable Pots Program and Australia's Northern Prawn Transferable Effort Units Program. Furthermore, they are often implemented in fisheries where existing size, sex and season regulations are effectively meeting biological goals, but there is substantial overcapitalization that hampers meeting economic goals. More research is needed to determine design attributes that ensure a tradable effort program that effectively meets biological goals. It may be possible to implement effort-based systems alongside other catch share programs.

APPENDIX C

Fisheries No Longer Managed Under Catch Shares

Examples of catch share programs that have ceased operation are rare. Catch share management is superior to other approaches in meeting a variety of fishery goals, as discussed throughout the Design Manual. However, there are at least two documented cases of fisheries that were once managed via catch share programs, but no longer are. The primary reason for their failure seems to be external factors that were not sufficiently addressed.

BRITISH COLUMBIA ABALONE INDIVIDUAL QUOTAS

The British Columbia Abalone fishery was managed with Individual Quotas(IQs) from 1980 until 1990, at which point the fishery was closed due to overfished stocks. IQs were put in place as a measure to reduce "social disruption" upon the establishment of a fishery-wide catch limit, and the program did achieve certain improvements, specifically lengthening the season. Unfortunately, the abalone (*Haliotis kamtschatkana)* stocks continued to decline under the IQ Program and managers closed the entire fishery in 1990 to prevent further overfishing (Muse, 1998). While the exact reason for the decline in stocks is unclear, many potential factors may have contributed including overfishing during the years leading up to the IQ Program, illegal fishing and environmental conditions limiting stock recruitment. Unfortunately, despite the closure, the stock has shown few signs of rebuilding. Illegal harvesting may be one of the main reasons for the lack of rebuilding (COSEWIC, 2009).

CHIGNIK SALMON COOPERATIVE

In 2002, select sockeye salmon (*Oncorhynchus nerka*) fishermen in Alaska voluntarily formed the Chignik Salmon Cooperative. While many fishermen chose to join, other fishermen continued to fish under the historic management scheme. The Cooperative was successful in increasing profits by concentrating effort among its most efficient members, fishing closer to port, spreading harvesting over a longer time span to allow for fresher delivery, and by sharing information on stock locations.

However, a suit was filed in 2006 over the legality of the Cooperative and the Cooperative was ultimately dismantled due to a court ruling on fairness. The suit focused on a key design feature: allocation. The initial allocation procedure assigned percentage shares of the catch on an equal basis among all fishery participants. As participants joined the Cooperative, those remaining under the historic management scheme had less fishing opportunity. Many of these fishermen thought this was unfair, because their historic landings were higher than those in the Cooperative.

These examples show a couple of reasons why fisheries may no longer be managed under catch share programs. In both instances, it was not the inner workings of the catch share program that caused it to be abandoned, but external factors. Appropriate design processes and choices, and the ability to adaptively modify the program over time will help catch share programs succeed.

APPENDIX D

Assessment Methods for Data-Poor Stocks

Recent changes to federal law mandate that Fishery Management Councils implement annual catch limits for all United States stocks by 2011 (NOAA 2010). In order to establish catch limits and determine appropriate managerial actions however, stock assessments must first be conducted. For fisheries with little or no data, this is a significant challenge as traditional stock assessments are costly and demand large quantities of time and information. Fortunately, there are tools available to help assess data-poor fisheries using easily gathered data and/or data already on hand.

This paper reviews literature concerning data-poor stock assessment methods currently available to fishery managers. It provides a user-friendly guide to these assessment techniques and outlines the minimum and optimal data requirements, the results each model produces, and important caveats and limitations to each method. The following model descriptions are purposefully condensed; however, additional information can be found on NOAA's Fisheries Toolbox website (http://nft.nefsc.noaa.gov/) and in the primary literature, located in the references section.

Depending upon the method used, data-poor assessment models allow managers to calculate estimates of overexploitation risk, current population biomass, sustainable yield, optimal fishing mortality rate, stock status relative to reference points, or total allowable catch. Each of these parameters can then be used to determine appropriate catch limits for target populations.

Data-poor models fall into two distinct categories: fishery evaluation methods and decision-making methods. Fishery evaluation methods are generally less data- and resource-intensive and use data on species-specific life history, catch and size trends, and other relatively easy-to-obtain information to assess changes in fish populations or vulnerability to exploitation. Decision-making methods require more data but allow managers to not only assess changes in the population, but also establish sustainable catch levels. However, these categories are not exclusive as some models may fall under both, e.g., the Depletion-Corrected Average Catch method; a fishery evaluation model that also establishes sustainable yield levels.

This document outlines 11 examples of data-poor assessment models (nine evaluation methods and two decision-making methods) in order of least data-intensive to most data-intensive. Minimum data requirements, optimal data requirements, model results, and caveats for each are summarized in box format. Since continuous, long-term datasets do not exist for all fisheries, data-poor assessment methods provide managers with the tools they need to set appropriate catch limits and sustainably manage target stocks.

QUICK VIEW: DATA-POOR ASSESSMENT METHODSS

Fishery Evaluation Methods

I. Extrapolation Method

Example: Robin Hood Approach

II. Life-history Vulnerability Analysis

Example: Productivity and Susceptibility Analysis (PSA)

III. Sequential Trend Analysis

Type 1: Population or Length-Based Index

Example 1: In-Season Depletion Estimator

Example 2: Depletion-Corrected Average Catch (DCAC)

Example 3: Depletion-Based Stock Reduction Analysis (DB-SRA)

Example 4: An-Index-Method (AIM)

Example 5: Reserve-Based Spawning Potential Ratio (Dynamic SPR)

Type 2: Per-Recruit

Example: Fractional Change in Lifetime Egg Production (FLEP)

Type 3: Environmental Proxies

Example: Multivariate El Niño Southern Oscillation (ENSO) Index (MEI)

Decision-Making Methods

I. Decision Trees

Example 1: Length-Based Reference Point

Example 2: MPA-Based Decision Tree

FISHERY EVALUATION METHODS

The following fishery evaluation methods are separated into three distinct categories, beginning with the least data-demanding assessment models: extrapolation methods, life-history vulnerability analyses, and sequential trend analyses.

Extrapolation Method

For stocks with little or no data, extrapolation methods may be the only assessment tools available for fishery managers. Using data from similar species and/or local knowledge from fishermen and other resource users, extrapolation methods provide managers with a starting point for the development of a precautionary management method. Due to assumptions associated with these techniques, managers should use extreme caution when extrapolating harvest limits for one stock based on an assessment of another stock, even when the stocks appear to be very similar.

Example: Robin Hood Approach

The Robin Hood approach uses observations and/or scientific understanding from similar, "sister" populations to help inform management decisions. Life-history characteristics and estimates for optimal fishing mortality can be "stolen" from related species or neighboring stocks and "given" to data-poor species. Model results vary as the Robin Hood Approach can be incorporated into any type of stock assessment model. Since life-history information from more data-rich species or regions will not always accurately transfer to target stocks, there is greater risk for management actions to lead to overfishing.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Anecdotal observations/local knowledge about target stocks	Life-history characteristics from related "sister" species	Dependent on type of stock assessment used
CAVEATS		
Trend indicator only; does not determine causation		
Significant uncertainty concerning biological knowledge and management actions		

Life-history Vulnerability Analysis

Life-history vulnerability analyses use basic life-history characteristics to determine potential stock responses to fishing pressure. Information such as growth rate, age at maturity, and fecundity can be used to assess vulnerability to fishing pressure and prioritize stocks for management. This model can also allow managers to better assess population models, and therefore make more informed decisions about optimal fishing levels. However, life-history vulnerability analyses only assess the relative vulnerability to fishing pressure and do not produce absolute population data about the risk of target stocks to harvest activities.

Example: Productivity and Susceptibility Analysis (PSA)

Using life-history data, the Productivity and Susceptibility Analysis (PSA) analyzes the risk, or vulnerability, of a stock to fishing pressure. Productivity, or the potential growth rate of the population, is ranked from low to high and based

upon a combination of the stock's intrinsic rate of increase (*r*), von Bertalanffy growth coefficient (*k*), natural mortality (*M*), fecundity, average age at maturity, maximum length, and maximum age (Honey et al. 2010; Patrick et al. 2009). Susceptibility of the stock to fishing pressure is also scaled from low to high. Susceptibility is based upon the fishing mortality rate (including discards) and species behavior, such as schooling and seasonal migrations, which may alter catchability (Honey et al. 2010; Patrick et al. 2009). PSA can also be used as a baseline comparison within multi-species populations where varying amounts of data exist for each species (MRAG 2009). Although productivity and susceptibility analyses are useful in determining potential conservation measures and management decisions, as with any model, PSA model results are only as good as the original data inputs. The PSA model can be downloaded from the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/).

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	Detailed and accurate life-history characteristics and fishing mortality data	Estimates of overexploitation risk
Fishing mortality data	Multiple independent data sources to increase accuracy	
CAVEATS		
Trend indicator only; does not determine causation		
Does not specify optimal harvest levels		
Only assesses relative, and not absolute, population vulnerability to fishing pressure		
Length and consistency of data strongly affects accuracy of model results		

Sequential Trend Analysis

Sequential trend analyses utilize time-series data in order to identify trends in a variable (or multiple variables) and determine changes in a stock or population. While trend analyses require relatively easy-to-collect data, (e.g., catch records, length-based reference points, spawning potential ratio) any changes detected only reflect relative change and are not measured in absolute values. Also, statistical calculations can not be used to determine a causal relationship between variables and observed changes in the stock. The following discusses three types of sequential trend analyses, in order of least data-intensive to most data-intensive, along with example assessment models of each.

Type 1: Population or Length-Based Index

Below are five examples of assessment models that use population or length-based data to calculate optimal catch limits.

Example 1: In-Season Depletion Estimator

Using up-to-date catch information, catch-per-unit-effort (CPUE) data, and life-history characteristics such as growth, survival, and recruitment parameters, the In-Season Depletion Estimator calculates the current stock biomass of target species. Abundance data from completed seasons is compared to current season information, allowing managers to apply harvest rates to biomass estimates to

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	In-season CPUE or effort time-series, at frequent intervals, using consistent data-collection methods	Estimates of real-time stock abundance/ biomass
In-season/current catch time-series		
CAVEATS		
Trend indicator only; does not determine causation		
CPUE is not always accurate due to effort creep, fishermen behavior, and/or stock dynamics		
Assumes ecosystem and fishery dynamics remain constant over time		

determine appropriate catch limits (Maunder et al. 2008). As with other data-poor assessment methods, the In-Season Depletion Estimator assumes ecosystem and fishery dynamics remain constant over time.

Sequential Trend Analysis

Type 1: Population or Length-Based Index

Example 2: Depletion-Corrected Average Catch (DCAC)

Depletion-Corrected Average Catch (DCAC) uses historical catch data (preferably ten years or more) and an estimated natural mortality rate (preferably 0.2 or smaller) to determine potential sustainable yield (MacCall 2009). An extension of potential-yield models, DCAC is based on the theory that average catch is sustainable if stock abundance has not changed substantially. The method differs from simple extrapolation of average catch to estimate sustainable yield by correcting for the initial depletion in fish abundance typical of many fisheries. DCAC divides the target stock into two categories: a sustainable yield component and an unsustainable "windfall" component, which is based upon a one-time drop in stock abundance for a newly established fishery. DCAC calculates a sustainable fishery yield, provided the stock is kept at historical abundance levels. The DCAC model can be downloaded from the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/).

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Historical catch time-series	Data gathered at frequent intervals, using consistent data-collection methods	Estimates of sustainable yield
	Natural mortality rate (*M*)	
CAVEATS		
Trend indicator only; does not determine causation		
Assumes ecosystem and fishery dynamics remain constant over time		

Sequential Trend Analysis

Type 1: Population or Length-Based Index

Example 3: Depletion-Based Stock Reduction Analysis (DB-SRA)

Depletion-Based Stock Reduction Analysis (DB-SRA) combines DCAC with a probability analysis to more closely link stock production with biomass and evaluate potential changes in abundance over time. Using Monte Carlo simulations, DB-SRA provides probability distributions for stock size over a given time period, under varying recruitment rates (Walters et al. 2006). The addition of a probability analysis increases the reliability and decreases uncertainties associated with historical biomass estimates generated from DCAC.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Historical catch time-series	Data gathered at frequent intervals, using consistent data-collection methods	Estimates of sustainable yield
	Natural mortality rate (*M*)	
CAVEATS		
Trend indicator only; does not determine causation		
Assumes ecosystem and fishery dynamics remain constant over time		

Sequential Trend Analysis

Type 1: Population or Length-Based Index

Example 4: An-Index-Method (AIM)

Based on a linear model of population growth, An-Index-Method (AIM) estimates biological reference points from catch and abundance data. By estimating catchability and harvest rates, managers can use AIM to determine stock size, and therefore the fishing mortality rate for a stable population. Since the length and consistency of input data strongly affects the outputs, AIM should be reserved for data-medium stocks where a linear growth model

appropriately reflects the target species. The AIM model can be downloaded from the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/).

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	Detailed population and age-length data	Relative fishing mortality rate
Catch time-series		
Abundance data (from CPUE or independent surveys)		
CAVEATS		
Trend indicator only; does not determine causation		
Linear model assumptions are not appropriate for all stocks		
Length and consistency of data strongly affects accuracy of model results		
Assumes ecosystem and fishery dynamics remain constant over time		

Sequential Trend Analysis

Type 1: Population or Length-Based Index

Example 5: Reserve-Based Spawning Potential Ratio (Dynamic SPR)

Currently in development, the Reserve-Based Spawner-per-Recruit (SPR) Assessment Model is an especially effective tool for data-poor species with highly irregular recruitment patterns (e.g., bocaccio and many invertebrate species along the West Coast) (Honey and He in prep). The model combines age or length data from inside and outside no-take marine reserves with life-history characteristics to estimate sustainable yield from spawning potential ratios. Depending on the species, this method requires data from an established no-take marine reserve (typically four to ten years without any fishing) before it produces meaningful results distinguishable from background noise (Honey and He in prep). Additionally, as the recruitment variability in a population increases, more data are required for the model's dynamic methods to work. The Dynamic SPR method is not suitable for species that lack data over their full range of life cycle stages, for example species that are only monitored nearshore but move offshore as individuals grow larger in length and age. In such cases, population development and ontogenetic growth shifts may lead to skewed data and assumptions about unfished biomass, thereby misrepresenting the structure of the target stock. Finally, such methods assume that marine reserve populations accurately represent an unfished biomass.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	Age-length data from an established (10+ years) no-take marine reserve	Estimates of sustainable yield
Catch time-series		
Age-length data from inside and outside no-take marine reserve boundaries		
CAVEATS		
Survey data may not accurately portray the stock structure due to development/growth shifts in the population		
Assumes reserve conditions represent an unfished biomass		
Assumes reserve regulations are well enforced		
Assumes ecosystem and fishery dynamics remain constant over time		

Sequential Trend Analysis

Type 2: Per-Recruit

In data-poor or data-medium situations where long-term, comprehensive catch data does not exist, per-recruit models can be used to determine estimates of optimal fishing mortality. By focusing on yield-per-recruit (YPR) or spawning stock biomass per recruit (SSBPR), managers can maintain a stock's population by preserving its reproductive capability. Calculations of lifetime egg production (LEP),

also known as egg production per recruit, can be used as reference points for harvest targets. As fishing pressure increases, the stock's age structure changes, which reduces LEP and the equilibrium egg production (the level of egg production needed to balance fishery mortality). Eventually equilibrium egg production reaches zero and the population collapses. Unfortunately this point is often unknown due to lack of data, larval source-sink dynamics, and environmental variability (Botsford et al. 2004).

Example: Fractional Change in Lifetime Egg Production (FLEP)
Fractional change in lifetime egg production (FLEP) can be used as an alternative to more data-intensive per-recruit models such as SSBPR. Length-frequency data from an unfished (or early exploited) population and the current population, along with information on growth and maturity, are used to determine a limit reference point that represents the persistence of a population. The fractional change is calculated as the ratio of LEP between the unfished and current populations (O'Farrell and Botsford 2005). While FLEP analyses help calculate optimal fishing mortality, this method only indicates population trends and correlations, forcing managers to make assumptions about the target stock.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Length-frequency distribution for an unfished or early exploited population and for the current population	Detailed life-history characteristics to increase accuracy	Limit reference point
Age-length relationship (von Bertalanffy growth curve)		
Length-egg production relationship	Known length-frequency distribution for an unfished population	
Natural mortality rate (*M*)		
CAVEATS		
Trend indicator only; does not determine causation		
Length and consistency of data strongly affects accuracy of model results		
Model results are sensitive to life-history assumptions		
Assumes ecosystem and fishery dynamics remain constant over time		

Sequential Trend Analysis

Type 3: Environmental Proxies
Environmental proxies use ecosystem indicators such as salinity, ocean temperature, rainfall, or river runoff to predict stock biomass and/or potential changes in a population for species whose life cycle is tightly linked to environmental variables. Due to the complexity of marine systems, however, a high degree of uncertainty is associated with the use of environmental proxies as it is often unclear whether or not a change in the environmental variable led to a direct change in population structure or abundance. Although environmental proxies can provide important data for management, they should not replace long-term monitoring of the fishery.

Example: Multivariate El Niño Southern Oscillation (ENSO) Index (MEI)
Recruitment of larvae to nursery habitats and/or recruitment of young fish to adult populations have significant effects on overall fishery dynamics and stock biomass. For example, studies conducted in the Gulf of California on leopard grouper (*Mycteroperca rosacea*) show that the density of larval recruits decreases exponentially with increasing water temperature caused by ENSO events (Aburto-Oropeza et al. 2007). Environmental fluctuations produced by ENSO events can alter the availability of suitable habitat as the biomass of Sargassum algae decreases with increasing water temperatures (Aburto-Oropeza et al. 2007). Including the MEI during larval recruitment phases improves the accuracy of assessment models to predict juvenile and adult biomass, creating adaptive management opportunities and improving fishery management techniques.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Time-series data concerning stock abundance from CPUE or fishery-independent surveys	Population model with life-history characteristics	Changes in population structure, biomass, and/or abundance over time in relation to changes in environmental variables
Time-series data concerning environmental proxies such as water temperature, rainfall, or river runoff	Understanding of processes that connect environmental parameters and fish production	
CAVEATS		
Trend indicator only; does not determine causation		

DECISION-MAKING METHODS

The following discusses two types of decision-making methods, both of which fall under the category of decision trees.

Decision Trees

Decision trees are step-by-step decision-making tools that can be scaled to fit any management framework and stock size. Given catch data and life-history characteristics, managers can use decision trees to examine trends in the population and better implement harvest control rules. In order to accurately determine stock trends, however, it is important for the resolution of input data to properly match underlying biological assumptions about the stock. For example, nearshore groundfish in Northern California exhibit sub-population dynamics characterized by short dispersal distances, small adult home ranges, and little connectivity between populations. Model inputs should reflect regional information rather than biological parameters that average data across the entire coastline.

Example 1: Length-Based Reference Point

Using easy-to-gather catch-length data, the Length-Based Reference Point Model provides managers with an assessment tool that evaluates whether a stock's spawning biomass is at or above a specified target reference point (Cope and Punt 2009). This information can then aid managers when determining optimal harvest levels. Data inputs include the proportion of the catch in a given length-class (L), length at 50% maturity, maximum length, and the length at which a stock's cohort provides the highest yield. These inputs are then used to calculate the proportion of mature fish, optimally sized fish, and large, highly fecund females in a population (Froese 2004). The length-based reference point method can be used even if data concerning mortality, fishery selectivity, and recruitment does not exist. Due to the use of specific size classes, this model may not be appropriate for stocks that exhibit little difference between mature (small) and optimum (medium) individuals.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	Detailed life-history characteristics to increase accuracy	Values to determine whether spawning biomass is above, at, or below the target reference point
Catch time-series	Knowledge of critical size classes with detailed age-length data	
Age-length data to estimate size-frequency distribution for an unfished or early exploited population and for the current population	Known age-length frequency distribution for unfished population	
CAVEATS		
Does not estimate optimal harvest levels		
Not appropriate for stocks with low "steepness" – little difference between mature (small) and optimum (medium) individuals		
Assumes catch-length data is representative of the fishery		

Decision Trees

Example 2: MPA-Based Decision Tree

Similar to the Length-Based Reference Point method, the Marine Protected Area-Based Decision Tree uses spatially explicit, easy to gather catch and age-length data to set and further refine total allowable catch (Wilson et al. 2010). Additionally, data gathered from inside no-take marine protected areas (MPAs) are used as a baseline for an unfished population. Model inputs are life-history characteristics such as size and age at maturity and natural mortality, catch-per-unit effort (CPUE) information, and age-length data collected from inside and outside marine reserves. Total allowable catch (TAC) is calculated using the current CPUE and target CPUE levels, and then further adjusted with each successive step of the decision tree. Although the MPA-Based Decision Tree allows managers to set and refine TAC, the model assumes populations within MPAs are representative of an unfished baseline. Also, because marine reserves are usually relatively small compared to fishing grounds, care must be taken when extrapolating results to areas that are significantly larger than the MPAs used as reference areas.

MINIMUM DATA REQUIREMENTS	OPTIMAL DATA REQUIREMENTS	MODEL RESULTS
Life-history characteristics	Detailed life-history characteristics to increase accuracy	Total allowable catch (TAC)
Catch-per-unit-effort (CPUE)	Knowledge of critical size classes with detailed age-length data	
Age-length data inside and outside no-take marine reserves	Known age-length frequency distribution for unfished population	
CAVEATS		
Not appropriate for stocks with low "steepness" – little difference between mature (small) and optimum (medium) individuals		
Assumes reserve conditions represent an unfished biomass		
Assumes reserve regulations are well enforced		

CONCLUSION

Many fisheries throughout the United States currently lack enough data to accurately assess target stocks using conventional stock assessment methods. However, continuing to fish stocks that are not assessed poses risks to the biological and economic sustainability of fisheries. Fortunately, new methods have been developed and tested that can allow managers to estimate a stock's vulnerability to fishing, stock abundance and productivity, sustainable yield levels, overfishing thresholds, and other important management reference points even when few data are available.

While these methods are relatively new, they have already been successfully used to assess several U.S. fish stocks, including Atlantic wolffish, New England red crab, and 50 groundfish species on the West Coast. The data-poor methods described here provide regional councils with the tools they need to develop assessments and set annual catch limits for all council-managed fisheries by the quickly approaching 2011 deadline. These methods, while subject to many caveats and qualifications, are generally much faster and less expensive than traditional stock assessments. While having long-term, continuous datasets for each species is the ultimate goal, data-poor methods can help managers extract more useful information from readily available data and reduce risks associated with fishing in ignorance.

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Glossary

Glossary

Accountable (syn. Accountability) – In reference to the attributes of a catch share program, participants are required to stay within their allocated share of the overall catch. *See* SEASALT.

Age-length data – Data comparing the length of an individual fish with its age.

All sources – In reference to the attributes of a catch share program, shares include all sources of fishing mortality (landed and discarded) and when combined do not exceed the catch limit. *See* SEASALT.

Allocation – Distribution of a secure share of the catch to individuals or groups.

Annual allocation unit – The measure which is used to determine the annual amount of fish each participant is allowed to catch, usually defined as total weight. It is often calculated as a percentage of the catch limit based on a participant's holdings. In the case of species and area-based program, the unit is also a specified area.

At-sea monitoring – The collection of information on fishing activities taking place at-sea, including harvesting, catch handling, biological sampling, fishing methods, and interactions with protected species. At-sea monitoring is conducted with onboard observers or an electronic monitoring system.

Average age at maturity (syn. Age at maturity) – The average age at which 50% of fish of a given sex reach reproductive maturity.

Bycatch (syn. Incidental catch, Non-target catch/species) – Fish other than the primary target species that are caught incidental to the harvest of the primary species. Bycatch may be retained or discarded. Discards may occur for regulatory or economic reasons (National Research Council [NRC], 1999).

Catch (syn. Harvest) – The total number (or weight) of fish caught by fishing operations. Catch includes all fish killed by the act of fishing, not just those landed (FAO, n.d.).

Catchability (syn. Vulnerability) – The extension to which a stock is susceptible to fishing. Catchability changes depending upon fish behavior and abundance and the type and deployment of fishing gear (Blackhart et al., 2006).

Catch accounting – The tracking of fishermen's catch, including landings and discards, against their share holdings.

Catch limit (syn. Total allowable catch) – The scientifically-determined acceptable level of fishing mortality.

Catch-per-unit-effort (CPUE) – The weight or number of fish caught with a specific unit of fishing effort (e.g., time and/or gear used).

Catch share (syn. Catch share program) – A fishery management system that allocates a secure privilege to harvest a specified amount of a fishery's total catch to an individual or group (groups can be community-based). A catch share program may also allocate a specific fishing area.

Catch time-series – Data showing total catch, either in weight or number of fish, compiled during a specific period of time (e.g., fishing seasons and/or years).

Community – The populations that live and interact physically and temporally in the same area (Blackhart et al., 2006).

Community Development Quota (CDQ) – A catch share program in western Alaska under which a percentage of the total allowable catch is allocated to eligible Alaskan villages to ensure continued opportunities to participate in western Alaskan fisheries and to provide economic and social benefits (Blackhart et al., 2006).

Community Fishing Quota (CFQ) – A catch share program in which shares are allocated to a specific community with certain rules and stipulations that tie the share, or the proceeds of the share, to that community.

Community Quota (CQ) – *See* Community Fishing Quota.

Concentration – A measurement of the percent of privileges held by one entity.

Concentration cap (syn. Accumulation limit) – The limit on the percentage of the shares any one shareholder can hold and/or fish.

Consolidation – The accumulation of shares by a relatively small number of shareholders.

Cooperative – 1. A type of catch share in which a group of participants is allocated a secure portion of the catch and collectively manage their allocation. 2. A group of people who come together to coordinate activities in some way.

Cost recovery – Partial or full recovery, by the government or management authority, of the costs of management, monitoring and/or enforcement of a fishery.

Derby-style fishing (syn. Olympic-style fishing (Canada), Race for fish) – Fishing conditions characterized by short seasons and severe competition for fish, often resulting in low profits and harvests that exceed sustainable levels.

Discard (syn. Regulatory discard, Economic discard) – To release or return a portion of the catch, dead or alive, before offloading, often because of regulatory constraints or a lack of economic value (FAO, n.d.).

Dockside monitoring – The monitoring of activities taking place upon a vessel's landing, including the weighing or counting of offloaded catch, biological sampling, and species make-up of catch.

Economic discard (syn. Commercial discard) – Fish that are not retained because they are of an undesirable size, sex, or quality, or for other economic reasons (16 U.S.C. 1802).

Ecosystem-based management – An approach that takes major ecosystem components and services – both structural and functional – into account in managing fisheries. It values habitat, embraces a multi-species perspective, and is committed to understanding ecosystem processes. Goals include rebuilding and sustaining populations, species, biological communities, and marine ecosystems at high levels of productivity and biological diversity so as not to jeopardize a wide range of goods and services from marine ecosystems while providing food, revenue and recreation for humans (FAO, n.d.).

Effort – *See* Fishing effort.

Effort-based – Privileges based on a percentage or absolute number of the total effort units available, often allocated as days, pots or trawl tows. This Design Manual does not consider effort-based programs to qualify as a catch share.

Effort creep – Changes in gear or vessel technology over time, which increase fishing efficiency and effectiveness.

Electronic monitoring – A technique employed to monitor at-sea fishing activities, often consisting of cameras, sensors and Global Positioning System (GPS) units used to record vessel and fishing location, fishing activity, catch (retained and discarded) and compliance with fishing rules.

Eligibility – Individuals or entities qualifying for initial allocation or permitted to acquire shares after the implementation of the program.

Enforcement – Measures enacted to ensure compliance with fishery regulations, including catch limits, gear use, and fishing behavior.

Enterprise Allocation (EA) – A type of catch share program in which shares are allocated to a fishing company who determines the management of the shares. This term has been used in Canada.

Equilibrium egg production – The level of egg production required to balance fish mortality (natural and/or fishing mortality) that occurs in a given stock.

Exclusive –1. In reference to the attributes of a catch share program, privileges are assigned to an entity (individual or group) and are clearly recognized and defendable by law. *See* SEASALT. 2. A program or privilege that permits only assigned users to participate, thereby ensuring that benefits and costs due to use of the privilege will accrue to the holder.

Ex-vessel value (syn. Dockside value, Landed value, Gross landed value) – A measure of the dollar worth of commercial landings, usually calculated as the price per pound for the first purchase of commercial harvest multiplied by the total pounds harvested.

Export value – The value of fishery products exported to a foreign nation. Export value is often higher than landed value due to value-added processing.

Fecundity – The potential reproductive capacity of a fish species, usually represented by the number of eggs produced in a reproductive cycle. Fecundity often increases with age and size (Blackhart et al., 2006).

Fish – Used as a collective term, includes molluscs, crustaceans and any aquatic plant or animal that is harvested.

Fish stock – *See* Stock.

Fish tags (syn. Tagged-based system) – A physical tag or marking placed upon a fish upon harvest, often used to monitor catch, ensure compliance, reduce illegal fishing, and assist in traceability.

Fish tickets – A record of purchase and documentation of harvest of a public resource. The fish ticket often records the species landed, the weight of each species, the gear used to catch the fish, catch dates, the processor, the price paid for the fish, and the area fished (Alaska Department of Fish and Game [ADFG], n.d.).

Fishery – The combination of fish and fishermen in a region, the latter fishing for similar or the same species with similar or the same gear types (Blackhart et al., 2006).

Fishery information – The information needed in a fishery for science and compliance, which can be collected through various forms of monitoring and self-reporting.

Fishery Management Council (FMC) – A regional fisheries management body established by the Magnuson-Stevens Fishery Conservation and Management Act to manage fishery resources in eight designated regions of the U.S. (16 U.S.C. 1852).

Fishery Management Plan (FMP) – A document prepared under supervision of the appropriate fishery management authority for management of stocks of fish judged to be in need of management. The plan must generally be formally approved. An FMP includes data, analyses and management measures (FAO, n.d).

Fishing community – A community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs and includes fishing vessel owners, operators, crew and processors that are based in such a community (16 U.S.C. 1802).

Fishing effort (syn. Effort) – The amount of fishing gear of a specific type used on the fishing grounds over a given unit of time (e.g., hours trawled per day, number of hooks set per day, or number of hauls of a beach seine per day). Sometimes referred to as effective fishing effort (FAO, n.d.).

Fishing mortality (syn. Mortality) – A measurement of the rate of removal from a population by fishing. Fishing mortality can be reported as either annual or instantaneous. Annual mortality is the percentage of fish dying in one year. Instantaneous mortality is that percentage of fish dying at any one time (Blackhart et al., 2006).

Group-allocated – A catch share program in which privileges are allocated to a clearly defined group of people, often a community or fishing association.

Growth rate – The increase in weight or length of a fish each year or season, divided by its initial weight; generally averaged for a species or stock, the rate at which individual fish grow.

Hail in / Hail out (syn. Hail program) – An approach used for monitoring that allows a vessel operator to communicate their fishing activity to a central clearinghouse. Reporting often includes commencement and completion of a fishing trip, location of fishing activity, and the intended point of departure and offloading of harvest.

Harvest – The total number or poundage of fish caught and kept from an area over a period of time (Blackhart et al., 2006).

High-grading (syn. Economic discards) – Form of selective sorting of fish in which higher value, more marketable fish are retained and fish that could be legally retained, but are less marketable, are discarded (NRC, 1999).

Individual Fishing Quota (IFQ) – A type of catch share program in which shares are allocated to individuals or individual entities. Recipients are generally fishermen and shares may or may not be transferable.

Individual Quota (IQ) – A type of catch share program in which shares are allocated to individuals or individual entities. Recipients are generally fishermen and shares are not transferable.

Individual Transferable Effort Quota (ITEQ) (syn. Effort-based) – A percentage of the total allowable effort, often in the form of days-at-sea or a set amount of gear, allocated to individuals. ITEQ is tradable between eligible participants.

Individual Transferable Quota (ITQ) – A type of catch share program in which shares are allocated to individuals or individual entities. Recipients are generally fishermen and shares are transferable.

Individual Vessel Quota (IVQ) – A type of catch share in which shares are allocated to an individual vessel. Shares are attached to the vessel rather than the vessel owner and shares may or may not be transferable. This has been used most commonly in Canada.

Individually-allocated – A catch share in which privileges are allocated to individuals or individual entities.

Input controls (syn. Input regulations, Input-based regulations, Input-based controls, Input measures) – Management instruments used to control the time and place as well as type and/or amount of fishing with the view to limit yields and fishing mortality; for example, restrictions on type and quantity of gear, effort and capacity and closed seasons (FAO, n.d.).

Intrinsic rate of increase (*r*) – The rate at which a stock or population increases in size; recruitment plus growth minus natural mortality.

Landings – The number or weight of fish offloaded at a dock by fishermen. Landings are reported at the points at which fish are brought to shore (Blackhart et al., 2006).

Large Marine Ecosystem – A geographic area of an ocean that has distinct bathymetry, hydrography, productivity, and trophically dependent populations (FAO, n.d.).

Length at 50% maturity – *See* Size at maturity.

Length-based data – Data based on the length of fish (e.g., length at 50% maturity and maximum length).

Length-frequency data – Data listing the number of individual fish at each length interval for a sample or catch; also known as size-frequency data.

Life-history characteristics – Basic biological information such as size and age at maturity, natural mortality, and fecundity for a specific species.

Lifetime egg production (LEP) – The number of eggs produced by a single female over the course of her lifetime; also known as egg production per recruit.

Limited – In reference to the attributes of a catch share program, catch limits are set at scientifically-appropriate levels. *See* SEASALT.

Limited access (syn. Controlled access, License limitation, Limited entry) – A fishery management approach that limits the number of fishermen participating in a fishery, usually by issuing a limited number of licenses.

Limited Access Privilege (syn. Limited Access Privilege Program) – In the U.S., a Federal permit, issued as part of a limited access system under section 303A of the Magnuson-Stevens Fishery Conservation and Management Act to harvest a quantity of fish expressed by a unit or units representing a portion of the total allowable catch of the fishery that may be received or held for exclusive use by a person (16 U.S.C. 1802). All Limited Access Privilege Programs are catch shares, but not all catch shares are Limited Access Privilege Programs.

Limit reference point – The point beyond which a stock or population is no longer biologically sustainable; usually expressed as maximum fishing mortality or minimum levels of biomass.

Logbook (syn. Logsheet) – A detailed, usually official, record of a vessel's fishing activity registered systematically onboard the fishing vessel, usually including information on catch and species composition, the corresponding fishing effort and location (FAO, n.d.).

Magnuson-Stevens Fishery Conservation and Management Reauthorization Act – The primary law governing marine fisheries management in U.S. federal waters (16 U.S.C. 1801 et seq).

Marine reserves – Sections of open ocean or coastline where extractive activities are illegal; also known as marine protected areas.

Maximum age – The oldest fish in a sample or catch, or the oldest recorded fish for a specific species.

Maximum Economic Yield (MEY) – The catch level that corresponds to the highest amount of profit that could be earned from a fishery (Blackhart et al., 2006).

Maximum length – The biggest fish, length-wise, in a sample or catch, or the biggest fish recorded for a specific species.

Maximum Sustainable Yield (MSY) – The largest average catch that can be taken continuously (sustained) from a stock under average environmental conditions. This is often used as a management goal (Blackhart et al., 2006).

Monitoring (syn. Catch control) – The collection of fishery information for the purposes of science, including setting catch limits and assessing stocks, and ensuring accountability, including catch accounting and enforcing fishery regulations.

Monte Carlo simulations – A randomized statistical simulation that produces the probabilities of various outcomes.

Mortality – A measurement of the rate of death of fish, resulting from several factors but mainly predation and fishing.

Multi-species fishery - A fishery in which more than one species is caught at the same time. Because of the imperfect selectivity of most fishing gears, most fisheries are "multi-species." The term is often used to refer to fisheries where more than one species is intentionally sought and retained (NRC, 1999).

Natural mortality – The number of fish removed from a stock due to natural death (e.g., predation, disease, etc.).

Non-target species (syn. Bycatch, Incidental catch) – Species not specifically targeted as a component of the catch but which may be incidentally captured as part of the targeted catch (Blackhart et al., 2006).

Onboard observer (syn. Observers) – A certified person onboard fishing vessels who collects scientific and technical information on the fishing operations and the catch. Observer programs can be used for monitoring fishing operations (e.g., areas fished, fishing effort deployed, gear characteristics, catches and species caught, discards, collecting tag returns, etc.) (FAO, n.d.).

Ontogenetic growth shifts – Changes in an individual, stock, or population due to development/growth (e.g., life cycle stages).

Open access – Condition in which access to a fishery is not restricted (i.e., no license limitation, quotas, or other measures that would limit the amount of fish that an individual fisher can harvest) (NRC, 1999).

Optimum Yield (OY) – The harvest level for a species that achieves the greatest overall benefits, including economic, social and biological considerations. Optimum yield is different from Maximum Sustainable Yield (MSY) in that MSY considers only the biology of the species (Blackhart et al., 2006).

Overcapacity – A level of fishing pressure that threatens to reduce a stock or complex below the abundance necessary to support Maximum Sustainable Yield and allow an economically sustainable fishing industry (Blackhart et al., 2006).

Overcapitalization (syn. Excess capacity) – In the short-term, fishing capacity that exceeds the capacity required to capture and handle the allowable catch. In the long-term, fishing capacity that exceeds the level required to ensure the sustainability of the stock and the fishery at the desired level. Fishing capacity in excess of what is required to reach the agreed catch or effort objectives materialized by agreed target reference points (FAO, n.d.).

Overfished – State in which a fish stock is below one half the biomass that produces Maximum Sustainable Yield.

Overfishing – A rate of fishing mortality that, unchanged, will result in an overfished state.

Permit Bank (syn. Quota Bank, Community License Bank) – Collection of harvesting privileges in which certain rules and stipulations govern the use of the privileges and the distribution of benefits.

Public resource (syn. Public good, Common resource) – A resource that is held collectively by all people, often managed by the government on their behalf.

Quota – The maximum number of fish that can be legally landed in a time period. It can apply to the total fishery or an individual fisherman's share under a catch share program (Blackhart et al., 2006).

Quota pounds (QP) (syn. Annual allocation) – *See* Annual allocation unit.

Quota shares (QS) – The percentage of the annual catch limit to which a catch share privilege holder has access to harvest.

Race for fish (syn. Derby-style fishing, Olympic fishing) – A pattern of fishing characterized by an increasing number of highly efficient vessels fishing at an increasing pace, with season length becoming shorter and shorter (FAO, n.d.).

Recruit – An individual fish entering the fishable stage of its life cycle.

Recruitment – The number of fish added to a fishable stock each year due to growth and/or migration into the stock.

Recruitment pattern – A pattern that characterizes recruitment over multiple seasons; may be regular or highly irregular depending upon the species.

Regulatory discards – Fish harvested in a fishery which fishermen are required by regulation to discard whenever caught, or are required by regulation to retain but not sell (16 U.S.C. 1802).

Scaled – In reference to the attributes of a catch share program, management units are set at the appropriate biological level, taking into consideration social and political systems. *See* SEASALT.

SEASALT – A mnemonic that describes commonly occurring attributes of catch shares.

Sector – 1. (of a fishery) A specific division of a fishery due to unique characteristics including, management regulations, gear types, fishing locations, purpose of activity, or vessel size. 2. (type of catch share) – A type of group-allocated catch share program, most commonly used in New England.

Secure – In reference to the attributes of a catch share program, the tenure length of shares is sufficiently long for participants to realize future benefits. *See* SEASALT.

Shareholder (syn. Privilege holder) – An individual or entity who holds a secure share in a catch share fishery.

Single-species fishery – A type of fishery in which fishermen target only one species of fish, although it is usually impossible not to catch others incidentally (Blackhart et al., 2006).

Size at maturity – The weight or length at which 50% of fish of a given sex reach reproductive maturity.

Spawning potential ratio – The ratio of spawning potential per recruit of a fished stock relative to the spawning potential per recruit of an unfished stock.

Spawning stock biomass – The total weight of males and females in a stock or population that contribute to reproduction.

Spawning stock biomass per recruit (SSBPR) – The expected lifetime contribution of the average recruit, or a recruit of a specific age, to the spawning stock biomass.

Species and area-based (syn. Territorial Use Rights for Fishing) – A catch share program in which participants are allocated access privileges based on specific areas, but are required to stay within catch limits for harvested species.

Species-based – A catch share program in which privileges are based on the number or weight of fish caught.

Stewardship – Responsible management of resources for future generations, such as maintaining populations of target and non-target species, protecting wildlife, conserving key habitats, and strengthening ecosystem resilience.

Stock – A part of a fish population usually with a particular migration pattern, specific spawning grounds, and subject to a distinct fishery. A fish stock may be treated as a total or a spawning stock. Total stock refers to both juveniles and adults, either in numbers or by weight, while spawning stock refers to the numbers or weight of individuals that are old enough to reproduce (Blackhart et al., 2006).

Stock age structure – The composition of a stock detailing the number of fish in different age classes.

Sustainable fishing – Fishing activities that do not cause or lead to undesirable changes in the biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next (FAO, n.d.).

Sustainable harvest (syn. Sustainable catch, Sustainable yield) – The biomass or number of fish that can be harvested without reducing the stock biomass from year to year, assuming that environmental conditions remain the same (Blackhart et al., 2006).

Tag-based – A system of catch shares in which a set number of tags are allocated in the beginning of the year based on an individual's holdings and every fish or standardized delivery weight must be tagged to be accepted for delivery.

Target reference point – The point to which a stock or population should be managed to maintain a sustainable

fishery; usually expressed as maximum fishing mortality or minimum levels of biomass

Target species (syn. Directed fishery) – Those species primarily sought by the fishermen in a particular fishery. There may be primary as well as secondary target species (FAO, n.d.).

Tenure length of shares – The duration for which an individual's or group's share is allocated.

Territorial Use Rights for Fishing (TURF) (syn. Species and area-based catch share) – An area-based management program, which assigns a specific area to an individual, group or community. To meet the definition laid out in the Design Manual, one or more species in the area must have a scientifically-based catch limit.

Time-series data – Data compiled during a specific time period, usually at regular intervals.

Total allowable catch (TAC) (syn. Catch limit) – The annual recommended or specified regulated catch for a species or species group (Blackhart et al., 2006).

Total catch – The landed catch plus discard mortality (Blackhart et al., 2006).

Transferable (syn. Transferability, Tradable) – In reference to the attributes of a catch share program, shareholders can buy, sell and/or lease shares. *See* SEASALT.

Vessel Monitoring System (VMS) – A satellite communications system used to monitor fishing activities. For example, to ensure that vessels stay out of prohibited areas. The system is based on electronic devices, which are installed onboard vessels. These devices automatically send data to a shore-based "satellite" monitoring system (Blackhart et al., 2006).

von Bertalanffy growth coefficient (*k*) – An assessment model parameter used to predict the length of an individual fish based upon its age.

Vulnerability (syn Catchability) – Equivalent to catchability, but usually applied to a specific part of the fish stock, such as individuals of a specific size length (Blackhart et al., 2006).

Yield-per-recruit (YPR) – The expected lifetime yield, in terms of weight, of an individual fish of a specific age.

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Fishery managers and stakeholders have been increasingly interested in catch shares as an approach for managing fisheries. This interest has been bolstered by recent reports indicating that catch share implementation "halts, and even reverses,…widespread [fishery] collapse" (Costello et al., 2008) and helps drive economic growth. Understanding different design options and how they can achieve various biological, economic and social objectives will help managers and stakeholders make informed decisions about catch share programs. This Design Manual is the first-ever comprehensive overview and roadmap of catch share design, drawing on hundreds of fisheries in over 30 countries, and expertise from over 60 fishery experts from around the world. However, the Design Manual is not prescriptive: It is a series of questions whose answers help guide and inform the catch share design process. Detailed discussions of design elements are coupled with case studies to outline and highlight options.

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