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WORKING PAPER SERIES 4

Market Design for Limited Access Privileges Programs in U.S. Fisheries

Proceedings of a workshop organized by Ecotrust

October 3–4, 2007

"I believe that enormous value can be created through market design. It requires a lot of work, but it requires much less work to come up with an elegant design and implement it than to do what's usually done, which is to implement a bad design and then fight over it for twenty years."

—Peter Cramton

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Market Design for Limited Access Privileges Programs in U.S. Fisheries: Proceedings of a workshop organized by Ecotrust

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About Ecotrust
Ecotrust is a conservation organization committed to strengthening communities and the environment from Alaska to California. We work with Native peoples and in the fisheries, forestry, and food sectors to build a regional economy based on social and ecological opportunities.

About the Working Paper Series
Ecotrust Working Papers integrate ecological and socioeconomic data to present a more holistic view of human interactions with the natural world. Drawing upon the research and analysis of a wide range of project partners, this series presents the results of an ongoing effort to envision a more reliable prosperity for the region's citizens.

A Note on This Working Paper

This document synthesizes the workshop discussion, both as an *aide memoire* for the participants and as a summary for those who did not attend. For the sake of brevity, we have shortened and paraphrased the words of workshop speakers—while making every effort to remain faithful to their intents. Edward Backus, Ecotrust's VP Fisheries, and Astrid Scholz, Ecotrust's VP Knowledge Systems, organized the workshop. Howard Silverman, Ecotrust's Director of Public Information, edited these proceedings.

Acknowledgments

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Executive Summary

In October 2007, Ecotrust convened a two-day workshop to bring experts in market design together with marine policy "market makers." Twenty-five people with agency, philanthropic, non-profit and for-profit expertise in the United States, Canada and Mexico joined us at the Harvard Business School to discuss Limited Access Privileges (LAP) programs and market-based incentives for fisheries management.

A key goal of the workshop was to learn from experiences in the design of markets for carbon emissions trading, health care clearinghouses, broadcast spectrum auctions and so on, and to apply that knowledge to the design of Limited Access Privileges programs and marine market instruments.

The workshop was conducted as a structured discussion between the invited experts and regional market makers, and centered on the following agenda elements:

- A synthesis and overview of current Limited Access Privileges programs;
- An overview of market design processes and objectives, with specific reference to the challenges encapsulated in the U.S. Commission on Ocean Policy (USCOP) recommendations;
- Discussion in smaller groups, using New England, West Coast, Gulf of Alaska and Sea of Cortez (Mexico) fisheries as discussion cases;
- A summary of design features identified and risks associated with alternative systems;
- And a discussion of research needs as well as legal or regulatory impediments.

Summary of Results

- A new awareness in the fisheries sector that the concepts of market design can be helpful in addressing market deficiencies
- An appetite within industry to seek real applications of tools in "sub-problems" of different fisheries; e.g. price transparent "all-in" auctions (New England), sector allocation splits (Alaska), bycatch cap-and-trade and spot markets (Alaska, New England), marine protected area design and development (Mexico) and many others
- The idea of a "clearinghouse" to expedite information sharing, project development and practical project implementation
- A greater understanding of the need to:
  - Develop and deploy scenario tools that demonstrate how market mechanisms would operate and how benefits would accrue to participants
  - Strategize on the development of actual and practical projects in New England, West Coast, Gulf of Alaska/Bering Sea and Aleutian Islands, and Mexico
  - Replicate the workshop in various forms, ideally around specific projects and opportunities
  - Build "unlikely partner" tactics in the development of package solutions that could make it through fishery management council processes

Introduction

With too many fleets pursuing declining fish stocks, many fishery managers and policy makers see market-based incentives as a way to align the long-term interests of fishermen and the fish they harvest. Others are concerned that "privatization" of the oceans would be analogous to selling off the national forests. Today, the problem is serious enough that conservation, community and business interests are reaching out to each other for assistance.

We believe that the successful design of market solutions to fisheries problems will benefit from the expertise of economists, derivatives experts, financial analysts and others who have been involved in the design of financial instruments, auctions and markets—in arenas such as the auctions of licenses for broadcast spectrum, carbon emissions trading and the development of health care markets.

The central feature of current market efforts in fisheries is quota systems, the latest variation in the U.S. being called Limited Access Privileges. The federal government has framed the objectives in the recently renewed Magnuson–Stevens Fishery Conservation and Management Act (December 2006), but market instruments are being designed ad hoc and by non-experts with vested interests.

The workshop reported in this proceedings was designed to advance the discussion and design of Limited Access Privileges in particular—and marine market instruments more generally—by bringing experts and practitioners from other markets sectors together with regional fisheries practitioners to explore and discuss how LAPs would be best designed to achieve the various goals and objectives articulated in federal fisheries legislation and by regional stakeholders.

The U.S. Commission on Ocean Policy recognized the importance of LAPs as a tool for achieving the mandates of the Magnuson–Stevens Fisheries Conservation and Management Act (MSA), and issued a range of recommendations, calling for national guidelines that require LAP programs to:

- Specify the biological, social and economic goals of the plan; recipient groups designated for the initial quota shares; and data collection protocols.
- Provide for periodic reviews of the plan to determine progress in meeting goals.
- Assign quota shares for a limited period of time to reduce confusion concerning public ownership of living marine resources, allow managers flexibility to manage fisheries adaptively, and provide stability to fishermen for investment decisions.
- Mandate fees for exclusive access based on a percentage of quota shares held. These user fees should be used to support ecosystem-based management. Fee waivers, reductions or phase-in schedules should be allowed until a fishery is declared recovered or fishermen's profits increase.
- Include measures, such as community-based quota shares or quota share ownership caps, to lessen the potential harm to fishing communities during the transition to dedicated access privileges.
- Be adopted only after adequate public discussion and close consultation with all affected stakeholders, to ensure community acceptance of a dedicated access plan prior to final Regional Fishery Management Council approval.

  (U.S. Commission on Ocean Policy, 2004, *An Ocean Blueprint for the 21st Century: Final Report,* Washington, D.C., U.S. Commission on Ocean Policy, p. 290)

Goals of Workshop

1) Expose a diverse range of persons working in U.S. fisheries to market design expertise from other market sectors based on public trust assets.

2) Encourage cross thinking about the application of market design strategies and structures to current developments in "limited access" or "quota" programs in U.S. regional fisheries.

3) Explore the issues and challenges in practical applications through case examples, including: New England groundfish restructuring and Bering Sea crab "rationalization" review.

4) Explore the development of practical and real-time projects in the actual design of LAP programs with various entities and the regional fishery management councils in 2008–2009.

Opening Comments by Ed Backus

Ecotrust defines successful resource management as an approach that explicitly addresses economic, ecological and social equity issues and outcomes. Therefore, a key question for this workshop is: How do we establish a successful "3e" approach to managing public trust assets such as fisheries?

The adoption of Limited Access Privileges programs is increasing in the United States now that Congress has lifted the moratorium on new quota programs. While many clear benefits have been shown to result from such programs, improvements are clearly needed, particularly in the area of social equity. How do we match and balance individual incentives with the public interest? How do we distinguish between interests and rights?

Many fishermen and other fishery participants fear this trend of "privatization" in perpetuity. In New Zealand's quota fisheries, for example, the government explicitly acknowledged that its approach was not designed to address local community issues, and so access rights were granted in perpetuity.

In developing this workshop we asked ourselves: What if we stepped back and drew on the experiences from other resource sectors where public assets have been developed through market mechanisms? Could we not learn from those processes and market results?

Quota programs in fisheries are a controversial topic. Many of you have very different views on "quota" programs, some of you have thrived in them, some of you are fighting them, and some of you want to expand them. We have not gathered a choir here; we have tried to create a forum for honest dialogue and learning.

But given the market orientation and trend to address overfishing, the race for fish, overcapitalization, improved business viability, bycatch reduction, the use of catch history, intergenerational transfer and other unaddressed social issues, we see the opportunity for a design approach. The design approach will hopefully be a place to chew over the issues and where disagreement can be used to craft solutions.

There are a range of U.S. quota programs that have been established since 1995. There is a very advanced case in British Columbia and emerging issues in New England, along the West Coast of the U.S., in the Gulf of Alaska and in the Gulf of Mexico.

The reauthorized Magnuson–Stevens Fisheries Conservation and Management Act now allows the formation of community and regional fishing associations and the use of auctions to distribute access to fisheries. Alaska has Community Development Quota and Community Quota Entity programs that function as community trusts. In fact, during the development of the Alaska halibut and sablefish programs in the early 1990s, the process seriously considered the use of quota auctions.

On a final note, we are not here to establish national standards for Limited Access Privileges programs or to establish a template of market design that fits all fisheries. We are here to work on economic, social and ecological outcomes in different fisheries, using the tools of market design.

Experiences with Limited Access Privileges Programs

The experiences of market makers from Alaska and British Columbia who have a close familiarity with Limited Access Privileges programs served to highlight key strengths, issues, frustrations, costs, and opportunities for program improvements.

B.C. Groundfish—Danielle Edwards

All of the B.C. commercial groundfish fisheries are managed under an individual transferable quota (ITQ) system. The regulations are the outcome of a consensus-based negotiation process that has been a great success overall. But the market end of the system has been left to work itself out, without consideration of conditions leading to market failure.

I manage a license bank to purchase bycatch quota and am personally responsible for 50 to 100 of the thousands of trades each year. To do a trade means calling as many as half a dozen people to find fish, setting up the trade and then ensuring that the person you are trading with signs their paperwork and sends it to the Department of Fisheries and Oceans (DFO). It's a very cumbersome process.

We have a very thin market. More than 60 species-area units are split between roughly 800 licenses and 300 vessels. At any given time, it may be near impossible to find the quota that one is trying to find. Those with small allocations might just sit on the license. In some cases, less than 50 percent of the total allowable catch (TAC) is caught each year, mostly due to the low value of these species.

We have high transaction costs. There is no cost for the actual transfer done by the federal fisheries department, but there is a time cost for setting up transfers and a monetary cost if transfers are done by the private quota trading company.

There is a market-power issue, with a few powerful individuals that are vertically and horizontally integrated in the fishery. There is no transparency in the quota system—no public registry and no means to find out from the department what individual quotas are uncaught.

All groundfish vessels must account for their bycatch and find quota for everything that they catch. We have two types of monitoring: Outside trawl groundfish vessels have 100 percent onboard observers, and the hook-and-line fleet has 100 percent electronic monitoring. Dockside monitors verify all groundfish landings.

For the electronic monitoring, there are two cameras that capture all the fishing activity on the boat. A GPS unit captures date, time and location information and everything is stored on a hard drive. At the end of the trip, the hard drive is removed and the camera footage and location data are used to audit the fisherman's logbook.

For the longline vessels, 10 percent of the hauls are randomly audited, meaning that the video is compared to the logbook, and the logbook to the dockside monitoring data. If they don't match, then all the camera coverage is viewed at the fisherman's expense.

For the vessels I work with, the monitoring costs for each trip are about $500–$600. Relative to the value of the catch, that monitoring cost can vary greatly, and that's a big concern. If all the video is reviewed, then the cost is closer to $3,000–$4,000. Because of the reluctance to ask somebody to pay that much, there's been some tolerance, and I think there has been good compliance, but not perfect.

Alaska Crab—Phil Smith

In the last several years, from the mid-'90s on, stocks have been declining, and the Department of Fish and Game has set what are called harvest guidelines. "Ok, we don't know how many fish or crab there are, but you can take between 12 million and 15 million pounds of, say, Bristol Bay red king crab this year. We're going to have observers on board. We're going to require daily reports on the number of pots you're putting down and the catch coming up. And we're going to shut it down if it's bad, or let you catch the limit if it's good."

That's how the sablefish plan was implemented, and a lot of the fishermen saw it and thought, "That looks good." And when the pollock fishermen went to D.C. and came away with the American Fisheries Act, which essentially rationalized the pollock fishery overnight, they looked at that and said, "That's really good; we're going to make money."

Meanwhile the crab fishermen were overcapitalized, and market conditions were all

over the place. They went to Washington and said, "Hey, we want some of that rationalization." Washington said, "We're going to direct the (Alaska Fisheries Management) Council to devise a program and consider such things as community needs, processor shares and so on. And we're also going to fund a buy-back program to remove some steel from the water."

In 2002, the Council adopted the basic structure of the crab program, which governs access to all nine Bering Sea crab species. One type of quota is allocated to permit holders, based upon fishing history, and three percent of all the harvesting quota was allocated to crew members, who actually did the fishing; most crab vessel owners don't fish. Another type of quota, which remains extraordinarily controversial, is processing quota. This attempts to overlay "rationalization" onto the whole market. Once a harvester captures his fish, now we have a program that tells him to whom he may sell it. Ninety percent of harvested crab must be sold to quota-bearing processors, and only 10 percent is free market. There is also a binding arbitration mechanism, which is sort of a toothless tiger, for disputes between harvester and processor.

The one saving grace is that there are requirements for periodic reviews by the Council, and for the first time in fishery management that I'm aware of, there are stringent data reporting requirements. Processors must report their costs and their profits, and harvesters and vessel owners must do likewise. These data are aggregated by a third party and provided to the Alaska Fishery Science Center in Seattle.

The impact of the program was absolutely dramatic. In 2004, there were 248 boats in the Bristol Bay red king crab fishery, and in 2005 there were 89 boats. That decapitalization was unexpectedly rapid and caused a lot of pain—there were a lot of crew members sitting on the beach. They might not have had much of a job before, nevertheless it was a payday.

This process wouldn't have happened without incredible political power behind it. First, telling the Council to design it, and then ramming it through Congress as a rider on an appropriation act. Those of us who have fought for years to get the politics out of fisheries got rolled entirely. I think it's an example of how not to approach these things.

Alaska Halibut—Mark Lundsten

In Alaska, we had a great advantage that, since the 1920s, when the Halibut Commission was formed, people were used to living with limits. The International Pacific Halibut Commission manages halibut in Washington, British Columbia and Alaska. If stocks are not managed throughout their range, the turn to the individual fishing quota (IFQ) program will be unpredictable, because you never know what the other guys will do with their share of the fish.

Our system didn't come through council committees. It came through phone calls and meetings with one Council member, one person from Sitka, a person from Petersburg and a person from Homer. We had the critical mass—a coalition that we identified before the fact.

Historical participation was the allocation choice, but no one really knew where it would go. Now with computer models, you can know where every allocation of every rationalization system is going to go. I think it should be an owner/operator family farm, pure and simple. And when you're out, you're out.

What I would do is make a system that's accessible to newcomers—that's the best you can do. So the crew can buy in. The transferability of that ownership should be very tightly controlled: who can trade it, how much you can own of it and how you use it. You have to be a bona fide crew member to buy it, you have to be on the boat to use it, you can only sell it to those other people—strictly controlling that market.

Background Presentations on Market Design

Presentations by market design experts offered workshop participants a chance to consider comparative difficulties and successes in the design and implementation of markets for other goods and services.

Peter Cramton

This is an exciting opportunity—to have this much brain power here focused on this very important problem. I believe that enormous value can be created through market design. It requires a lot of work, but it requires much less work to come up with an elegant design and implement it than to do what's usually done, which is to implement a bad design and then fight over it for twenty years.

One industry that I've been involved with is mobile phones, which all use licensed spectrum that they purchased via auction from the FCC, our communications regulator. Before 1994, the licenses were assigned through what's commonly called a "beauty contest," where, in essence, everyone goes to the FCC and says, "I've got a wonderful idea, I'd like to use some spectrum, please give it to me." There were so many people that it took the FCC a decade to allocate licenses. And so then they said, "Okay, let's apply the spectrum randomly." And then of course, some dentist in Boston gets the New York City license, which is worth hundreds of millions of dollars, and there's a big stink. So now, of course, we auction them off. And in fact, many of the large companies actually wanted auctions, because they wanted a sensible process to get the spectrum that they very much needed for their businesses.

Spectrum is organized by bandwidth, a particular frequency in the spectrum, and also by geographic location. Each allotment of bandwidth is different, but licenses with neighboring frequencies are very similar, so there's substitution as well. I'm working right now with a wireless company that wants to put up 40,000 cell sites—additional antennas on the existing sites—an investment of around $15 billion. Certainly, every industry includes investment, and there's lots of investment that a fisherman makes, but a lot of that investment is portable. It's kind of like airlines; an airline buys a plane and that's portable capital. The significance is that with portable capital you can have shorter-term markets. So you can have 1-year or 2-year markets, as opposed to a market for spectrum, in which it makes sense to have a very long-term market, say 20 years.

Another industry that I'm currently working on is greenhouse gas allowances, in particular the Regional Greenhouse Gas Initiative (RGGI) in the Northeast and Mid-Atlantic states. Here again, the government objective, the primary objective, I believe should be efficiency. Let's achieve the target level of emissions at minimal cost. It's a divisible good; every ton of carbon is the same. There are no location issues; the location is the world. So that simplifies the market. Also it's a long-term pollutant. It doesn't matter if you emit next week or next year; the emissions accumulate over decades. What all this means is that a short-medium-term market makes sense.

One of the big questions is how we should assign these allowances. Quite frankly, if I were a big emitter of carbon, what I would like is grandfathering. That would be great for me because then I would get this entitlement to pollute for the rest of time, if it's structured that way. I don't favor this argument, especially for pollution, because I don't think the polluter has an entitlement to pollute forever after. I think that our ecosystem belongs to the public, and to the extent that there are costs associated with emissions—that those costs should be paid for by the emitter and not by me.

The argument that is frequently made by the emitter is: If I have to go to the auction to buy allowances, then I'm going to raise the cost of electricity. I completely agree that consumers don't like high electricity prices, but the reality is that the program is what's raising the price of

electricity, not whether you grandfather or auction. For example, if I gave you a bag of gold, you'd sell it for the market price, and if instead we held an auction for the bag of gold, you'd pay the market price. Has the gift to you, or the auction, affected the price of gold? The value's the same. What determines the price of gold? The scarcity of the resource. It's exactly the same thing with greenhouse gas allowances. If I'm given them, the allowance has an opportunity cost; I have the opportunity of selling them for the market price. The price of electricity still reflects the opportunity cost, and that's the market price.

Timber auctions are maybe the most similar to fisheries—you have a lot of small businesses. I worked on a large project in British Columbia. What we did was to auction some percentage and then use the auction price to set the prices for the long-term tenures. Some of the issues here are the importance of local markets and the absence of competition, because of the difficulties of transportation. Logging is done with helicopters, and it's very expensive to move this stuff around—so you've got limited competition.

Market design involves many steps, and I want to run through them: objective, product design, auction design, transition, testing, and final implementation.

The first is the objective: What's the purpose of the market? I've mentioned efficiency already—maximizing gains from trade, creating as much value as possible, having reliable price signals, being concerned about competition in the marketplace, and addressing market power issues. Revenue maximization is sometimes an objective; sometimes it's the overriding objective. Transparency is often an objective, especially for public assets such as fisheries. Neutrality: treating people equally and fairly. Risk minimization is important for all the market participants. This

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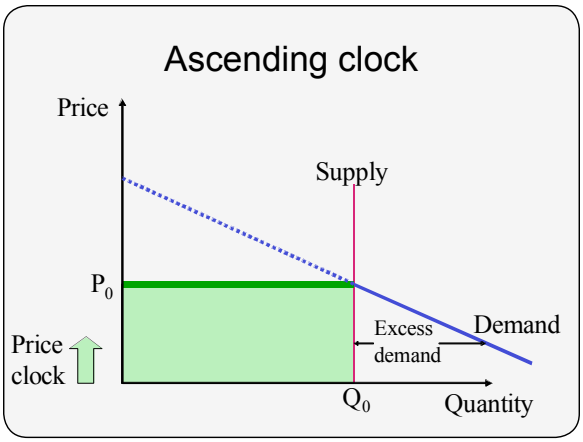
>
> —Peter Cramton



is especially important in electricity, where the dollars involved are extremely great and there can be tremendous price volatility in the spot market. Liquidity is an issue; it's good to have a secondary market. You may want to establish derivative products. Simplicity is an important objective. It should be simple for the participants, for the market operator and for the regulator. Simple does not mean the shortest market rules; short market rules can often be unbelievably complex for the participants. Lastly, consistency: meaning consistent with other elements of the market and, ideally, consistent with best practices. These objectives are often complimentary. So we can address all of them with a single market design.

Product design is one of the most important steps. Thinking about greenhouse gases, the questions include: What is the relevant area? What is the time period? Can the allowance be banked or borrowed? What sources are covered? Are we going to grandfather or are we going to auction?

With auction design, there are lots of possibilities. Is it going to be a sealed-bid (static) auction or a dynamic auction? How do bidders express their preferences? What's the pricing rule? What's the information policy—what do the parties know when they're bidding? How frequently are auctions conducted—this would be very important for risk management—and how far in advance, which can affect composition?

One example of an auction is the uniform-price auction or the single-price auction. What happens is the bidders put in bids, and the auctioneer aggregates the bids to form the demand curve, which is crossed with the supply curve to determine the clearing price. All the bids above the clearing price are won.

One of the nice things about a uniform-price auction is that it assigns to the highest value. Nor does it have quantity risk. You can be a small bidder and say, "I want to buy this much quantity and I want to pay the market price." Well, that's what the uniform price auction is going to do for you. We often do this as a dynamic process. We start at a low price, running an ascending clock auction, asking bidders how much they would like at this low price. They say they want a lot because the price is so low. We have excess demand. Then we raise the price, and keep raising it until we find the market clearing price.

This can be done with a single product. It's even more valuable with many products—as you might have with fisheries. For example, you might have so much haddock, tuna and so on, and you might want to have a portfolio of allowances or quota. The market design can accommodate that.

I've just run out of time, but another important step is the transition. Every market has a transition. Sometimes it's simple, and sometimes it's complicated, depending on the circumstances.

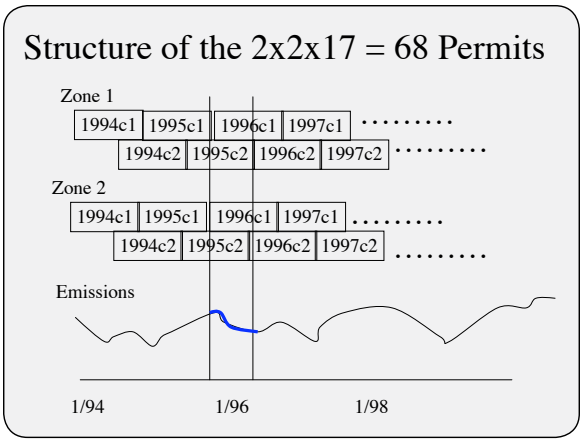
John Ledyard

I am going to talk about one example of how market design was used, what was done and the steps along the way. The example I am going to use is called RECLAIM, which stands for Regional Cleaner Incentive Market of L.A. It was an environmental permit market for nitrous oxides and sulfur oxides that began to develop in 1994.

RECLAIM has some similarities to limited access programs, and it obviously has some differences. And the point that I think is crucial is that the technology and the art of market design has changed significantly in the last ten years.

So why market design? The idea is if you create markets, somehow you will improve efficiency, there will be gains from the program, and everybody is better off. Obviously it does not mean that everybody gets to share in those gains: Some people win, some people will lose. And you can't just say let there be markets, because there are a lot of issues. What they did in Russia, for example—there were a lot of details that were forgotten about, and it went to hell.

There are two kinds of solutions; one is to let markets sort of naturally evolve. Local



arrangements—norms of behavior—are sometimes very good at managing these kinds of common property resource problems. The second way it is usually done is through a king or government bureaucracy telling everybody what to do, and that tends to be somewhat inefficient. In L.A., the control was very much of this top-down management model. Emissions were controlled in detail down to the valves you could use on your oil refinery plant. The process was adversarial and expensive; everybody had lots of lawyers. New technology was not being adopted, because the minute you announced that you had found a new technology, you were forced to adopt it, even if it was a very expensive process.

So everybody was living with it, and L.A. was somewhat polluted. But then it was decided that nitrous oxide emissions and sulfur oxide emissions had to be reduced by 50–70 percent within about seven years. Everybody knew this was going to be a problem. Firms figured it would be hugely expensive to regulate. Environmentalists could see that there would be threats to leave L.A. and that the program standards might unravel. Even the regulators were worried. So a kind of coalition was formed to lead the way through a market design process. You don't ask the economist to help unless things are really bad. It's triage.

There were two proposals—this gives you an idea of where we started. The firms wanted one asset. That would be like having an asset for a pound of fish anywhere in the world. It would be one pound of emissions—whether Nox or Sox—sometime in the next 30 years, and wherever in L.A. To an economist that would be real neat; the market would work really well. But the environmentalists said: That's nuts, we want one pound of Sox, in Pasadena, in August—a really narrowly defined asset.

Automated Credit Exchange created

- Allowed portfolio bids
- Bids were private unless bidder wanted to "sunshine" part of it to encourage contras
- Trades chosen to maximize gains from trade
- Prices chosen to encourage "honest" bidding
- Charged 3% to each side

The firms' proposal means you lose regulatory control; you don't really achieve the objectives that you are after. If you get the asset too specific, however, there are no gains from trade.

One issue was time. In an expiring permit program, you could use a permit only for a year. You would have so many permits in 2007, and so many in 2008. It turns out there is a problem with that design. What happens if at the end of 2008, either it has been a good year economically or a bad year? In a good year, everybody needs more permits, and the price goes way up. If it is a bad year, the price goes way down. The allocation problem is nasty, the volatility is huge and the gains disappear. It's really a mess.

There are two possible solutions. One is banking that allows you to accumulate and soften the shock between years, but the problem with that is it allows hot spots to occur, so banking was out. The second alternative was overlapping the securities, and that is what we proposed. Through experimental testing, we were able to show that the volatility went away with overlapping.

A second dimension in L.A. is the space problem, because there is a prevailing wind. If you are not careful to regulate the flow of pollution, you could actually have a problem. So we created different permits. There was discussion of about 37 different zones, but in fact we ended up with two. And the idea was you could not sell permits upwind; you could only sell them downwind. That gave the L.A. Air Quality Management District (AQMD) regulatory control.

If we had 37 zones, with trade restrictions, that would have been 2,516 different permits over the 17-year period. And that is a nightmare. So we got them down to two zones, which made it 136 permits. That is still a lot, but it turns out we were able to produce some market technology that allowed firms to deal with this. This is the issue of transaction costs after the design.

Employment was a big issue. The proposed solution by AQMD and by the labor union was that each trade should be analyzed for its employment effects before it was allowed to take place. In actual practice, it turned out that the employment effects were very small. To me it was obvious; to others it was not.

There are different kinds of ways of dealing with safety valves in these programs. You don't have to have a permanent commitment to something. The result was a rule that said if the price of these permits gets up too high, we are going to stop the program, put it on hold. And so the program actually went on hold in 2002, because of electricity prices.

What was created was a permit to produce one pound of Sox in 2002, cycle two—that's part of the overlapping time periods—and the zone, which is either upwind or downwind. So a permit had all these details. And this is going to run from 1994 to 2010, so there are 136 assets that a firm has to contend with. At the time, we were not sure it was even going to work.

One difference from fisheries is that the beneficiaries of better air quality are really not participants in the program. They are the residents of L.A. And so the regulatory commission was sort of acting as the representative for these people. That is a market failure problem because of collective action, but that's another issue. The firms themselves had a mutual interest in getting some kind of program in place.

The next step is we have all these rights—who get

> "[Grandfathering] ignored many stakeholders. It ignored new entrants, who are not at the table. It ignored externalities, and it ignored implementation costs."
>
> —John Ledyard

them? The economic argument is that, without transaction costs, it doesn't matter. You still get the benefits of the program, but the politics of the argument is that you aren't going to get the program unless you get this right. In L.A., there were two principles. One is from economics: The initial allocation does not affect efficiency. But the second principle is: It does affect distribution. RECLAIM chose grandfathering; actually, this was a very simple choice for them because in the end they knew if they did not have the firms on their side it was not going to go any place. Even the environmentalists understood that. But this approach ignored many stakeholders. It ignored new entrants, who are not at the table. It ignored externalities, and it ignored implementation costs.

Overall, the place where RECLAIM was successful was by bringing the cost of compliance down. Whereas before, there was a newspaper article about Arco leaving L.A. or some aircraft company going out of business almost every other day. Those types of articles stopped. Once firms got into this program, the existing asset cemented their commitment to the program. And technology development got really underway, because all of a sudden it was in their interests to find a cheaper way of doing things. The people who did good technology development won, and that's a real bang for the buck.

Al Roth

One of the things I'm going to focus on are the ways in which the details matter and the ways in which similar markets sometimes turn out to be different. I'll tell you about some medical and other labor markets that have had some failures and solutions and how those differences have played out. And I'll talk about the kidney exchanges we're building in New England and elsewhere.

I'm going to concentrate on failures of thickness, which means not enough people transacting at the same time; of congestion, having a lot of people available to transact but not being able to deal with all of the transactions that may come up in the time that is allotted; and of safety: Are we making a market that's safe to participate in?

Among these entry-level professional labor markets that I've studied, some are markets for new doctors, for instance, or for new law graduates that want to be appellate court clerks. These are

Market failure and market design

- There are some common causes of market failure
- Some of these have reasonably robust solutions via market design
- But all markets are different, and the details of the differences often matter a lot
- Some things that work well in many markets don't work in others
- In particular, some things that may work for some fisheries may not work for others…

fancy entry-level professional labor markets, and there are high stakes on both sides. And one of the ways that employers compete is they try hiring a little earlier than their competitors. First it happened slowly and then it happened quickly, and this race to hire became obstructive, because when offers come very early—two years ahead of graduation from medical school—you can't tell who the best candidates are.

Also, the markets became very dispersed in time. People weren't hiring at the same time. So if you were looking for a job in this market, you faced a very thin market. You would get an offer, and you would have to say yes or no before the other people who might possibly want to hire you got around to hiring. You see a lot of exploding offers, in which you have to say yes or no immediately before you can learn what other offers may be coming to you.

Many of the markets I'm going to tell you about have adopted some kind of centralized clearinghouse. So the way American doctors get their jobs these days is sometime in their senior year they go interviewing at hospitals, and then, rather than get individual offers, they submit a rank order list of preferences to a clearing house called the National Resident Matching Program.

The important thing about a successful clearinghouse is that it produces what we call a stable match. It shouldn't be that after you've gone through the match, you find there's some employer you would have liked to work for and he would have liked to hire you but somehow the clearinghouse didn't put you together.

I want to tell you about the market for gastroenterologists because of the failure that it experienced and the way we were able to put

> "I'm going to concentrate on failures of thickness … of congestion … and of safety."
>
> —Al Roth

it back together. In the more orderly market, 60 percent of the employers have started interviewing by February, and there's going to be a match in June. As gastroenterology unraveled, from year to year, the 60 percent mark moved back from February to December to November to October. If you didn't hire early, you found that some of the people you hoped to interview had already taken jobs. And so mobility fell down. Hospitals started to hire people who came from the same hospital or the same locality. The national market collapsed into a bunch of local markets because if you're hiring a year or two years ahead of employment, lots of information is lost about people who are getting their training farther away.

The professional gastroenterology organizations felt that they had no power to directly enforce a hiring process. So the question was how to make everyone feel confident that their competitors would wait. The reason I'm hesitating to wait is that I'm afraid you will hire the good candidates before I can get them. So what the gastro organizations did is they instituted rules that said that a job candidate who gets an offer before the match is entitled to accept it and change his mind later if he gets a better offer. And this actually worked pretty well.

The orthopedic surgery professional organizations have the same problem, but they can't use the same solution—because they say, you know aspiring orthopedic surgeons just cannot say yes to an orthopedic surgery director and later say no. On the other hand, the orthopedic organizations have some muscle that the gastroenterologists didn't have. They said, "If employers make early offers, we won't let them present papers at the professional meetings." Their talk is all about sanctions.

A group of guys who deal with both problems are federal judges. It turns out there's no way you can empower law students to break promises to federal appellate judges. They make real exploding offers. The purpose of the interview is to decide whether I would like you to work for me. And the professional organizations of judges have got no power on judges. So clearinghouses will not work for them unless they can break that cycle.

At some level, those markets each have their problems. And when they're all unraveling, I could show you similar graphs for each of them. But the design solutions depend on understanding them at a level of detail that I didn't have available to me until I'd studied them for years. So there are a lot of people in this room who have studied various fisheries for years. Your responsibility is to help make us aware of the relevant details that make some things work or fail.

Let me move on to a really different kind of market, about kidney exchange. There are 70,000 people waiting for cadaver kidneys in the United States, but we only manage to do about 11,000 cadaver transplants a year. So we have a big shortage of kidneys, and it's costly to wait. About 4,000 patients a year die while waiting.

There's another way to get kidneys, which is live donation. You guys all have two kidneys, and, if you're as healthy as you look, you could remain healthy with just one. But not everyone who's healthy enough to give a kidney can give a kidney to whom they want. There's only about a 50 percent chance that one of you could take my kidney.

So what kidney exchange is about is: I give a kidney to your patient and you give a kidney to my patient because we weren't able to give them to the people we wanted. And the question is: Can we get these exchanges going?

The problem with this market is it wasn't thick. Before 2004—there are 14 transplant centers

Conclusions: What have we learned from market design?

- To achieve efficient outcomes, marketplaces need make markets sufficiently
  - Thick — enough potential transactions available at one time
  - Uncongested — enough time for offers to be made, accepted' rejected, transactions carried out…
  - Safe — safe to participate, and to reveal relevant preferences
- Some kinds of transactions are repugnant…and this is one of the constraints that face a market designer.
- Different markets are different: the particular technologies, rules, customs, and norms in an industry have to be well understood and taken into account for market design to be successful.

in New England, but there were five exchanges that had managed to be arranged. So what my colleagues and I have done is started to organize kidney exchanges. And enabling legislation has gone through the House and the Senate to allow us to do this in a national way, but it hasn't been signed yet and there are other obstacles.

One of the difficulties we're having as we grow is that you have to make markets safe to participate in, which is an issue for the transplant centers—because unless we can promise the transplant centers that they will get transplants, then they might not want to participate.

And this gets me to the question of repugnance. In almost every market there are some things that you would like to do but can't for one reason or another. For kidneys, for instance, you can't buy and sell them.

Think about something like labor markets. Indentured servitude and slavery—there used to be markets for slaves in the United States. So there are some things that are now repugnant but didn't used to be so. And there are other things, like interest on loans, that used to be repugnant but are no longer so.

Often things that are not repugnant on their own become a bit repugnant when we add money to them. Adoption is a good thing, but you can't buy the child from its birth mother. Love and sex are good things, but we have laws against prostitution. When you invite me to dinner at your house, I can bring a bottle of wine, or I can invite you back to dinner at my house—those are in-kind payments. But I can't pay you in money. The reason we're able to do kidney exchange, even though we can't buy and sell kidneys, is that it's an in-kind transaction.

So to make markets work, we have to make them thick. And so now I'm waiting to learn what makes the different fisheries different from each other—because I'm sure there are differences between crab and red snapper that I don't understand, and that will have a bearing on what you can do with them.

Case Discussions of Prospective Limited Access Privileges Programs

Breakout sessions allowed participants to delve into the specific characteristics of individual fisheries and to test ideas from the contributions of the market design experts. Of note is Peter Cramton's proxy design for New England groundfish, which deepened the discussion.

New England Groundfish Fishery

Fishery Characterization

- Fifteen species are managed under the New England Fishery Management Council multispecies fishery management plan, and several are further differentiated as stocks, based on geographic region.
- Current management includes geartype restrictions, vessel size, area closures and days-at-sea limits. The fishery has seen a reduction of days at sea, from 116 in 1996 to 46 in 2006 (Category A permit).
- Cod, pollock and haddock are among primary targeted species and accounted for roughly $40 million in 2006 landings. Species abundance fluctuates greatly, and in any given year, the "weakest link" species may vary.
- In many New England ports, the fleet has been pushed out by land values and development pressures. Gloucester, New Bedford, Portland and Chatham have protected their fleets with subsidies. Small, independent operators dominate the fishery. There are 1,000 permitted vessels, but as few as 400 are active.
- In some stock-areas, days-at-sea regulations limit the ability to reach TAC, which is a target, not a hard TAC.
- Days-at-sea permits are tradable, including outside of a geographic stock-area. Permit trading is heavily controlled by two brokers and is not transparent.
- Days-at-sea permits are leasable. Landings are attributed to the lessee, but days-at-sea are debited from the lessor.
- Observer coverage is spotty and based on fragmented interests, without centralized decision making or adequate funding. Capacity to electronically submit landing totals through a mandatory vessel monitoring system is in place, but landings are currently tallied via hard-copy trip reports. There is currently an eight-month lag time in compilation of landings data by the agency.
- Historical note: A quota system was adopted in 1977 but rejected in 1982.

Peter Cramton's Proxy Design

- TAC by species, and sometimes species-area, for a total of 30 products.
- Transition period of grandfathering, with shares automatically placed at auction. If my historic catch is five percent of cod, I can decide whether I want to buy my five percent back, in which case I don't have to pay a penny, regardless of what the auction price is. Or I can go from five percent to eight percent, in which case I'd be buying three percent. Or I might want to reduce, sell three percent in the auction market. This prices the liquidities. It facilitates trade and price discovery. Next year, the grandfather of five percent of the cod is reduced by 20 percent, and over five years reduced to zero, easing new entry in the fishery. The fishery is now held publicly and generates revenue. Catch shares become simply another input in the production process. Fishermen need boats, they need nets, and they need shares.
- Format: single-price, ascending clock auction, a dynamic auction where nothing settles until the auction closes. In the first round, we see perhaps 300 percent of the TAC being bid. The auctioneer keeps raising the price until the demand is equal to the supply, and at that point the clock stops, and that would define the clearing price for a single product. We handle 30 products with 30 clocks. And so there are 30 prices, and they all start at a penny and all operate in the same way.
- To prevent bid sniping, require that the bidders' quantities, as prices go up, can only go down. That's called the activity rule, based on revealed preference. A more sophisticated activity rule could also allow for substitutability between products.
- One variation is a clock-package auction, used in left shoe–right shoe situations, in which I don't want one unless I can also have the other.

Bidders make package bids, i.e. 40 percent cod and 60 percent flounder, and the auction clearing enforces those packages. This variation is actually less desirable, because the clearing is less transparent.

- Period: At least two times and perhaps four times a year, i.e. 25 percent of the catch in each of four auctions.
- How far in advance of the season is a variable that affects risk, i.e. if share prices will influence decisions about equipment purchase.
- Parties could trade outside the auction mechanism, and that competition would help to keep the mechanism honest.
- Shares cannot be banked or borrowed.
- Penalty of two times the smoothed auction price for overcatch.
- Monitoring enforcement.
- I would recommend against partitions, as they often lead to a thinner market.

Discussion

(Danielle Edwards, Vito Giacalone, Jacob Kritzer, Seth Macinko, Paul Parker, Al Roth, Astrid Scholz, Ernst Ulrich von Weizsacker)

- New England Fisheries Management Council (NEFMC) Amendment 16, which takes effect in 2009, mandates quota-managed sectors, as well as a common pool for fishermen unaffiliated with sectors. Many aspects of an ITQ system are unaddressed in the regulations, and there is perceived to be an opportunity to influence market development.
- Formulas for allocation of quota to fishermen are currently under discussion. The formula is expected to rely on catch history, as well as other factors. Quota then accrues to the fishermen's sectors, not to individuals. Sectors, not individuals, will be responsible to NMFS for management of quota. For individual fishermen, sector membership will help to alleviate risk, as quota is smoothed over an aggregated group.
- There are currently 18 entities that operate as "sectors," but consolidation is expected as sectors take on the new and important role of quota aggregators. Each sector entity currently includes at least 10–15 vessels.
- The potential for recruitment of individuals with large quota shares may indicate a need for a clearinghouse or matching system. Although individuals currently commit to a sector entity on an annual basis, there is increasing recognition that sector-jumping is not a healthy practice. Trust among fishermen within a sector is crucial, because fishermen that carelessly catch weak stocks can shut down a fishery. With the emergence of this new market, there is also the possibility that fishermen who are known to be careless but who, based on catch history, are awarded a large allocation would be courted by sectors and then told or paid not to fish.
- There may be a pressing need for intra-sector market to facilitate the assignment of quota ("shadow ITQs") among fishermen within sectors. Sector managers could, in effect, emerge as brokers for their members.
- In Chatham, there is a geographically based, longline harvesting coop. Other entities are more geographically and geartype-diverse.
- Formation and management of sector entities has been underwritten by foundation support. There may be a need for business planning to enable greater self sufficiency.
- There may also be a need for an inter-sector market to facilitate trades between sectors. Sector managers will face the complexity of allotting quota among sector fishermen, while potentially also making decisions about trading quota with other sectors. A transparent inter-sector marketplace would facilitate price discovery and minimize the possibility of sectors colluding against another.
- Although mandated under NEFMC Amendment 16, emerging markets may be confounded by the fact that catch levels average roughly only 60 percent of TAC. There are frequent and unexpected fluctuations in species abundance, and although there is no consistently identifiable bycatch stock, catch of seasonally weak stocks often impacts fisheries, as temporal and spatial closures are designated mid-season to take into consideration revised biomass projections.
- A benchmark biological reassessment of stocks levels is in progress and revised stock productivity assumptions is expected to lead to lower TACs.
- Observer coverage currently relies on both federally and private funding. Control boats

have 100 percent coverage, and the rest of the fleet 20–30 percent, with minimal variation between the two. Industry would like to see regulations and federal funding for complete coverage.

- Currently, retention of nontarget species is not allowed. Quota is measured by weight and a sample is taken to assess the total. Juveniles are counted against quota, even though survival rates for discarded juveniles can be high among select geartypes: estimated at 80 percent for cod caught by longliners, unknown for haddock.

Hawaiian Swordfish Fishery

Fishery Characteristics

- Single-species harvest fishery, without its own TAC, but regulated by bycatch of turtles. Bycatch is defined as an encounter with one of two species, leatherback (limit of 16 encounters) or loggerhead (limit of 17 encounters).
- Encounters are considered harmful, even though mortality rate is estimated to be as low as 10 percent, as nonfatal encounters may affect ability of turtles to live to reproductive age.
- Observers on every boat.
- Longline, limited entry fishery of 35 vessels.
- Example of bycatch as constraint: 2006 fishery opened in January and closed by bycatch limit in early March.
- Fishermen are exclusively Vietnamese-American. They never received the federal disaster relief funding that was allocated to offset loss associated with bycatch regulation.

Discussion (all)

- An effective market assumes heterogeneity in likelihood of encountering a turtle or capacity for technological innovations to reduce encounters. The current use of circular hooks is one example of innovation.
- The fishery currently exhibits a collective goods problem: There is incentive to fish as quickly as possible, before the bycatch limit for the fishery is reached. And so a market would perform the essential function of aligning incentives with goals. The market would allow price discovery of the externality (turtles).
- We can posit that the market price would reflect fluctuating expectations of hitting the limit in any season.
- It would be a very lumpy market – 17 turtles for 35 vessels. Two equivalent designs would be to trade 1,700 permits and require 1,000 to buy a turtle, or to trade in permits valued at a thousandth of a turtle.
- There would be a fixed compliance period and no need for participants to comply on a real-time basis. A participant's banking of seasonal permits would be based on risk sensitivity and price expectations. If a participant has a turtle encounter, he/she must purchase permits to supplement those not already banked. At the end of the compliance period there's a true-off period, in which participants must buy the required permits or be forced to pay a penalty.
- A market with 35 participants would not be overly thin. Many markets function well with only a handful of participants accounting for the majority of trades.
- Allowing outsiders to participate (i.e. environmentalists) could further limit catch through their seasonal purchase and retirement of turtle permits.
- The market might increase efficiency, i.e. reduction of turtle bycatch, to the point that a TAC is needed on swordfish.

Gulf of Alaska Groundfish Fishery

Fishery Characteristics

- Geographic extent: from Yakutat Peninsula, around Prince William Sound and Kodiak Island, to Sand Point on Alaska Peninsula.
- Annual ex-vessel value of $60–$70 million, including 38 metric tones of cod in 2006.
- By comparison, Bering Sea trawl fishery has annual ex-vessel value of $1.2–$1.5 billion, including two million metric tones of pollock.
- State of Alaska jurisdiction extends from shore to three miles out. State waters are open access. State may not, under current statues and perhaps under state constitution, create an IFQ for its waters.
- Federal jurisdiction: limited entry, license

limitation program fishery, split into three geographic areas.

- Total catch is frequently 60–80 percent TAC. Four geartype-defined sectors, each with a separate sub-TAC.
- Some secondary species (halibut, etc.) are classified as prohibited species catch (PSC). If caught, may not be retained.
- Spotty observer coverage.

Discussion

(Ed Backus, Jennifer Bloeser, Alan Haynie, Darius Kasprzak, John Ledyard, Amanda Leland, Mark Lundsten, Phil Smith, George Sugihara)

- Perhaps a science policy problem: TAC is set based on a lagging basis, stocks are highly variable and the fishery is depressed. But it's not clear that TAC is wrong; perhaps it represents the best level for a highly variable system.
- Size of fish is highly variable but has not noticeably diminished over time. General assumption is that Pacific cod don't migrate.
- State-water, largely small-boat fishermen are reluctant to see an IFQ program. Driving the desire for rationalization among federal-water fishermen: general sense that others benefited, including Bearing Sea fishermen under the AFA and halibut and sablefish fishermen under IFQ program.
- PSC discards represent revenue loss to the fishery targeting the fish. Emergence of bycatch market would need to address market safety issue: participants in IFQ-regulated halibut fishery (longliners) would not appreciate other geartypes entering the market, if that catch were then included in the TAC (as it is in British Columbia). Perhaps revenue from Bering Sea halibut bycatch would need to go to halibut fishery.
- Added consideration: more halibut killed in Bering Sea trawl fishery than in the halibut fishery—but they are juvenile, of lower weight, quality and value. Also, halibut bycatch does not appear to be threatening the viability of the stock or of the fishery. Perhaps it represents an acceptable sacrifice in the enormously valuable Bering Sea fishery.
- Possible intermediate step: create a market for non-retainable bycatch quotas on an individual vessel basis.
- In Gulf of Alaska groundfish, cleaner geartypes currently catch less and make less money. May be possible to incentivize fishermen to switch to cleaner geartypes by not allowing for sector sub-TACs of bycatch quota.
- Bycatch quota trading would require observer coverage. Bearing Sea has 200 percent observer coverage, while Gulf of Alaska coverage is spotty.

Mexican Fisheries

Fisheries Characteristics

Miguel Angel Cisneros

There are twenty fisheries in Mexico for which we have TACs, but we do not always have accurate information for setting the TAC by good stock assessments. It is no wonder this is so; it is very expensive to do that kind of evaluation each year.

In some tropical countries and in tropical regions like the southern part of Mexico, we are dealing with a huge diversity of species but really small biomasses, so it is very difficult to deal with. It's very labor and resource intensive, and management is difficult. So basically you have to manage your diversity; that's why we think we cannot manage most single species stocks.

In our country, more and more we've seen setting aside MPAs, marine protected areas, by the ministry of the environment. We think it's a good idea, but it creates a difficult position for enforcement. It's a good idea because we can prove by setting up an MPA we can allow for production of species that, economically speaking, are very good for fisheries in general.

Since July, we have a new fisheries law that seeks decentralization. As it is now, something like 15 percent of Mexican fisheries are overexploited. Also, aquaculture is increasing five percent per year, so it is very important, economically speaking, for the future. It is becoming a general rule to say that every state has to produce its own management plan for some of the resources. But most of the states have the right to manage their fisheries, and knowing that they have the pressure to create more jobs, it is going to become more and more difficult.

We are seeing trends in our country of sustaining, if you will, the fisheries by subsidy. This is new to

our country, and there is a trend in which more support from government is being demanded.

Luis Bourillon

I just want to say something else about the social aspect of fishing, especially for the small-scale fishing communities in Mexico. I think it is a large part of the coastal population that does fishing in a commercial way—small operations extracting a multitude of fisheries with different fishing arts throughout the year.

One element that is very interesting to hear from all the examples is the level of organization that is needed in order to adjust or design markets. In the small market sector, the basic form of organization in the past was the cooperative system. Before 1992, the only way that you could have access or rights to the most valuable resources was to be a member of a cooperative. When the law changed, the cooperative system really started collapsing. So now we have very small groups of three, four or five fishermen forming a cooperative. And the level of organization that is needed in order to engage in design, I think, in many parts of Mexico is not there.

Alejandro Robles

I think we have cultural challenges, in that in some areas, 40 percent of the fishers fish illegally. Poor fishermen manage to have access to fishing even though they don't have permits. It's a form of solidarity, because they are colleagues.

One of the main issues right now is the shrimp fishery, which is a very high-value fishery in the Gulf of California. There is an endangered species of porpoise called the *vaquita*. About two years ago, a U.S. organization threatened to boycott the Mexican fisheries if the *vaquita* was not protected, and that created a reaction. So, there were discussions about how to compensate fishermen who had to stop fishing and what role markets could have in changing the system. For example, today there are no markets in which people who have an interest to conserve the vaquita. Moving from chaos into a system that plays by these rules is probably the greatest political challenge we have.

Discussion

(Luis Bourillon, Miguel Angel Cisneros, Peter Cramton, Alejandro Robles)

Project 1: Reduction of gillnets to protect *vaquita*

- Approach: purchase of gillnet reductions over a period of time (3 to 5 years), with mandatory elimination of all gillnets at conclusion of period.
- Register all current gillnets; unregistered gillnets are illegal through entire period.
- Budget is obtained to purchase as many reductions as possible (early retirement of gillnet in voluntary period).
- Annual auction secures gillnet reductions and allows those with higher fishing value to postpone retirement, those with lower fishing value to receive compensation for retirement.
- Proposal: annual uniform-price, sealed-bid auction for reductions, in which each fisherman submits a schedule of the price per gillnet required to retire n gillnets, thus representing each fisherman's supply curve, which must be upward sloping, indicating that a higher price per gillnet is required to retire more gillnets.
- The government forms the aggregate supply curve and then picks a point on the supply curve to determine the clearing price for the current year.
- Offers at or below the clearing price are accepted; those above the clearing price are rejected.
- The purchase is staged across the four years, for example, of the program so that a retirement in year one is four times more valuable than a retirement in year four.
- Objective is to best utilize the budget to reduce gillnet use before mandatory elimination of gillnets at the end of the voluntary period.

Project 2: Establish "use zones" to protect sensitive areas and compensate fisherman

- Establish use zones (conservation, commercial fishing, diving, sport fishing, sport fishing and diving) to optimize use of bay.
- Conduct simultaneous clock auction to determine use in each zone.

- Construct map of relevant zones through individual interview of parties from each of the four groups; ask for ranking of areas, best to worst for the groups' use.
- Construct partition of bay into a number of zones that are largely consistent with each groups preferences; err on the side of making too many zones, since the auction will allow a group to aggregate multiple zones.
- Establish allocation of auction revenues, e.g. 10 percent enforcement; 25 percent conservation; 5 percent brokers; 60 percent commercial fisherman.
- Conduct simultaneous clock auction to determine use of each zone; price of each zone starts at low level and increases—so long as more than one party bids for the zone.
- Members of each group have a free-rider problem; hence, it makes sense for each group to bid as one in the auction; for example, commercial fisherman bid through one commercial fisherman organization, which aggregates all the values of the fisherman.
- Note that as long as commercial fisherman win less than 60 percent of the value of all the zones, they will receive a net payment; to the extent that the sport fishers, divers, and conservationists win more, the payment to commercial fisherman will be larger.

Group Discussions

Achieving Conservation Outcomes

Peter Cramton

The economist represents ecology in efficiency. When an economist measures the gains from trade, the presumption is that the ecological values are contained in the efficiency. With respect to fisheries, my presumption, which is problematic to be sure, is that the ecology is represented by the TACs. And I'm taking those as inputs in the market design. But it's outside the model.

Al Roth

One of the kinds of market failures that Peter referred to and that we're accustomed to seeing in auctions that have qualified bidders is in providing public goods. If some of the parties are not qualified bidders then their interests may not be represented, as when the general public has an interest in the health of the fishery that is distinct from the fishermen. And Peter's quite right that we're hoping that it is captured in the TACs.

One ecological concern is that your target fish may be the food for my target fish, and so possibly some people who are qualified bidders may have interest in fish that they don't want to catch themselves. That's probably easier to capture in the market than the interest in the sea turtles because they're not a marketable catch. So unlike economists, who occasionally make mistakes, we're hoping that the fishery biologists never do. And that all the interests are captured in the TACs.

Jacob Kritzer

I agree that lot of the conversation goals should be met in setting the TAC, and fishery science needs to move from single-species TACs to ecosystem-based TACs.

The system itself has inherent conservation benefits in that it changes the way people fish. You fish in a more paced, measured, strategic way. You're less reckless, less careless, less likely to go over the TACs, less likely to fish in damaging ways, less likely to get bycatch.

I don't think that implementing a market-based fishing strategy means you do away with all of the other regulations. You may decide, for instance, that you want to target fish above a certain size. So you pair these market-based approaches with fewer and more sensible traditional regulations.

Jennifer Bloeser

The trend in fisheries management now is systems based on single species. As a fisheries biologist, I'm very concerned about all the ecological ramifications of these fisheries being covered in the TACs. There's a timeliness to do with how quickly fisheries biology is able to match the development of market programs. Fisheries biology moves at a glacial pace.

Phil Smith

Theoretically and I think in actuality you can demonstrate an increased sense of stewardship on the part of those to whom the privilege has been allocated. Stewardship is an important, but hard-to-measure benefit from these types of programs. One example we talked about yesterday was the whole effort to come up with ways to avoid bycatch of endangered species. Also, up to three percent of the increased rents from the fishery under the Magnuson Act are returned to the management agency to pay for the hands-on costs of management and enforcement, and in some jurisdictions, you'll see cooperatively funded efforts, where industry itself is paying for a lot of the biological study—and paying for the right reasons. I think the market-based system gives participants a stake and improves the sense of connectedness to the resource and to the management regime.

Darius Kasprzak

I'd like to point out that LAPs are not appropriate for every fishery. Time, trip and gear limits work very well in some cases. I'll give you an example: the black rockfish fishery that I participate in. Up until a couple years ago, it was fished derby style, and large boats were hammering it. But instead of privatizing it, the state of Alaska turned it into a trip-limit and time-limit fishery. And the fish are being well taken care of—there's no pressure on them. And this was all done very easily.

Seth Macinko

I don't think this emphasis on ownership and stewardship is supported. Take the practice of highgrading; here's an example of where the

market may exacerbate detrimental practices. We tend to look for tight, causal relationships, but the fact of the matter is you can have good stewards or bad stewards under public ownership regimes, and you can have good stewards or bad stewards under private ownership regimes.

Alan Haynie

There's been this sell that stewardship comes with privatization—I don't believe that's empirically supported to the degree that proponents claim that it is. In fact, switching to private property rights can create new environmental problems. To maximize the value of your quota, you might throw something off and catch more of it—that's been observed in a number of fisheries.

When you create private property rights, you have a greater stake in the future returns of your stock. But that's spread over the entire health of your stock. So when it comes down to a fishing decision—I'm going to catch this fish—that future value is diluted across the entire fishery.

On the other hand, there are environmental problems that we don't have individual incentives to deal with. If you can put private incentives—if you can put a price—on the cost of the action of catching the sea turtle or catching an albatross, then people are going to respond to those incentives.

Vito Giacalone

One of the problems here is the shift, from the cowboy days of doing the best you can with the time that you have, to a stewardship role of protecting, not the sea turtle, but my investment. If I have a three percent quota share, and it's three percent of 10,000 metric tons and we're going to try to rebuild 30,000 metric tons, I've got a big incentive to be involved so that the rebuilding happens as quickly as possible.

Business wants stability in the market. The marine biology has been very fickle. They've been trying to find out what's going on with these stock relationships in a very complicated ecosystem, and getting people to be confident in the market is going to be difficult. I think you'd see industry support fishing at a conservative TAC, fishing at a responsible level minus some for precaution. But don't collapse the market as a result of having three years left to a 10-year rebuilding plan, where we can't get there from here because the market falls apart. If the political influence on the science continues the way it is, we could end up in a situation where we have this wonderful market with no way of exceeding the TAC, and it's all over anyway.

Jennifer Bloeser

On the West Coast, we have eight species that are overfished and are constraining species. The level of catch for these species is going to be represented in a TAC. But having single-species ITQs would result in the problem that Vito is saying. As the fish are rebuilding, how do we structure so that: one, you're not negatively affecting the rebuilding, and two, the catch of those overfished stocks is not constraining the healthy stocks.

There are these ideas that there are conservation gains implicit in the development of market programs. And in the groundfish fishery that's how the discussion goes. You develop a program, and therefore you have ecological gains. But what the discussion has evolved to here is that there are opportunities in the development of the system to be explicit about what you want these ecological or conservation gains to be. I'm not necessarily saying that this existing system has problems or that this system is going to be better or worse. Just that there's some explicitness—not that there's an assumption that there's better stewardship or conservation gains automatically. You figure out what you want, you deal with overfished species in a very explicit way. And that's the way you go about building the system.

Phil Smith

Let me say that I'm appropriately chastened by the reactions to my comment about stewardship and ownership and the connectedness between the two—I don't think that I meant to imply that stewardship is automatic. I'm just saying that there are some incentives that result from holding some unique privilege to participate in the health of an ecosystem or of an aspect of it.

There are certainly incentives for bad acting. Dr. Parzival Copes from Simon Fraser University has written exhaustively on this question of highgrading and data fouling. In the case of highgrading in the Bristol Bay crab fishery last year, there was about $1.2 million in highgrading observed, so the next year, the state mangers

cut the TAC by a like amount, and they quit highgrading. There are lots of ways to respond, but you have to understand that there are some bad people out there, and you have to design a system to catch them.

Amanda Leland

I'll speak from my personal experience as the federal lobbyist for the Environmental Defense Fund. We've been engaged in the Gulf of Mexico red snapper IFQ fishery for a long time, and it's been a highly contested fishery. Red snapper has been overfished for going on 20 years—the stock is in dire straits.

Last year NMFS decided they were going to ratchet down the catch by 40 percent—and this is 40 percent of almost nothing. The IFQ was going into place January 1, 2007, and the commercial fishermen that we had been working with came to D.C. and, for the first time, lobbied their members of Congress and NMFS in support of a 40 percent cut in their catch. They're basically not making money on that fishery right now, and they're willing to take a 40 percent cut for the next year, because they argued that if we don't take this 40 percent cut now, we're not going to have an industry in five years. From my perspective, that's a pretty compelling argument for conservation.

Closing Discussion

Peter Cramton

A big task of market design is solving market failures. In fact, when you need a market designer is when there's a market failure that needs to be solved. Otherwise you don't need a market designer; you just let the market rip. The reality is there's a very serious market failure here that everybody's quite aware of. That's why we need market design, and the market design needs the rule of law, enforcement, contracts and so on.

Seth Macinko

Let's be careful that we don't confuse markets with privatization. In fact, I would make quite the opposite point. The U.S. Commission on Ocean Policy suggested that limited duration shares were necessary or advisable to reassert public ownership. It's very easy for ideological baggage to slip in whenever you're introducing markets.

Mark Lundsten

The guys who are poaching for Patagonia tooth fish 400 miles off Australia are privatizing that resource one trip at a time. The problem is not that it's privatized, because we all privatize fish when we catch them. The problem is that there's no system.

Alan Haynie

My favorite example of people unexpectedly happy with privatization is the San Diego fast pass program, where you can drive in the carpool lane as an individual driver. Before it was passed, 75 or 80 percent of people said, "No, that's terrible." Well, somehow it got through anyway, and a year later, 75 or 80 percent of people said, "We approve of this; we love this." Originally, they thought only the rich were going to use it. But the real impact was that one day your kids are sick at home, and you're going to use it. So people may be skeptical of new markets at first, but it's possible to have big changes in how people perceive them over time.

Education is the next big direction. In Alaska, IFQs were absurd at one point. "Don't mention markets," was the reaction. I think individually and collectively we have a lot of work to do. We have to figure out how to look at these different ideas—not just auctions—but the idea that there's value in having transparent information about the value of environmental goods and fishery resources.

John Ledyard

There are a number of ways to become comfortable with alternative markets. One of the tricks we use at Cal Tech is experimental; we create online scenarios so you can participate in a simulated process. You can make them very simple or very complex, and it's possible through the educational process to become comfortable with these things.

Amanda Leland

One thing we need to keep in mind is that there are also legal realities that we operate under—that we must achieve optimum yield. If the TAC isn't being achieved, then the TAC is going to change from a management perspective, based on the constraints of the federal law.

Astrid Scholz

Part of the reality is that we're not creating markets in a vacuum. We're creating them in the context of what's largely single-species management. So the question is: How do we design these instruments in ways that accelerate and create the incentives for market participants to demand a change in the way a fisheries biologist operates, for example? We can talk about ecosystem-based management for 10 years, and it's a fabulous goal to figure out a way to design these private incentive systems that basically accelerate change.

Phil Smith

One of the things I've relearned is a lesson I was given by my father many years ago, which is to accept the inevitability of gradualness. An understanding of the potential of market-based solutions has been slow in coming. It's been a long time, and a whole bunch of people have been scared to death of these things. And I think that a lot of meetings like this and a lot of meetings with stakeholders are slowly expanding the awareness of what these things are really about and how they can be shaped to benefit participants rather than to merely keep privileges for a favored few.

We didn't really talk about it, but these programs can't work—no matter how elegant the design and no matter how connected the industry is to the outcome—in the absence of a functioning bureaucratic infrastructure that is operating on the behalf of the public interest: to make sure that the rules are followed, that people are treated equally and fairly, and that people with a beef have a way to appeal and have their concerns met. I toss that out as a former bureaucrat. The game begins with the consensus on the need to do something, but it doesn't end with the completion of the design. There's a lot of work to keep it running

Vito Giacalone

I've been really excited by listening to the discussion here. There have been a lot of fresh ideas, and I've learned a lot by listening to the experts and people working in fisheries on the other side of the country.

Paul Parker

We've had similar bits of this group together, and there used to be more baggage, there used to be more hesitancy. Everybody had more agendas. Now, I think we have a really great opportunity.

Summary of Shared Knowledge

Features of market design:

- Market design gains its power from the "design" and can be used to address deficiencies and failures in markets.
- Market design needs to be driven by clear objectives.
- Regulations are needed to create stable, functioning markets.
- Cap-and-trade systems require caps that account for the biophysical systems within which human activity takes place.
- Product design: area, time, banked/borrowed, "sources covered" and allocative relationship to status quo.
- Initial allocations do not affect ultimate economic efficiency.
- Grandfathering protects existing investments, but ignores new entrants, externalities and implementation costs.
- Transitions in the development of markets need attention. They are influenced by who has power and how the starting rules are established.
- Markets display characteristics of: thickness (or thinness), congestion and incentives.
- A successful market will be safe for participants.
- Good market design builds trust and supports political structures.
- Lumpiness in markets comes from variation in quality and value of what is being traded.
- Automated exchanges can facilitate transparency and spur technological development.

Features of market design additionally specific to fisheries:

- Market design objectives are stated in the MSA.
- Successful market design requires biologically accurate TACs as design inputs—as well as reliable reporting and enforcement of TACs.
- Investment in public and private infrastructure is required in order for LAP programs to function.
- Successful design requires observer programs that are cost effective and comprehensive. A well designed system will generate revenues to account for enforcement.
- Current quota trading systems are not transparent.
- Market design can address externalities such as bycatch.
- Spot markets can mitigate "damage" (e.g. closures due to bycatch).
- Successful market design may require small expert groups to work together to produce complete plans for presentation to management authorities.
- Design in fisheries can benefit greatly from the knowledge of market design experts, who may lack specific fisheries experience.
- Functioning markets may help to make the case for the development of markets for ecosystem services, which could also be designed to benefit some fisheries market makers.

Appendices

A. Magnuson–Stevens Fishery Conservation and Management Act (relevant excerpts)

National Standards

(1) 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.

(2) Conservation and management measures shall be based upon the best scientific information available.

(3) 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.

(4) Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

(5) Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

(6) Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

(7) Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

(8) Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities by utilizing economic and social data that meet the requirements of paragraph (2), in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities.

(9) 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.

(10) Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

Limited Access Privileges

(b) DISCRETIONARY PROVISIONS. Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, may—

(6) establish a limited access system for the fishery in order to achieve optimum yield if, in developing such system, the Council and the Secretary take into account—

(A) present participation in the fishery;

(B) historical fishing practices in, and dependence on, the fishery;

(C) the economics of the fishery;

(D) the capability of fishing vessels used in the fishery to engage in other fisheries;

(E) the cultural and social framework relevant to the fishery and any affected fishing communities;

(F) the fair and equitable distribution of access privileges in the fishery; and

(G) any other relevant considerations;

(c) REQUIREMENTS FOR LIMITED ACCESS PRIVILEGES.

(1) IN GENERAL. Any limited access privilege program to harvest fish submitted by a Council or approved by the Secretary under this section shall—

(A) if established in a fishery that is overfished or subject to a rebuilding plan, assist in its rebuilding;

(B) if established in a fishery that is determined by the Secretary or the Council to have over-capacity, contribute to reducing capacity;

(C) promote—

(i) fishing safety;

(ii) fishery conservation and management; and

(iii) social and economic benefits;

(F) specify the goals of the program;

(G) include provisions for the regular monitoring and review by the Council and the Secretary of the operations of the program, including determining progress in meeting the goals of the program and this Act, and any necessary modification of the program to meet those goals, with a formal and detailed review 5 years after the implementation of the program and thereafter to coincide with scheduled Council review of the relevant fishery management plan (but no less frequently than once every 7 years);

(H) include an effective system for enforcement, monitoring, and management of the program, including the use of observers or electronic monitoring systems;

(I) include an appeals process for administrative review of the Secretary's decisions regarding initial allocation of limited access privileges;

(J) provide for the establishment by the Secretary, in consultation with appropriate Federal agencies, for an information collection and review process to provide any additional information needed to determine whether any illegal acts of anti-competition, anti-trust, price collusion, or price fixing have occurred among regional fishery associations or persons receiving limited access privileges under the program; and

(K) provide for the revocation by the Secretary of limited access privileges held by any person found to have violated the antitrust laws of the United States.

B. Readings

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Macinko, Seth. "In Search of Transition, Community and a New Federalism: 6 Questions to Confront on the Road Towards a National Policy on Dedicated Access Privileges." Paper prepared for presentation at the Managing Our Nation's Fisheries II Conference. May, 2005.

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United States General Accounting Office. "Individual Fishing Quotas: Methods for Community Protection and New Entry Require Periodic Evaluation." *Report to Congressional Requestors*. February, 2004.

Core Quota Papers

Environmental Defense. "Sustaining America's Fisheries and Fishing Communities: An Evaluation of Incentive-Based Management."

Grafton, R. Quentin, et al. "Incentive-Based Approaches to Sustainable Fisheries." *Economics and Environment Network*. Australian National University. September, 2005.

Harte, Michael. "Funding Commercial Fisheries Management: Lessons from New Zealand." Elsevier, Ltd. 2007.

Kerr, Suzi, Richard G. Newell, and James N. Sanchirico. "Evaluating the New Zealand Individual Transferable Quota Market for Fisheries Management." Motu Economic and Public Policy Research Trust. 2003.

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Sanchirico, James N. and Susan S. Hanna. "Sink or Swim Time for U.S. Fishery Policy." *Issues in Science and Technologies*. Fall, 2004.

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Bloeser, Jennifer. "West Coast Groundfish Management."

C. Participants

Edward Backus is Vice President of Fisheries at Ecotrust (based in Newport, Oregon) where he oversees the Marine, Copper River (AK) watershed and State of the Salmon programs. He is currently developing the North Pacific Fisheries Trust in support of community-based fisheries management.

Jennifer Bloeser is the science coordinator at the Pacific Marine Conservation Council, a non-profit marine conservation organization based in Astoria, Oregon. She served as a co-chair of the Habitat Steering Group of the Pacific Fisheries Management Council and conducts collaborative research with fishermen.

Luis Bourillon was the executive director for eight years of Comunidad y Biodiversidad A.C. (COBI), a non-profit Mexican conservation organization that is promoting community-based marine resource conservation in México. He recently started the Direction of Projects in the Mesoamerican Reef for COBI.

Scott Burns is the director of the Marine Program at the Walton Family Foundation. Prior to this position, he directed the World Wildlife Fund's Marine Conservation Program, helping to establish the Marine Stewardship Council seafood certification program.

Peter Cramton is professor of economics at the University of Maryland, chairman of Market Design Inc., and president of Criterion Auctions. His research focuses on auctions, bargaining and market exchange.

Danielle Edwards hails from a multi-generation fishing family on the west coast of Vancouver Island, British Columbia. Danielle is currently employed with Ecotrust Canada in their fisheries program and manages the Pacific Coast Fisheries Conservation Company, a small bycatch quota bank company.

Jim Engle-Warnick is an experimental economist in the Department of Economics of McGill University. He tests theories in repeated games, develops computer-based instruments to measure peoples' preferences, and has begun doing some experiments in the field.

Vito Giacalone of Gloucester, Massachusetts, is the Governmental Affairs chairman for the Northeast Seafood Coalition representing 300 fishermen and 60 seaside businesses. Vito is known for his hard work in developing management alternatives in New England groundfish fishery.

Alan Haynie is a research economist for NOAA's National Marine Fisheries Service at the Seattle-based Alaska Fisheries Science Center. One major area of his current research explores the relative potential merits of salmon bycatch quota in the Bering Sea pollock fishery versus spatial protective measures.

Darius Kasprzak is a lifelong resident and commercial fisherman from Kodiak Island, Alaska. He represents the Alaska Jig Boat Association before the North Pacific Fisheries Management Council, a group of over 70 independent operators.

Jake Kritzer is a marine scientist with the Oceans Program at Environmental Defense. His areas of expertise include demography, population dynamics, fisheries biology, and spatial ecology.

John O. Ledyard is the Allen and Lenabelle Davis Professor of Economics and Social Sciences at the California Institute of Technology. His current research explores the use of markets to solve problems and to improve public sector decisions.

Amanda Leland is an ocean policy specialist with Environmental Defense in the Washington, D.C., office. She leads the Oceans Program's federal ocean policy initiatives, including sustainable fisheries, habitat conservation and ocean funding, and she works to ensure that economic incentives are aligned with conservation.

Mark Lundsten retired from fishing in 2002 after 27 years working in the Gulf of Alaska and Bering Sea, mostly as the owner/operator of the *Masonic,* a 70-ft. halibut/sablefish longliner. He helped design and implement the halibut/sablefish IFQ program of the North Pacific Fisheries Management Council.

Seth Macinko is assistant professor of Marine Affairs at the University of Rhode Island. His research areas

include fisheries management, property rights, culture and resources, and fishing communities.

Miguel Ángel Cisneros Mata is Director in Chief of the National Fisheries Institute of the Government of Mexico *(Director en Jefe: Instituto Nacional de Pesca (INP) Gobierno de Mexico.)* He is a specialist in marine mammals and fisheries ecology and management of the Sea of Cortez.

Andreas Merkl is a principal with the California Environmental Associates, a for-profit consultancy in San Francisco. He is also the chairman of the Sea Change Investment Fund, a venture capital fund dedicated to investments in the sustainable seafood sector, and the managing director of the Conservation and Community Investment Forum, a not-for-profit organization dedicated to environmentally transformative investment opportunities.

Paul Parker is the executive director of Cape Cod Commercial Hook Fishermen's Association. Paul is experimenting with economically stable means for fishing organizations, non-profits or municipalities to protect their local fishing fleets and promote sustainable fishing practices.

Alejandro Robles is the Executive Director of Noroeste Sustentable, Guaymas, Sonora, Mexico. He is a former fisheries officer with the Mexican government and is an expert in the fisheries, marine mammals and biodiversity of the Sea of Cortez.

Al Roth is the George Gund Professor of Economics and Business Administration in the Department of Economics at Harvard University, and in the Harvard Business School. His research, teaching and consulting interests are in game theory, experimental economics and market design.

Astrid Scholz is Vice President for Knowledge Systems at Ecotrust. She manages Ecotrust's analytical, technical and cartographic capacities and a variety of projects that link the social, economic and ecological systems of the bioregion.

Howard Silverman is Director of Public Information at Ecotrust. Howard writes about economics, sustainability and citizenship at www.PeopleandPlace.net.

Phil Smith is a lifelong Alaskan who was raised in rural coastal communities. In the 1970s, he served as executive director of the Rural Alaska Community Action Program, and for over 20 years has been a manager of both state and federal programs that limit access to commercial fisheries. Phil is now an independent consultant on fisheries issues.

George Sugihara is a professor at the Scripps Institution of Oceanography at the University of California, San Diego. He is currently developing strategies and options for applying market tools to the conservation of fisheries and ocean resources.

Ernst Ulrich von Weizsäcker is dean of the Bren School of Environmental Studies and Management at the University of California, Santa Barbara. He has served as a member of the Bundestag, the federal parliament of Germany, where he was appointed chairman of the Environmental Committee. He is currently a member of the Club of Rome, a global think tank devoted to improving society.

D. Glossary

American Fisheries Act (AFA): Federal legislation that effectively rationalized the pollock fisheries of the Bering Sea (Alaska), downsizing fleets and allowing the formation of harvester cooperatives among other measures.

Fisheries and Oceans Canada (DFO): The department within the Canadian government that oversees the marine fisheries on the Atlantic, Pacific and Arctic coasts of Canada.

Individual Fishing Quota (IFQ): A fishery management program that allows an individual or entity the privilege to harvest a percentage of the Total Allowable Catch (TAC).

Individual Transferable Quota (ITQ): An IFQ program that allows individual quota to be transferred from one person or entity to another.

Limited Access Privileges (LAP) programs: Quota-based fishery management programs.

Magnuson–Stevens Fishery Conservation and Management Act (MSA): The primary law governing marine fisheries management in United States federal waters.

National Marine Fisheries Service (NMFS): The National Oceanic & Atmospheric Administration (NOAA) agency that conserves, protects and manages living marine resources, now renamed NOAA Fisheries.

Prohibited Species Catch (PSC): Prohibited species catch (bycatch) are harvests taken in a fishery (e.g. Bering Sea pollock) that are disallowed in that fishery. All prohibited species catch (PSC) is to be avoided, and if caught, prohibited species must be returned to the sea with a minimum of injury.

Total Allowable Catch (TAC): A commercial quota. A percentage of the TAC, called the quota share, is allocated to each qualifying individual or entity when the IFQ/ITQ program is implemented.

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