# The Anatomy of a Multispecies Individual Fishing Quota (IFQ) "Market" in Development

Daniel S. Holland and Karma Norman

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**Daniel S. Holland and Karma Norman**
Conservation Biology Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Blvd. E.
Seattle, WA 98112

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# Abstract

In 2011 an individual fishing quota (IFQ) system was implemented for the limited entry trawl component of the Pacific groundfish fishery in the United States as part of a fishery rationalization program that included cooperatives for the at-sea whiting component of the fishery. The IFQ system allocates quota shares (QS) for 29 IFQ stocks and individual bycatch quota (IBQ) shares for Pacific halibut. Each year quota share owners are issued quota pounds (QP), which can be used to balance their own catches of IFQ species or can be traded or sold. Transferability allows QP to be acquired by the fishermen who can generate the most value with it. The complex multispecies nature of this fishery and the requirement to balance all catch with QP makes QP transferability a critical part of this IFQ system, since fishermen have limited ability to control the species composition of their catch and may need to acquire QP to cover unplanned catch.  Although a web-based system was created to enable QP transfers, this did not create a functional QP market automatically. Rather the market (and a variety of other mechanisms for distribution of QP) is developing organically as quota holders, fishermen, and intermediaries develop trading and contractual relationships, and as QP values are determined and evolve. We describe the structure of the QP market, how it has developed, and how it is performing. We discuss the impediments to QP market efficiency and make recommendations on how more efficient multispecies markets might be facilitated in this and other multispecies IFQ fisheries.

# Introduction

In January of 2011 an individual fishery quota (IFQ) system was implemented for the limited entry trawl component of the Pacific Coast groundfish fishery in the United States as part of a fishery rationalization program that included cooperatives for the at-sea whiting component of the fishery. The IFQ system allocates quota shares (QS) for 29 IFQ stocks and individual bycatch quota (IBQ) shares for Pacific halibut. Each year quota share owners are allocated quota pounds (QP) which can be used to balance their own catches or can be traded or sold. QPs must be transferred from a QS account to a vessel account in order to be fished, and can also be transferred between vessel accounts. QS was not initially transferable, but became so in 2014.

The IFQ program was a major change from the previous system which set species quotas on what an individual could land during each 2-month period but allowed fishermen to discard fish once they reached their landings limit and continue fishing for other species. IFQ rules require fishermen to balance <u>all</u> IFQ species catch with QP, whether the fish is landed or discarded. Fishermen whose catches exceed their QP holdings must acquire QP from other quota holders or cease fishing and potentially face penalties. Since fishermen have limited ability to control the species composition of their catch, a well-functioning QP market is essential to enable them to match catches with QP. Transferability of QP also offers the possibility for fishermen to adjust their catch and quota pound portfolios to better fit their business plans by acquiring or selling QP. Businesses can now buy and sell QS to adjust their annual QP allocations, but we focus on the QP market in this report, as QS trading was only allowed as of 2014.

For most fishery participants, buying and selling QP was a completely new activity when the IFQ system was implemented.  The National Marine Fisheries Service (NMFS) provided a publicly available listing of IFQ permit holders and their QS and QP holdings (https://www.webapps.nwfsc.noaa.gov/ifq/), and a web-based system to implement transfers of QP between permit holders. This provided a relatively simple and efficient means to transfer QP and provided some information on who might have QP to sell, but it did not automatically create a functional QP market. The market is developing organically as quota holders, fishermen, and intermediaries develop trading relationships.

QP transfers can provide useful information to fishing businesses, fishery managers, and other fishery stakeholders. Price information on prior QP sales provides a basis for negotiating sale prices. Price information provides businesses important information for business planning (e.g., whether to expand or contract their planned catches of various IFQ species and buy or sell QP accordingly). Theoretically, QP prices should provide an indication of profitability of the fishery and thus a means to assess economic performance of the fishery (Newell et al. 2007). Prices of QP should provide a measure of the profit that can be generated from an additional pound of quota in the current year. In a multispecies fishery, the value of QP may be more complex because an additional pound of quota for one species may allow more catch of other species for which QP is not limiting (Holland 2013). For example, if a fisherman typically catches 1 pound of canary rockfish for every 1,000 pounds of sablefish and has additional sablefish QP but no canary QP, an additional pound of QP might be worth much of the profit that could be gained from landing an additional 1,000 pounds of sablefish. Analysis of QP transfers can also reveal geographic and sectoral shifts of quota ownership and fishery participation that are important to fishery managers and stakeholders. Understanding these shifts can be particularly important in evaluating and minimizing adverse economic impacts on fishing communities as mandated by National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and

potentially for evaluating optimal yield as mandated under National Standard 1 of the MSA. Information on transfers can be used to construct social networks that reveal how the market is structured and how thick the market is, which may be helpful in identifying impediments to market efficiency.

We analyze all QP transfers made in years 2011–2013, the first 3 years of the Pacific Coast Groundfish IFQ program's operation. We explore the structure of the QP market, how it has developed, how it is performing, and where it appears to be failing to work efficiently. We explore the characteristics of the QP market and trading networks in terms of how they are organized. As we show, arm's length sales of QP for cash represent only a small part of the overall system for distributing and redistributing QP among vessels. A variety of other mechanisms—including intra-firm transfers, contractual relationships, barter, and risk pools—account for the bulk of transfers. Our findings identify a number of factors that can inhibit development and operation of an efficient QP market in a multispecies IFQ program, and we discuss how policies can facilitate or impede the operation of QP markets and other mechanisms for getting QP to those who can make best use of it.

# Background on the IFQ Program

The Pacific Coast Groundfish FMP covers more than 90 species, including 64 rockfish species, 12 flatfish species, 12 roundfish species, and six species of sharks and skates harvested off the coasts of California, Oregon, and Washington using a number of gears.  The fishery has traditionally been divided into a trawl fishery and a fixed gear fishery, each with a different set of regulations and allocations of the overall total allowable catch (TAC) of the species they catch. The limited entry trawl sector of the groundfish fishery includes a demersal trawl fishery that targets a wide variety of rockfish, roundfish, and flatfish species, as well as a distinct midwater trawl fishery for Pacific whiting that takes only minimal amounts of other groundfish.

In 2011 an IFQ system was implemented for the limited entry trawl sector of the Pacific Coast Groundfish Fishery.[1] The IFQ includes 25 species or species groups divided into 29 separate IFQ stocks and one IBQ stock (Table 1).[2] Vessels fishing in the IFQ fishery also land a number of other species that are not included in the IFQ program and thus do not require balancing catch with QP. Although the IFQ system was implemented for the trawl sector of the groundfish fishery, a "gear switching" provision allows fishermen to use longlines or fish pots to harvest IFQ quota pounds while registered to a trawl limited entry permit.  This partially integrates a fishery that had been managed with largely separate management approaches and allocations for trawl and fixed gear sectors, although a separate fixed gear fishery still remains. Many trawl participants who have traditionally fished with trawl gear have used the provision to switch gears on one or more trips, and some traditional fixed gear fishermen have entered the IFQ program by registering their vessel to a trawl limited entry program, opening a vessel account, and obtaining QPs.

This report focuses on the IFQ component of the trawl fishery and the transfers of QP between participants in that fishery. Catches of IFQ species during the first 3 years of the program have been far below the total QP allocated for all but a few species (Table 1). Catches exceeded 90 percent of allocated QP for only three stocks (Pacific whiting, sablefish north of 40°10' latitude, and petrale sole).

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[1] Part of the allocation for Pacific whiting is allocated to catcher-processors and vessels delivering to at-sea processors, and these sectors are managed with cooperatives rather than IFQs.

[2] Sablefish, lingcod, shortspine thoryheads, minor shelf rockfish, and minor slope rockfish each have separate IFQ stocks north and south of specified latitude.

The reasons why much of the allocations is left unharvested are not completely clear and likely vary from species to species.  A lack of markets for fish, or prices too low to make harvest economical, may be part of the reason, but concerns about availability of quota pounds to cover unexpected bycatch may also have discouraged targeting of some species that are found in areas where bycatch risk is high.

Prior to implementation of the IFQ program, there was substantial concern that very small total quotas for several overfished rockfish species might constrain catches of other IFQ species. Species of concern included bocaccio, canary rockfish, cowcod, darkblotched rockfish, Pacific Ocean perch, widow rockfish, and yelloweye rockfish. The most severe example is yelloweye rockfish, which had a total allocation of only 1,323 pounds of QP in 2011 and a median QP allocation of only 4 pounds.  There was also concern about Pacific halibut that cannot be retained, but catches must be matched with individual bycatch QP. In response to these concerns a number of fishery participants formed risk pools in which they pooled QP for the overfished rockfish species and for Pacific halibut IFQ (see Holland and Jannot 2012).  The risk pools reduce the risk that an individual fisherman will be shut down by an unexpected bycatch event and fail to find anyone to sell them QP.  However, to ensure that risk pool members take due care to avoid bycatch, the risk pools also require members to follow a number of rules designed to reduce bycatch, for example avoiding certain areas with high bycatch risk (Holland and Jannot 2012).

During the first 3 years of the IFQ program, catches have in fact not exceeded 50 percent of total QP in aggregate for any of these potentially constraining rockfish species.  Yelloweye catches were only 10 percent of QP in 2011 and only 6 percent in 2012 and 2013. For canary rockfish, which was frequently mentioned by fishermen as one of the biggest concerns, catches have not exceeded 28 percent of total QP in any year. Although aggregate catches have been far below QP, catches tend to be very uneven, so some individuals have caught more than the QP they were originally allocated and had to acquire additional QP. Anecdotal reports indicate that many other fishermen may have opted not to pursue certain species in shelf areas because of the risk of exhausting QP allocations for species like yelloweye and canary rockfish and being forced to tie up if they could not find QP on the market.  This suggests a failure of the market to distribute QP effectively and a lack of confidence in the QP market as a source of QP should an individual need to acquire more. Our analysis can neither confirm nor dispute this hypothesis explicitly, but we do present evidence that the market is highly complex and arguably inefficient to date.

**Table 1: Catches as a Percentage of Total IFQ Quota Pound Allocations 2011–2013**

| Catches vs. Total IFQ Quota Pound Allocations | 2011 | 2012 | 2013 | 2014 | 2014 Sector Quota Pounds |
|---|---|---|---|---|---|
| Arrowtooth flounder (TAC dropped 60% in 2013) | 20% | 26% | 63% | 50% | 7,643,603 |
| Bocaccio rockfish South of 40°10' N. | 9% | 15% | 17% | 11% | 174,165 |
| Canary rockfish | 14% | 28% | 26% | 26% | 90,610 |
| Chilipepper rockfish South of 40°10' N. | 21% | 22% | 36% | 29% | 2,352,883 |
| Cowcod South of 40°10' N. | 1% | 5% | 22% | 20% | 2,205 |
| Darkblotched rockfish | 36% | 36% | 44% | 35% | 613,789 |
| Dover sole | 35% | 33% | 36% | 29% | 49,018,682 |
| English sole | 1% | 2% | 3% | 5% | 11,598,189 |
| Lingcod (combined North and South of 40°10' N.) | 16% | 21% | 21% | 11% | 3,592,323 |
| Longspine thornyheads North of 34°27' N. | 49% | 48% | 59% | 50% | 3,993,453 |
| Minor shelf rockfish North of 40°10' N. | 3% | 8% | 6% | 7% | 1,119,948 |
| Minor shelf rockfish South of 40°10' N. | 3% | 15% | 25% | 12% | 178,574 |
| Minor slope rockfish North of 40°10' N. | 17% | 27% | 25% | 23% | 1,740,285 |
| Minor slope rockfish South of 40°10' N. | 14% | 33% | 31% | 26% | 834,736 |
| Other flatfish | 17% | 16% | 19% | 20% | 9,245,746 |
| Pacific cod | 22% | 35% | 14% | 15% | 2,483,309 |
| Pacific halibut (IBQ) North of 40°10' N. | 28% | 43% | 31% | 25% | 236,660 |
| Pacific ocean perch North of 40°10' N. | 39% | 45% | 45% | 36% | 247,535 |
| Pacific whiting | 98% | 96% | 99% | 83% | 263,309,103 |
| Petrale sole | 93% | 100% | 92% | 97% | 5,242,593 |
| Sablefish North of 36° N. | 94% | 91% | 100% | 95% | 4,382,790 |
| Sablefish South of 36° N. | 86% | 44% | 15% | 32% | 1,439,839 |
| Shortspine thornyheads North of 34°27' N. | 50% | 50% | 60% | 50% | 3,025,822 |
| Shortspine thornyheads South of 34°27' N. | 17% | 1% | 7% | 5% | 110,231 |
| Splitnose rockfish South of 40°10' N. | 3% | 4% | 3% | 4% | 3,472,501 |
| Starry flounder | 2% | 1% | 0% | 2% | 1,665,592 |
| Widow rockfish | 40% | 45% | 41% | 66% | 2,191,020 |
| Yelloweye rockfish | 10% | 6% | 6% | 6% | 2,205 |
| Yellowtail rockfish North of 40°10' N. | 24% | 32% | 27% | 40% | 6,479,055 |

# Characteristics of QP Transfers

Because all QP transfers must be done through an online system operated by NMFS, we are able to analyse the full population of QP transfers. When making QP transfers through this system, the account holder making the transfer must indicate, along with the quantities of QP to be transferred, whether the transfer is a "self-trade" (meant to indicate a transfer within a company), a "cash sale," a "barter," "cash and barter,", or "other." Barter is meant to indicate swaps of QP (e.g., 1,000 pounds of petrale sole for 200 pounds of canary); however, there were some indications that individuals were designating a transfer as barter when in fact the compensation was in some form other than QP.  In 2013 a parenthetical clarification, "swap quota pounds for quota pounds," was added next to the radio button for "barter."

The great majority of QP transfers made are identified as self-trades (Table 2).   At the beginning of the year, individual quota share account holders are allocated QP and must transfer this into vessel accounts for it to be used to balance catch; therefore, many of these self-trade transfers are quota share permit owners transferring QP to their own vessel account, while others are between vessel accounts owned by the same company. Depending on the year, from 33 percent to 39 percent of annual transfers are self-trades.  If transfers of each species in multiple species transfers are each counted as separate transfers, then from 52 percent to 57 percent of all transfers are designated self-trades, reflecting the fact that these transfers have, on average, a larger number of species included than other transfer types.

If we consider only what appear to be arm's-length transfers (those that were not self-trades), the most frequent transfer designation is "other."  Although transferors are asked to describe any non-monetary compensation for the transfer, this is not required and the field is generally left blank. Descriptions that are provided suggest that "other" includes transfers made to and from risk pools and cooperatives, contractual arrangements where payment is a share of revenue when fish is landed, and various miscellaneous reasons (such as gifts, corrections to prior transfers, and bycatch QP to go along with a separate sale of target species QP).  Depending on the year, trades designated as "other" make up from 46 percent to 57 percent of all transfers that are not designated as self-trades (Tables 2 and 3), and from 54 percent to 66 percent if each species in a multispecies trade is counted as a separate transfer. Single-species transfers make up the majority of transfers designated as "other" when considering each multispecies transfer as a single transfer. However, if each species transferred in a multispecies transfer is considered as an individual transfer, then multispecies transfers are more common since each multispecies transfer tends to include a number of species.

A substantial number of transfers are described as barter. As noted above, this category was meant to designate swaps of QP, though it may in fact include some transfers where another form of in-kind compensation was used, particularly prior to 2013. There is no explicit link between the transfers that make up different sides of a barter transaction. Attempts to match up both sides of barter trades have been successful for only a fraction of transfers identified as barter through 2012. We have not yet attempted to match up barter trades reported in 2013. Barter transfers accounted for 16 percent to 22 percent of annual transfers other than self-trades. Barter's share of not-self transfers is smaller (9% to 15%) if each species of multiple species transfers is considered a separate transfer; however, the number of species transferred in multispecies barter transfers tends to be smaller than for other types of multispecies transfers.

Cash sales include both single-species and multispecies transfers. Although the transferor is asked to provide a price per pound for each individual species in the multispecies trade, this is not required and rarely filled out.  The overall value of the sale must be indicated (though a value of zero can be entered), and this provides a way to calculate price per pound for single-species transfers.  With enough multispecies transfers with a total value assigned, it might be possible to estimate species-level prices from multispecies cash sales and possibly barter trades using a hedonic framework (Holland 2013). But, to date, data have been insufficient to support such an estimation (see section on QP prices).

The number of single-species cash sales increased each year during the first 3 years of the program, from 292 in 2011, to 340 in 2012 and 384 in 2013 (Table 2). Although the total number of single-species cash sale transfers increased, they fell as a percentage of all non-self-trades, from 22 percent to 21 percent of the total.  Multispecies cash sales fell from 8 percent to 3 percent of non-self-trades between 2011 and 2013.  Multispecies cash sales had, on average, 17, 21, and 24 species per transfer in 2011, 2012 and 2013, respectively. Consequently, multispecies cash sales make up a higher proportion of overall non-self-trades when each species is counted as a separate transfer or if the share of total pounds transferred is considered. If we consider each species as a separate transfer, multispecies cash sales accounted for 23 percent of non-self-trades in 2011, but fell to 15 percent by 2013 (Table 3).

The amount of transfer activity, and the prevalence of different transfer types, varies significantly by IFQ stock. Table 5 shows total transfers in 2014 by transfer type as a percentage of total QP allocated for each IFQ stock. Note that, because QP can be transferred more than once, these totals exceed 100 percent of the total QP allocated. Much of the QP that was later traded in "market" transactions (i.e., not self-trades) was first transferred from a quota share account to a vessel account. Cash sales range from a low of 4 percent of total QP for splitnose rockfish to a high of 28 percent for Pacific cod. As noted above, while there are fewer multispecies cash sales than single-species cash sales, cash sales for many of these species are primarily part of sales of multispecies packages. QP of only a few species (Pacific whiting, petrale sole, and sablefish) is frequently sold individually, while every species is included in several multispecies cash sales each year (Table 6).

**Table 2: Count of Transfers by Type, Year, and Single vs. Multiple Species Transferred (with multispecies transfer counted as one transfer)**

| Transfer | 2011 | | 2012 | | 2013 | | 2014 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Type | Single | Multi | Single | Multi | Single | Multi | Single | Multi |
| Cash Sale | 292 | 101 | 340 | 67 | 384 | 63 | 411 | 62 |
| Barter | 223 | 66 | 275 | 48 | 262 | 35 | 191 | 37 |
| Cash and Barter | 23 | 11 | 37 | 11 | 48 | 12 | 31 | 9 |
| Other | 409 | 201 | 606 | 260 | 663 | 400 | 596 | 360 |
| Self-Trade | 423 | 408 | 512 | 308 | 641 | 327 | 528 | 326 |
| Not Self Transfers | 2157 | | 2464 | | 2835 | | 2551 | |

**Table 3 Count of Transfers by Type, Year, and Single vs. Multiple Species Transferred (with each species in multispecies transfers counted as a separate transfer)**

| Transfer | 2011 | | 2012 | | 2013 | | 2014 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Type | Single | Multi | Single | Multi | Single | Multi | Single | Multi |
| Cash Sale | 292 | 967 | 340 | 763 | 384 | 733 | 411 | 676 |
| Barter | 223 | 394 | 274 | 187 | 262 | 166 | 191 | 190 |
| Cash and Barter | 23 | 60 | 37 | 50 | 48 | 116 | 31 | 68 |
| Other | 409 | 1870 | 606 | 1520 | 663 | 2649 | 596 | 2409 |
| Self-Trade | 423 | 5107 | 512 | 3648 | 641 | 5411 | 528 | 3817 |
| Total | 9768 | | 7937 | | 11073 | | 8917 | |

**Table 4: Total Pounds of QP Transferred by Type, Year, and Single vs. Multiple Species Transferred in Millions of Pounds**

| Transfer | 2011 | | 2012 | | 2013 | | 2014 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Type | Single | Multi | Single | Multi | Single | Multi | Single | Multi |
| Cash Sale | 8.6 | 21.9 | 15.8 | 21.2 | 10.7 | 16.6 | 13.7 | 15.0 |
| Barter | 37.7 | 16.5 | 23.5 | 5.9 | 15.4 | 3.7 | 12.7 | 4.6 |
| Cash and Barter | 1.3 | 0.7 | 3.6 | 1.4 | 1.5 | 3.1 | 1.5 | 5.8 |
| Other | 63.2 | 78.2 | 69.4 | 40.3 | 69.9 | 79.7 | 100.9 | 66.8 |
| Self-Trade | 26.5 | 269.2 | 81.7 | 144.1 | 68.0 | 187.7 | 58.3 | 219.3 |
| All Transfers | 524 | | 407 | | 456 | | 499 | |

**Table 5: Total Sector Allocation of QP by IFQ Stock in 2013 and Percent Transferred by Transfer Type. Note that percentages exceed 100 percent because QP can be transferred more than once.**

| OPTIMAL_YIELD_CATEGORY | Sector Quota Pounds | Cash Sale | Cash and Barter | Barter | Other | Self-Trade |
|---|---|---|---|---|---|---|
| Arrowtooth flounder | 7,643,603 | 15% | 1% | 4% | 27% | 83% |
| Bocaccio rockfish South of 40°10' N. | 174,165 | 11% | 13% | 10% | 110% | 42% |
| Canary rockfish | 90,610 | 21% | 1% | 5% | 76% | 68% |
| Chilipepper rockfish South of 40°10' N. | 2,352,883 | 14% | 5% | 3% | 76% | 68% |
| Cowcod South of 40°10' N. | 2,205 | 9% | 18% | 20% | 211% | 34% |
| Darkblotched rockfish | 613,789 | 16% | 1% | 7% | 58% | 81% |
| Dover sole | 49,018,682 | 8% | 3% | 4% | 36% | 73% |
| English sole | 11,598,189 | 11% | 4% | 2% | 37% | 63% |
| Lingcod North of 40°10' N. | 2,546,670 | 11% | 3% | 5% | 38% | 72% |
| Lingcod South of 40°10' N. | 1,045,653 | 9% | 2% | 4% | 35% | 64% |
| Longspine thornyheads North of 34°27' N. | 3,993,453 | 21% | 2% | 11% | 45% | 79% |
| Minor shelf rockfish North of 40°10' N. | 1,119,948 | 14% | 3% | 1% | 33% | 73% |
| Minor slope rockfish North of 40°10' N. | 178,574 | 13% | 3% | 3% | 70% | 58% |
| Minor shelf rockfish South of 40°10' N. | 1,740,285 | 15% | 2% | 3% | 37% | 69% |
| Minor slope rockfish South of 40°10' N. | 834,736 | 9% | 1% | 5% | 88% | 56% |
| Other flatfish | 9,245,746 | 12% | 8% | 3% | 53% | 57% |
| Pacific cod | 2,483,309 | 20% | 2% | 3% | 36% | 66% |
| Pacific halibut (IBQ) North of 40°10' N. | 236,660 | 13% | 0% | 8% | 38% | 60% |
| Pacific ocean perch North of 40°10' N. | 247,535 | 20% | 0% | 7% | 48% | 75% |
| Pacific whiting | 263,309,103 | 5% | 1% | 4% | 44% | 72% |
| Petrale sole | 5,242,593 | 29% | 1% | 18% | 46% | 78% |
| Sablefish North of 36° N. | 4,382,790 | 27% | 3% | 15% | 41% | 83% |
| Sablefish South of 36° N. | 1,439,839 | 18% | 6% | 1% | 64% | 52% |
| Shortspine thornyheads North of 34°27' N. | 3,025,822 | 19% | 1% | 8% | 57% | 79% |
| Shortspine thornyheads South of 34°27' N. | 110,231 | 6% | 3% | 2% | 72% | 35% |
| Splitnose rockfish South of 40°10' N. | 3,472,501 | 4% | 4% | 1% | 65% | 54% |
| Starry flounder | 1,665,592 | 6% | 4% | 1% | 32% | 84% |
| Widow rockfish | 2,191,020 | 24% | 7% | 8% | 84% | 74% |
| Yelloweye rockfish | 2,205 | 23% | 0% | 3% | 71% | 57% |
| Yellowtail rockfish North of 40°10' N. | 6,479,055 | 19% | 2% | 5% | 36% | 76% |

**Table 6: Counts of Single-Species and Multispecies Cash Sale Transfers of Each IFQ stock 2011–2014**

| IFQ | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|
| Species | Single | Multi | Single | Multi | Single | Multi | Single | Multi |
| Arrowtooth flounder | 1 | 46 | 2 | 32 | 10 | 27 | 8 | 19 |
| Bocaccio rockfish South of 40°10' N. | 3 | 13 | 4 | 9 | 5 | 12 | 7 | 10 |
| Canary rockfish | 5 | 21 | 16 | 24 | 12 | 28 | 17 | 24 |
| Chilipepper rockfish South of 40°10' N. | 3 | 20 | 7 | 24 | 9 | 24 | 13 | 21 |
| Cowcod South of 40°10' N. | 2 | 13 | 2 | 9 | 4 | 12 | 2 | 8 |
| Darkblotched rockfish | 4 | 38 | 7 | 31 | 10 | 34 | 10 | 25 |
| Dover sole | 6 | 54 | | 31 | 5 | 25 | 1 | 20 |
| English sole | 1 | 38 | | 27 | | 21 | | 26 |
| Lingcod | 2 | 29 | 4 | 23 | 2 | 46 | 1 | 54 |
| Longspine thornyheads North of 34°27' N. | 5 | 53 | 13 | 39 | 20 | 33 | 24 | 28 |
| Minor shelf rockfish North of 40°10' N. | 1 | 24 | 2 | 22 | | 24 | 9 | 18 |
| Minor slope rockfish North of 40°10' N. | 1 | 30 | 6 | 26 | 5 | 19 | 2 | 18 |
| Minor shelf rockfish South of 40°10' N. | 3 | 35 | 6 | 25 | 3 | 25 | 4 | 28 |
| Minor slope rockfish South of 40°10' N. | 7 | 31 | 7 | 29 | 9 | 24 | 1 | 19 |
| Other flatfish | 1 | 41 | 1 | 22 | | 24 | 2 | 31 |
| Pacific cod | 14 | 21 | 11 | 23 | 1 | 22 | 5 | 24 |
| Pacific halibut (IBQ) North of 40°10' N. | 5 | 23 | 10 | 27 | 22 | 28 | 17 | 23 |
| Pacific ocean perch North of 40°10' N. | 3 | 32 | 4 | 26 | 17 | 30 | 19 | 24 |
| Pacific whiting | 31 | 43 | 82 | 26 | 63 | 21 | 34 | 30 |
| Petrale sole | 40 | 53 | 23 | 37 | 56 | 31 | 60 | 27 |
| Sablefish North of 36° N. | 64 | 56 | 49 | 37 | 78 | 26 | 67 | 25 |
| Sablefish South of 36° N. | 67 | 35 | 34 | 26 | 8 | 23 | 22 | 16 |
| Shortspine thornyheads North of 34°27' N. | 2 | 56 | 11 | 39 | 12 | 32 | 11 | 36 |
| Shortspine thornyheads South of 34°27' N. | 3 | 24 | 1 | 25 | 3 | 22 | 4 | 15 |
| Splitnose rockfish South of 40°10' N. | 1 | 26 | 1 | 25 | 1 | 21 | | 17 |
| Starry flounder | 2 | 27 | | 22 | | 21 | | 16 |
| Widow rockfish | 7 | 34 | 12 | 31 | 11 | 30 | 36 | 26 |
| Yelloweye rockfish | 7 | 25 | 11 | 22 | 12 | 25 | 14 | 18 |
| Yellowtail rockfish North of 40°10' N. | 1 | 26 | 14 | 24 | 6 | 23 | 21 | 30 |

The choice between barter and cash sales appears to be somewhat dependent on whether the parties have some existing linkages. If we consider only "market" transfers (those identified as either barter, cash, or cash and barter), there is a clear preference for using barter over cash sales as the mechanism of trade when both parties own vessels that land fish to the same processor (Figure 1). In contrast, cash sales are preferred for parties that do not share a processor (Figure 1). For parties that do not fish to the same processor, 67 percent of market transfers are cash sales and 28 percent are barter, whereas for parties that do fish to the same processor only 28 percent are cash sales and 64 percent are barters. It is not clear why this is the case, but it may be that processors tend to broker barter trades between vessels that land fish to them, and they may favor barter arrangements over cash when they themselves make transfers to vessels that fish to them.

**Figure 1: Percent of Annual Cash and/or Barter Transfers that were Cash Sales vs. Barter Depending on Whether the Parties Involved Landed Fish to the Same Processor.**
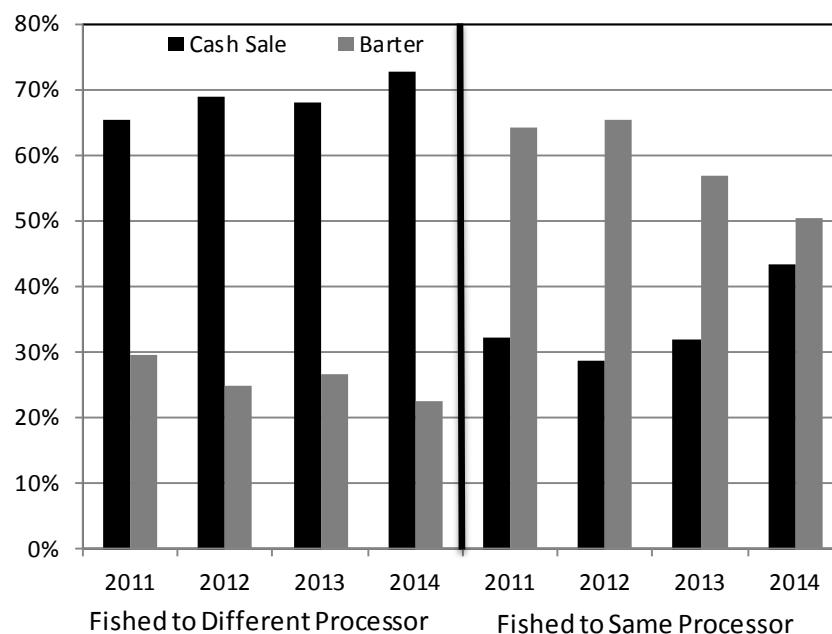


The movement of QP between states may be of some interest to stakeholders and managers to assess some of the distributional implications of the IFQ system. Geographical shifts in QP may also help differentiate whether spatial shifts in fishing activity are the result of vessels moving or of QP moving to vessels. This information can also reveal how the market is organized and the extent to which proximity (e.g., being from the same state) makes trading relationships more likely.

In terms of total transfers from 2011 to 2014 that were not self-trades, approximately 62 percent were between account owners from the same state. However, when considering only market transfers (cash and or barter), only 50 percent are between account owners from the same state. Cash sales are also about 50 percent intra-state trades. The ratio of trades to and from different states differs substantially. The ratio of transfers to California from other states relative to transfers from California to other states is 0.36, indicating a much higher likelihood of transfers moving QP out of California than into it (Figure 2). The opposite is true for Oregon and Washington; Oregon has a substantially higher ratio of incoming transfers to outgoing than either California or Washington when considering all transfers that are not self-trades and all market transfers. However, for cash sales both Washington and Oregon have around 1.8 incoming cash transfers per outgoing transfer.

**Figure 2: Ratio of Transfers to a State from Another State to Transfers from a State to Another State by Type of Transfer for Transfers Occurring in the Years 2011–2014.**
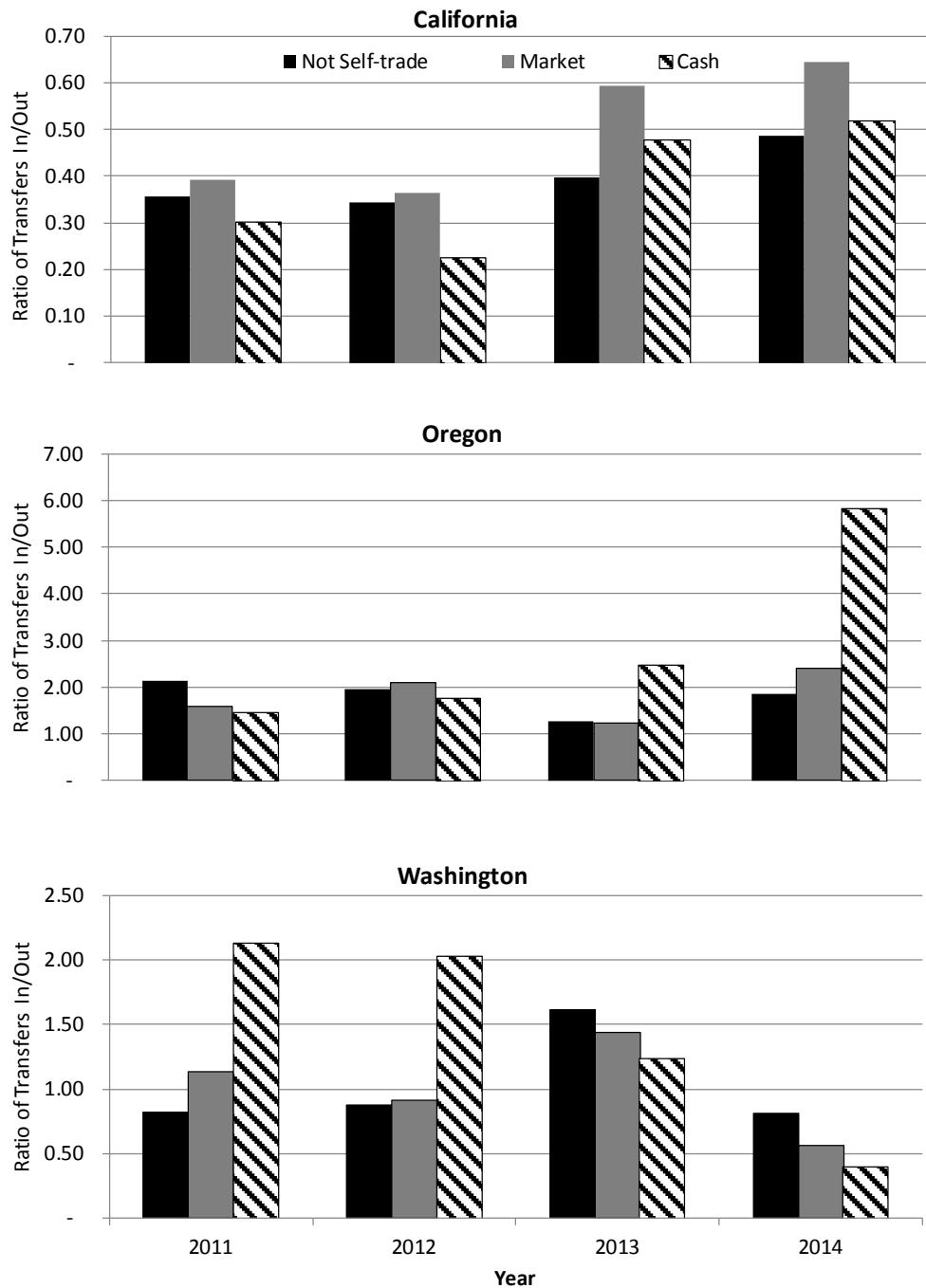
# QP Trading Patterns and Networks

Ultimately the QP market and the overall system for distributing QP is a set of trading relationships that can be represented by quota account owner-to-owner linkages for which transfers were observed. This arguably provides a better idea of the thickness of the market than the quantity of transfers. It is illustrative to examine the thickness of this trading network overall and for specific types of transfers (Table 7).Overall there are more than 300 unique QS and/or vessel account owners (most of these have both QS and vessel accounts and some have multiple accounts). Despite the relatively small number of owners, if each of these owners transacted with all the others, this would result in very large set of trading relationships, but in fact the total of intra-owner trading relationships is relatively small, growing from 540 to 600 (Table 7). This suggests that on average each owner trades with about two others, but some have many links and others have only one or none.

If we consider only linkages that undertook cash or barter transfers, the number falls by about one-third, rising from 389 in 2011 to 408 in 2013. There are fewer than 300 owner-to-owner links for which cash transfers, including both single-species and multispecies transfers, were observed in a given year. Only about 11 percent of total linkages were observed to use the Jefferson Trading website (an auction site that enables individuals to post QP for sale in auctions or for immediate purchase at a particular price) to facilitate trades in 2011, but this nearly doubled to 117, or 20 percent of all owner-to-owner linkages, in 2013. This could also be an underestimate, as not all transfers that took place on Jefferson Trading could be matched to transfers in the NMFS database. Sablefish was transferred across 40 to 50 percent of these linkages depending on the year, but only 16 to 23 percent had transfers of canary rockfish, suggesting a relatively thin market for this species (which is often mentioned as one that constrains fishermen's ability to use other QP).

**Table 7: Number of Linkages between QS and/or QP Owners by Transfer Type and Year**

|  | Number of Unique Links | | | | Percent of Total Links | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| YEAR | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 |
| Not Self Transfers | 540 | 564 | 600 | 608 | 100% | 100% | 100% | 100% |
| Cash and/or Barter | 389 | 369 | 408 | 394 | 72% | 65% | 68% | 65% |
| Cash Sales | 259 | 245 | 292 | 273 | 48% | 43% | 49% | 45% |
| Jefferson Auction | 62 | 85 | 117 | 137 | 11% | 15% | 20% | 23% |
| Same Processor | 160 | 158 | 159 | 137 | 30% | 28% | 27% | 23% |
| Sablefish | 270 | 228 | 234 | 223 | 50% | 40% | 39% | 37% |
| "Bycatch" Species | 202 | 234 | 280 | 309 | 37% | 41% | 47% | 51% |
| Canary Rockfish | 86 | 130 | 132 | 138 | 16% | 23% | 22% | 23% |

Although some trading relationships are essentially anonymous and facilitated by a broker or the Jefferson Trading website, most are not. Rather they involve the two trading partners finding each other somehow and negotiating a trade. Individuals who land fish to the same processor might be more likely to know each other and have an idea of what QP each other has and needs. Processors may also be in a position to act as brokers, either acquiring and distributing QP to vessels that fish to them, or facilitating trades between those vessels—sometimes even acting as account managers.  When considering the linkages between individuals that do or do not fish to the same processor, it is clear that for those who do not fish to the same processor the trading relationship is more likely to be based on cash transactions, whereas those who fish to the same processor are likely to use non-cash means of compensation (Figures 3 and 4).

**Figure 3: Percent of Linkages between Account Owners that Landed Fish to the Same Processor that Did or Did Not Undertake Some Cash Transactions**
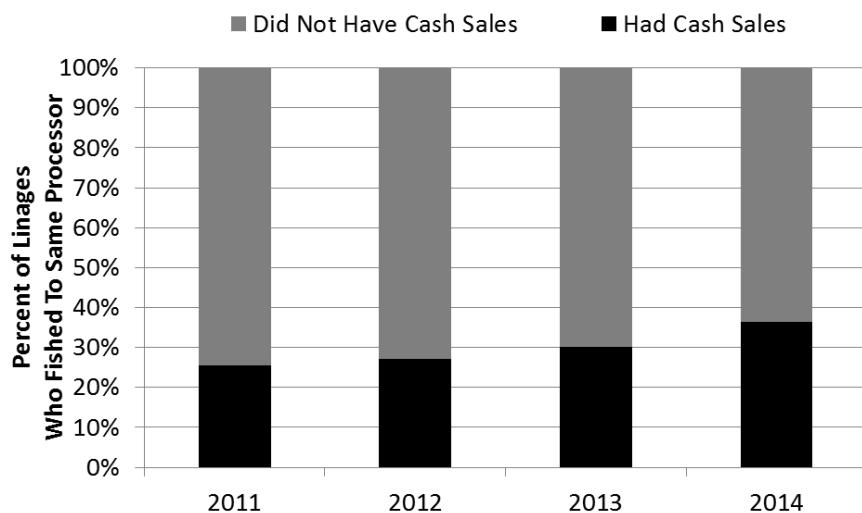


**Figure 4 Percent of Linkages between Account Owners that Included some Cash Transactions that Did or Did Not Land Fish to the Same Processor**
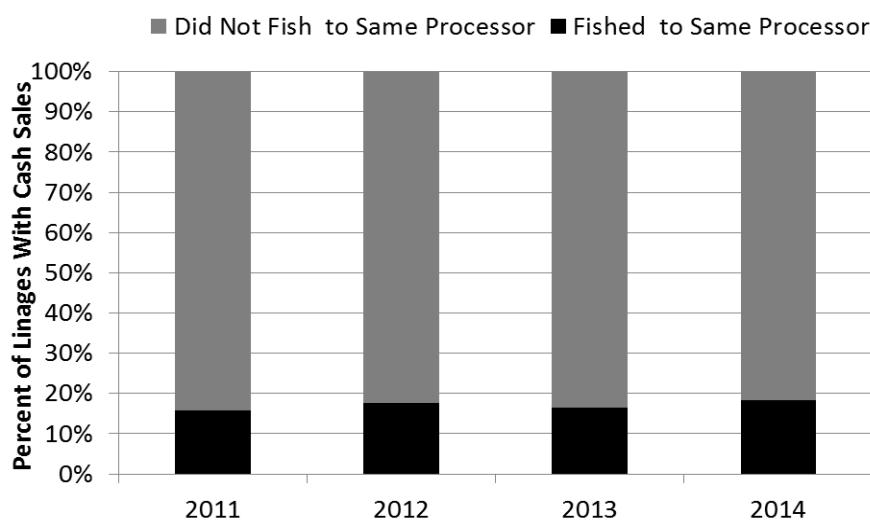
In the prior section we noted that a higher share of transfers indicated QP moving from a California owner to an owner from anther state than the reverse, but that the opposite was true for Oregon and Washington, which had more incoming than outgoing inter-state transfers. The same is true when we look at the trading relationships and consider the ratio of the number of linkages with outgoing inter-state trades relative to linkages with incoming trades (Figure 5). More California owners are "exporting" QP than are "importing" it, and the reverse is true for both Oregon and Washington. The difference is particularly strong when we consider just linkages that were observed to utilize Jefferson Trading. Oregon owners who use Jefferson Trading are more than 4.5 times more likely to be QP buyers than sellers, whereas Californian owners who use Jefferson Trading are nearly 4.5 times as likely to be selling QP.

**Figure 5  Ratio of the Number of Trade Linkages between Account Owners that Have Incoming Interstate QP Transfers Over Those Having Outgoing Interstate Transfers for Years 2011–2014.**
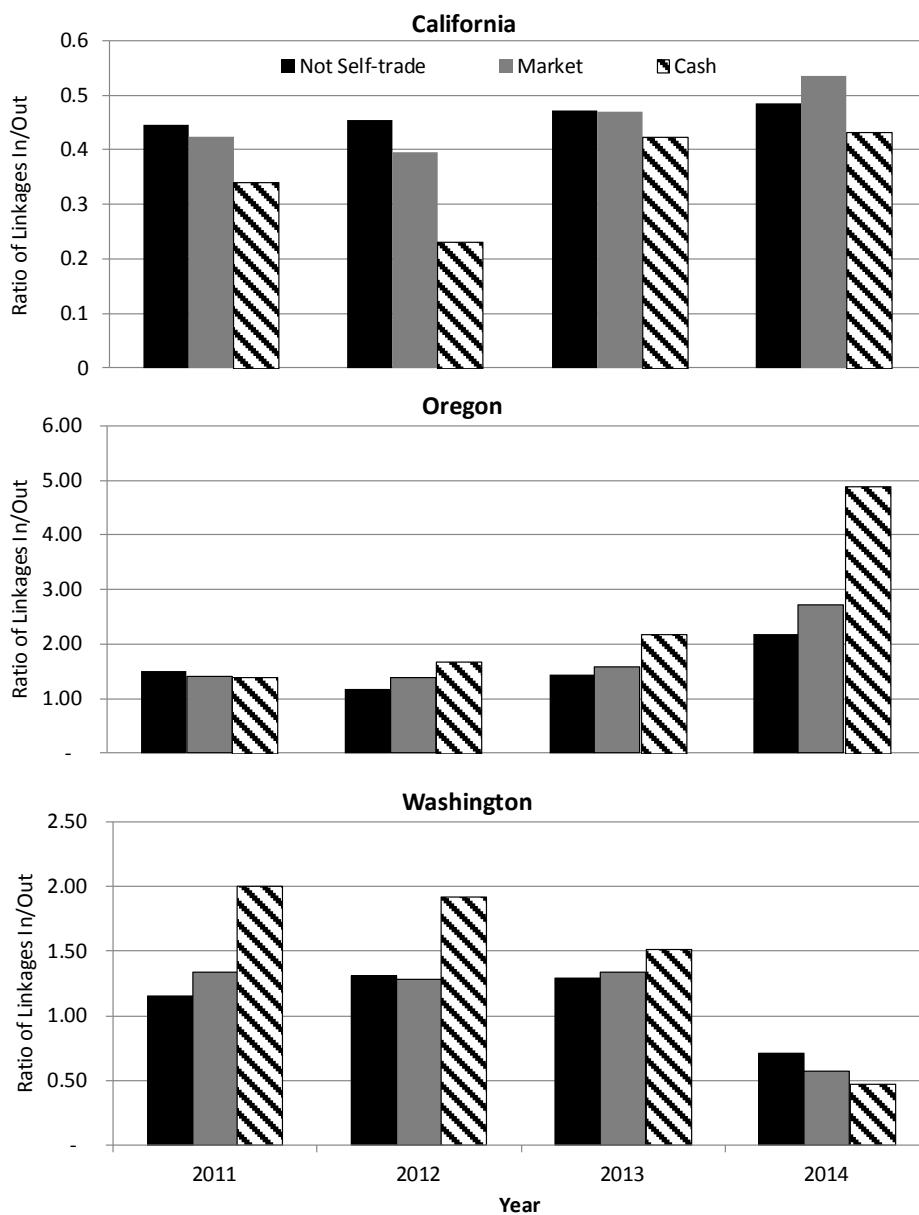
# Network Analysis

We use UCInet network analysis software (Borgatti et al. 2002) to analyse networks of QP trading for different categories of transactions.  Network images can be useful in understanding the qualitative characteristics of the QP market, in particular the degree to which trading is coordinated. The network software UCInet is used to map networks visually, showing unique quota account owners (who in some cases own multiple QS or vessel accounts) as nodes. Although we count separate accounts as one account owner if the name of the account owner is the same or self-trades occurred between the accounts, some of these account owners may not be fully independent—e.g., in some cases multiple account owners could be subsidiaries of a larger entity.  Arrows between the nodes indicated where trading activity has taken place and the direction of transfers.  The color, size, thickness, shape, etc. of symbols representing account holders and linkages between them can be made to vary with characteristics, which can reveal qualities of the network that might not be immediately obvious from simply looking at data. For example, one can vary the color of nodes by whether they are active vessels to identify how QP moves from inactive to active quota owners or through brokers.  The network analysis software also provides quantitative measures such as network density (which might be considered a proxy for market thickness in this case) or node centrality (which provides a measure of the importance of particular account owners in the overall network). Comparison of networks over time can tell us whether the market is thickening or thinning and how it is changing qualitatively.

In Figure 6, the network for all transfers not labelled by the transferor as self-trades is shown. The size of the nodes and the centrality of their position in the network reflects the number of linkages they have in the network. Additionally, in Figures 6 through 9, nodes that include at least one vessel account to which landings were attributed are colored blue, while those without active vessels are colored red.  The thickness of the lines connecting nodes is proportional to the number of transactions between those nodes and, in Figure 8 bright green lines indicate trades between nodes that were mediated by a "market maker."

While the network of trading linkages between account owners is complex, it is in fact fairly sparse relative to potential density.  A commonly used measure of network density is the ratio of the actual number of linkages between nodes over the potential number if all nodes were linked to all others. This measure of density for the network based on all transfers that were not self-trades was 0.0272 in 2011 and 0.0486 in 2014.

**Figure 6 Networks of Trading Relationships in 2011 (upper) and 2014 (lower)  Based on All Transfers Not Identified as Self-Trades**
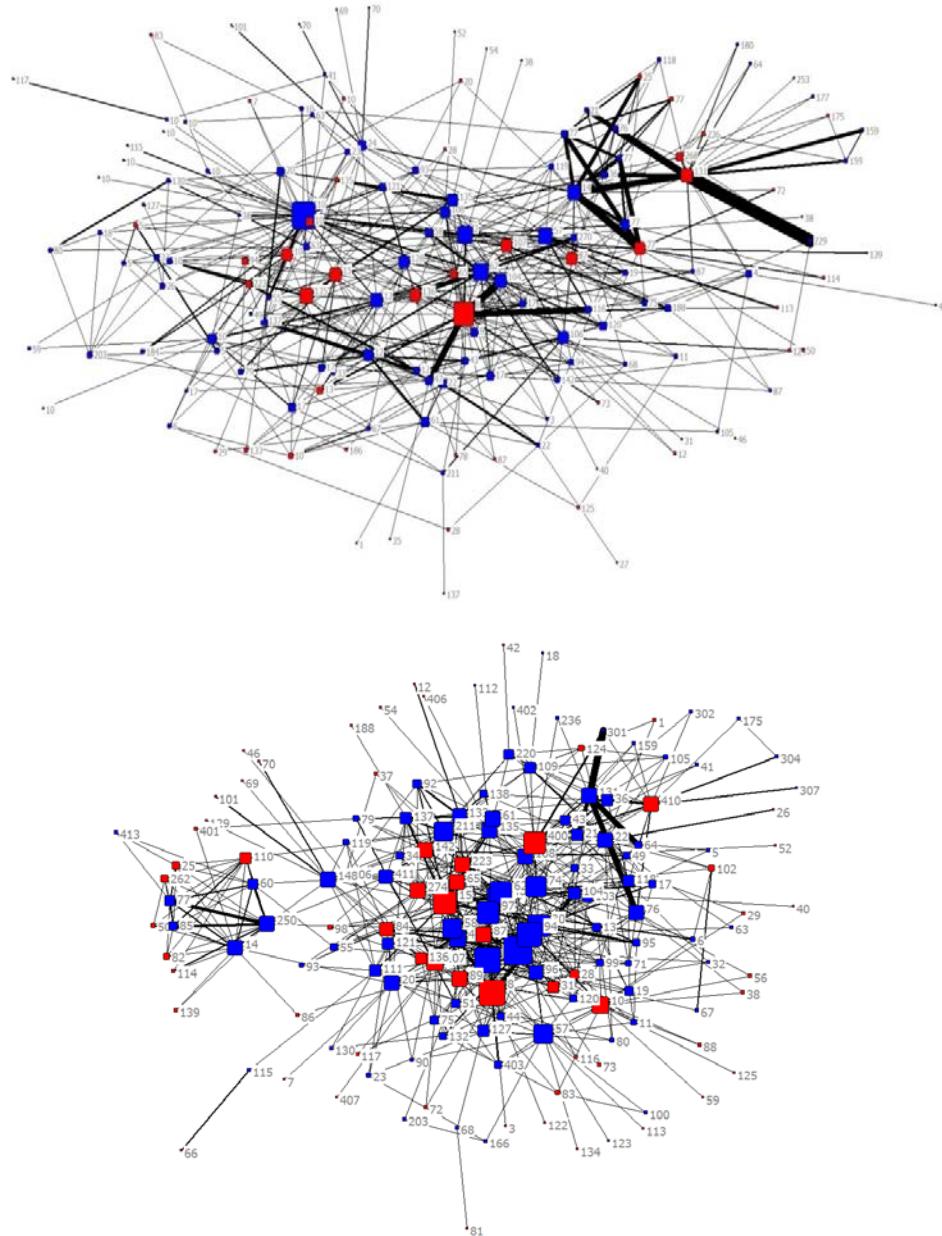
If we consider only transfers labelled by the transferors as cash sales, barter, or cash and barter, which we consider to be "market" transactions, the density of the network is only 0.0198 in 2011 and 0.0182 in 2014, indicating a much smaller set of trading relationships between account holders relative to the network with all transfers that were not self-trades (Figure 7).

**Figure 7 Networks of Trading Relationships in 2011 (upper) and 2014 (lower) Including Only Linkages with Cash and/or Barter Transfers**
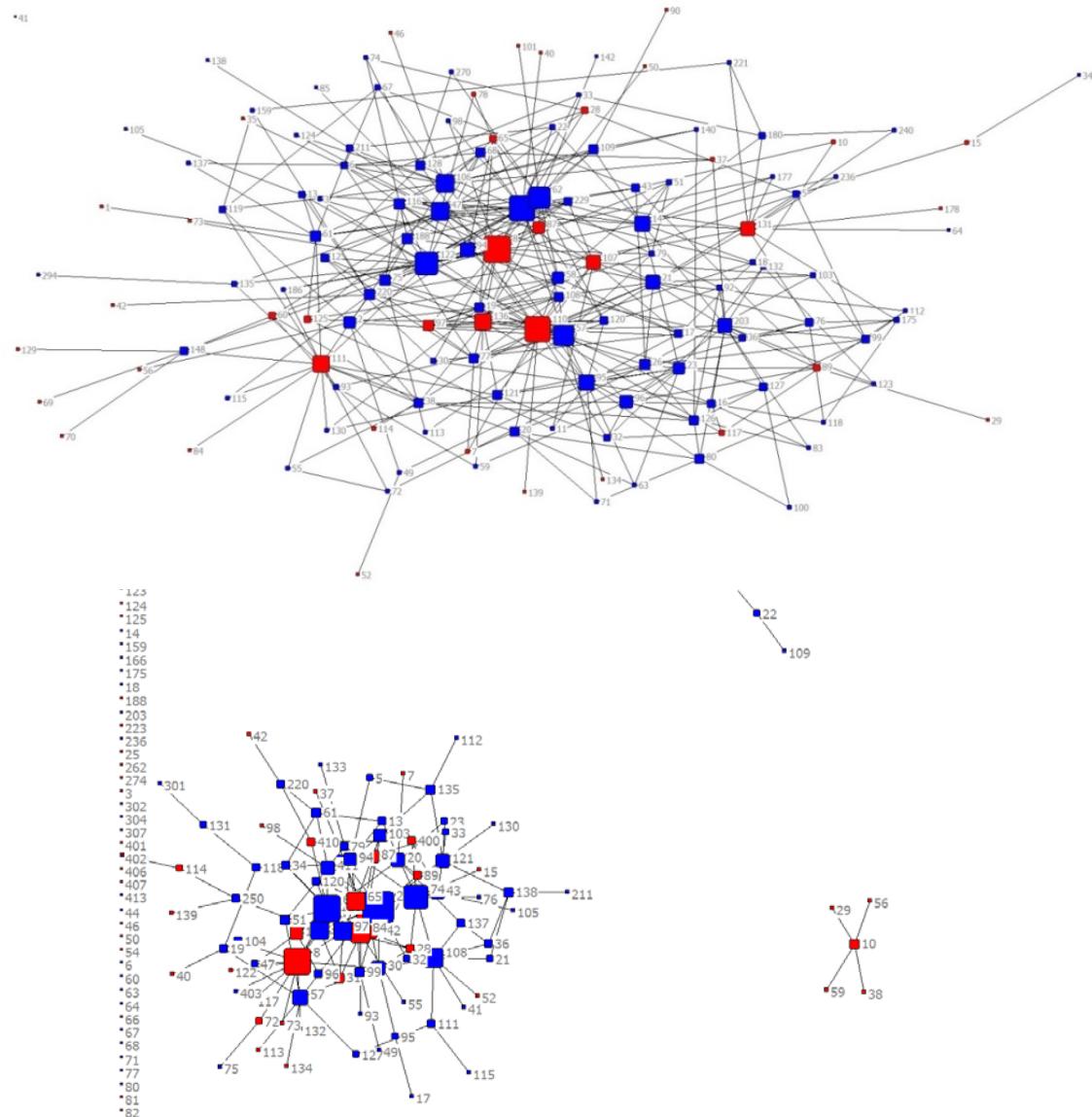
The network is sparser still when only linkages involving at least some cash sales are included in the network. Density falls to 0.0116 for 2014. As noted earlier, a significant proportion of cash sales are facilitated by Jefferson Trading. The density of this network (e.g., relationships between account holders that we could identify as using Jefferson Trading to facilitate cash trades, highlighted in green) was only 0.0027 in 2011, about a quarter the density of the network for all cash sales. But density for the Jefferson Trading network increased by about one-third to 0.0036 in 2012 and to 0.0052 in 2013. In 2014 the density for the Jefferson Trading network was 0.0059, more than twice the density in 2011 (Figure 8).

**Figure 8 Networks of Market Maker Trading Relationships in 2011 (upper) and 2014 (lower) Including Only Linkages with Cash Sales**
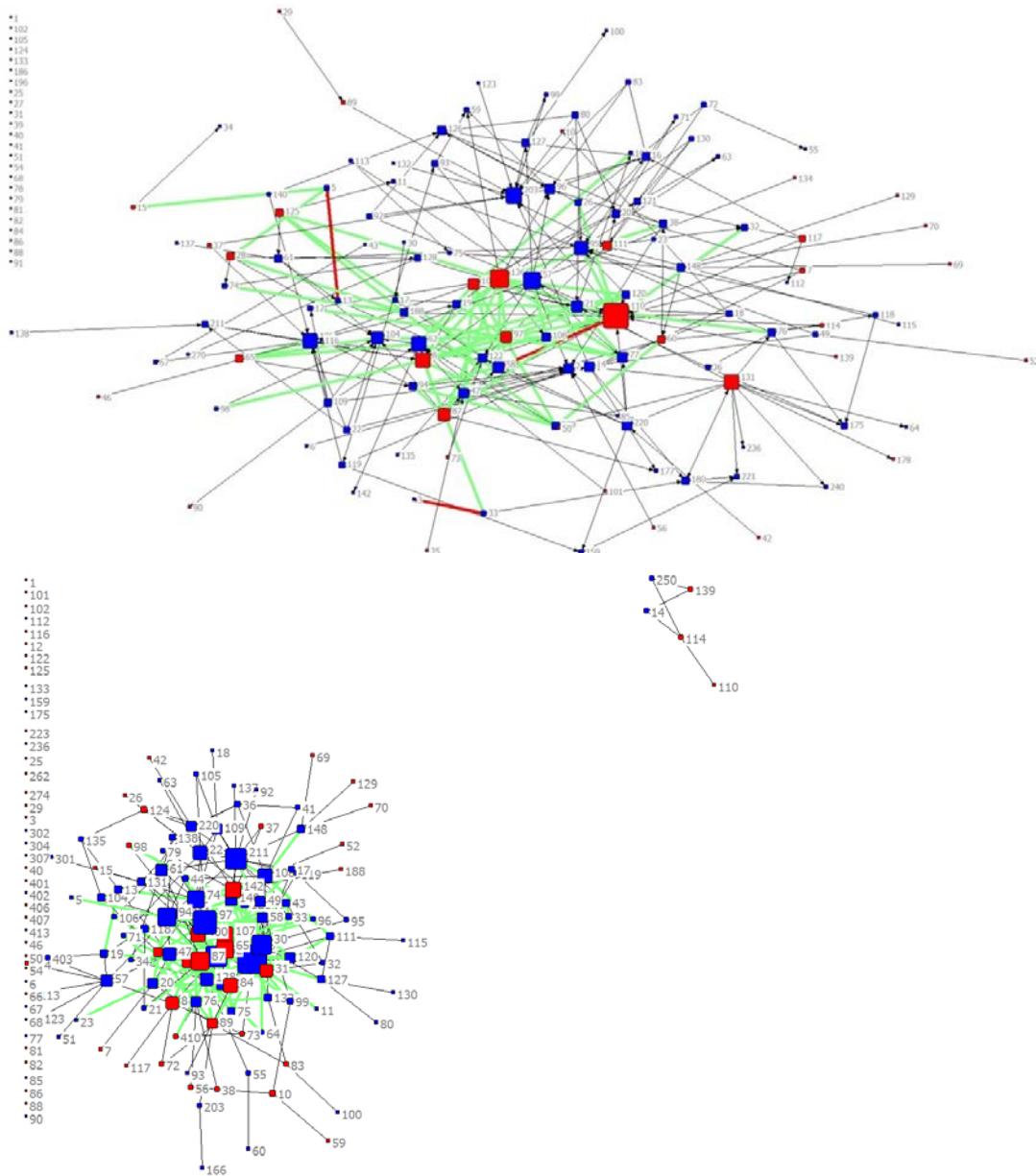
The networks presented above include transfers of all IFQ species, but it useful to consider networks for particular species or species groups. For example, one of the most heavily traded species is sablefish. However density of this network (Figure 9), at 0.0095, is only about one-third of that of the network for all species transfers. If we consider a species like widow rockfish (not shown), which is primarily an incidentally caught species, the network is thinner still with a density of only 0.0079.

**Figure 9 Networks of Sablefish Trading Relationships in 2011 (upper) and 2014 (lower) Including Only Linkages with Cash Sales**
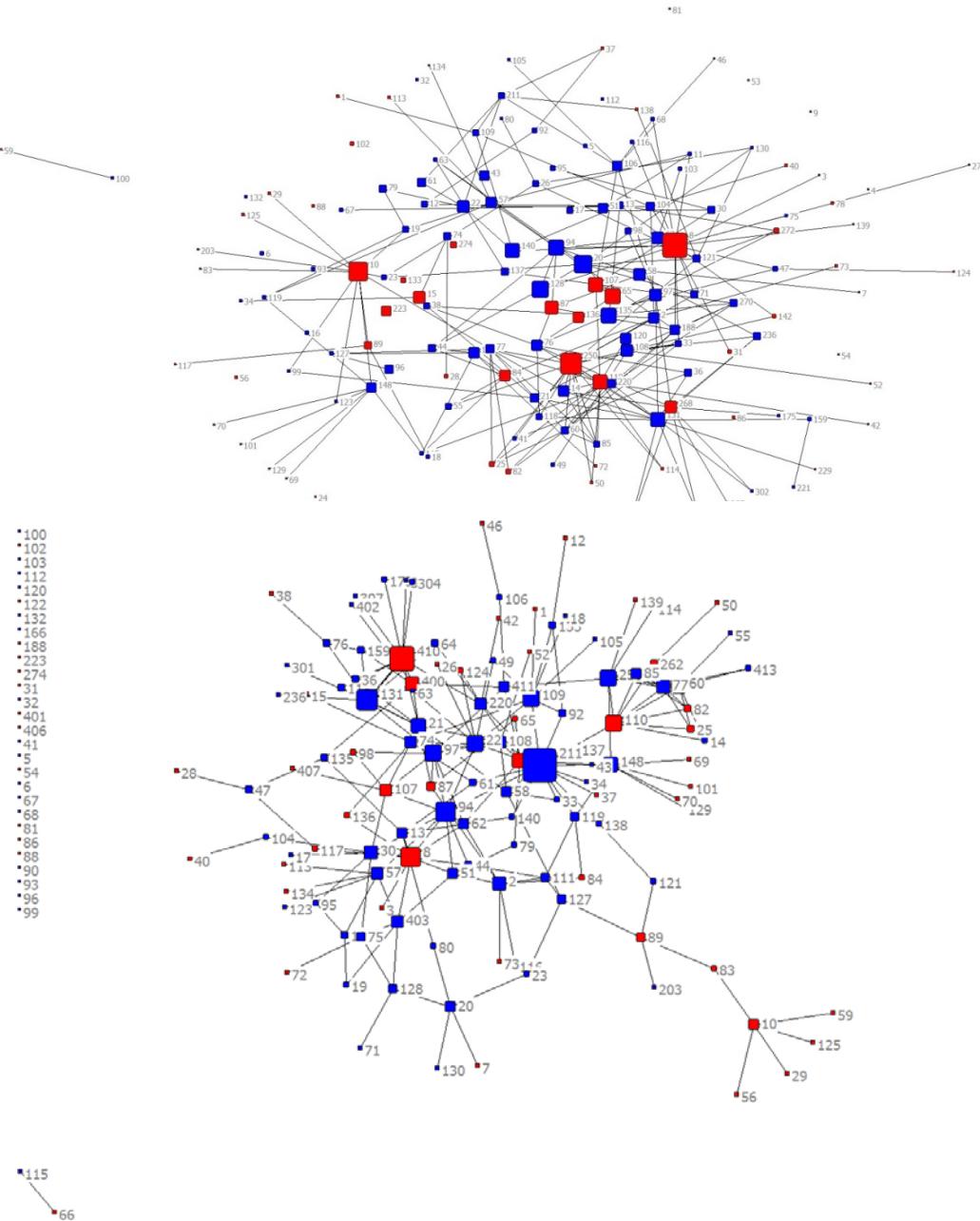
Lastly, Figure 10 uses three node colors to highlight the state of origin for quota owners: red represents California, blue represents Oregon, and black represents Washington state. This suggests that all three states have some entities with many connections (recall that the size of the nodes and the centrality of their position in the network reflect the number of linkages they have in the network), and that there are many linkages between entities from different states, rather than a set of isolated state networks.

**Figure 10 Network of Trading Relationships in 2014 Highlighting Trades between States**
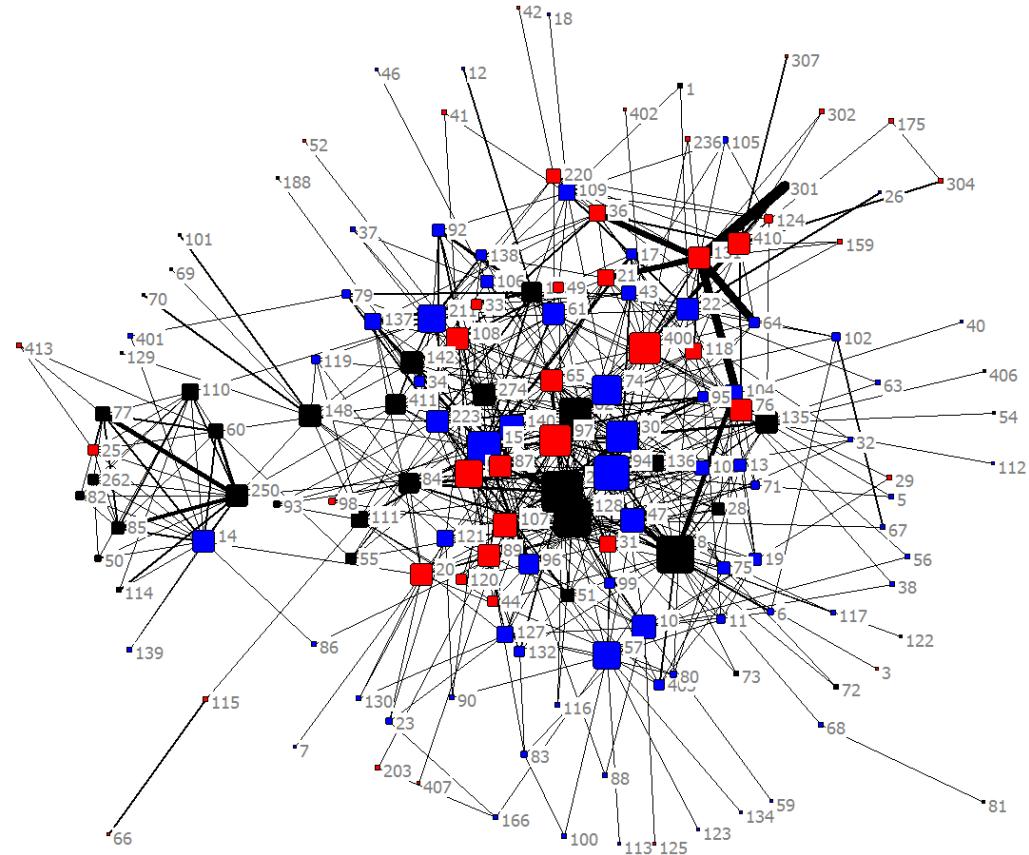
# QP Prices

Although cash sales that include only a single species make up only a fraction of QP transfers, they are the only means by which QP prices can be estimated given the amount of market activity to date. In principle, species-specific QP implicit prices might be estimated from multispecies QP cash sales using a hedonic framework, and implicit relative values for barter data might be revealed by a modified hedonic model (Holland 2013). However, there do not appear to be enough multispecies cash sales or enough variation in their make-up to estimate a hedonic model with reliable prices. Hedonic models estimated with combined single-species and multispecies cash sale data yield prices nearly identical to the averages from single-species trades when the appropriate weighted least squares estimation model is used,[3] and price estimates are not statistically significant (and many appear unrealistic) for species that did not have single-species cash sales.

For cash sales that only included a single species, we calculate annual prices and price dispersion (Table 8). To maintain confidentiality, prices are shown only when they represent transfers from at least three unique buyer-seller combinations. Thus, for some of the more rarely traded species, it is not possible to present prices. The number of IFQ stocks with reportable prices (i.e., more than three sellers and buyers) increased from 16 stocks in 2011 to 22 stocks in 2013. The number with at least 10 priced cash transfers increased from just five stocks in 2011 to 11 stocks in 2013. Thus there are signs that the activity in the cash market for QP, and the availability and reliability of price information, is increasing. However, the market is still quite thin for most species.

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[3] Holland (2013) undertook a Monte Carlo analysis that demonstrated that bias in price estimates from a hedonic price model from multispecies QP sales could be estimated with a weight least squares estimator using weights equal to 1 over the sum of the squared quantities in the trade.

**Table 8 Average Annual Prices, Count of Transfers, and Coefficient of Variation (CV) of Prices, for Single-Species QP Cash Sales Reported to NMFS with Prices**

| | | 2011 | | | 2012 | |
|---|---|---|---|---|---|---|
| OPTIMAL_YIELD_CATEGORY | Price | C.V. | Count | Price | C.V. | Count |
| Arrowtooth flounder | | 0% | - | | 80% | 2 |
| Bocaccio rockfish South of 40°10' N. | | 42% | 3 | | 0% | 1 |
| Canary rockfish | | 18% | 4 | $ 1.49 | 57% | 15 |
| Chilipepper rockfish South of 40°10' N. | | 36% | 3 | $ 0.03 | 62% | 7 |
| Cowcod South of 40°10' N. | | 10% | 2 | | 101% | 2 |
| Darkblotched rockfish | $ 0.40 | 119% | 4 | $ 0.22 | 49% | 6 |
| Dover sole | $ 0.05 | 74% | 5 | | 0% | - |
| English sole | | 0% | - | | 0% | - |
| Lingcod | | 77% | 2 | $ 0.05 | 38% | 4 |
| Lingcod North of 40°10' N. | | 0% | - | | 0% | - |
| Lingcod South of 40°10' N. | | 0% | - | | 0% | - |
| Longspine thornyheads North of 34°27' N. | $ 0.04 | 84% | 5 | $ 0.05 | 55% | 12 |
| Minor shelf rockfish North of 40°10' N. | | 0% | 1 | | 30% | 2 |
| Minor slope rockfish North of 40°10' N. | | 0% | 1 | $ 0.04 | 11% | 4 |
| Minor shelf rockfish South of 40°10' N. | | 0% | - | | 0% | 2 |
| Minor slope rockfish South of 40°10' N. | $ 0.05 | 85% | 7 | $ 0.03 | 33% | 7 |
| Other flatfish | | 0% | - | | 0% | 1 |
| Pacific cod | $ 0.05 | 28% | 11 | $ 0.02 | 52% | 9 |
| Pacific halibut (IBQ) North of 40°10' N. | $ 1.31 | 45% | 5 | $ 1.19 | 19% | 10 |
| Pacific ocean perch North of 40°10' N. | | 69% | 3 | | 56% | 3 |
| Pacific whiting | $ 0.02 | 70% | 29 | $ 0.04 | 31% | 65 |
| Petrale sole | $ 0.34 | 29% | 38 | $ 0.40 | 12% | 20 |
| Sablefish North of 36° N. | $ 1.06 | 41% | 58 | $ 1.04 | 36% | 47 |
| Sablefish South of 36° N. | $ 0.76 | 54% | 62 | $ 1.05 | 9% | 31 |
| Shortspine thornyheads North of 34°27' N. | | 71% | 2 | $ 0.05 | 59% | 9 |
| Shortspine thornyheads South of 34°27' N. | $ 0.17 | 58% | 3 | | 0% | 1 |
| Splitnose rockfish South of 40°10' N. | | 0% | - | | 0% | 1 |
| Starry flounder | | 0% | - | | 0% | - |
| Widow rockfish | $ 0.44 | 62% | 6 | $ 0.34 | 57% | 9 |
| Yelloweye rockfish | | 105% | 4 | $ 21.76 | 33% | 9 |
| Yellowtail rockfish North of 40°10' N. | | 0% | 1 | $ 0.01 | 39% | 10 |

**Table 8 continued**

| OPTIMAL_YIELD_CATEGORY | 2013 | | | 2014 | | | Average Pounds Tranferred |
|---|---|---|---|---|---|---|---|
| | Price | C.V. | Count | Price | C.V. | Count | |
| Arrowtooth flounder | $ 0.01 | 81% | 8 | $0.00 | 76% | 8 | 49,059 |
| Bocaccio rockfish South of 40°10' N. | $ 0.20 | 17% | 4 | | 15% | 7 | 1,449 |
| Canary rockfish | $ 3.09 | 26% | 12 | $2.12 | 35% | 17 | 300 |
| Chilipepper rockfish South of 40°10' N. | $ 0.02 | 64% | 8 | | 32% | 12 | 23,163 |
| Cowcod South of 40°10' N. | | 54% | 4 | | 35% | 2 | 13 |
| Darkblotched rockfish | $ 0.53 | 51% | 10 | $1.08 | 22% | 10 | 1,947 |
| Dover sole | $ 0.00 | 91% | 3 | | 0% | 1 | 118,385 |
| English sole | | 0% | - | | 0% | - | - |
| Lingcod | | 0% | - | | 0% | - | 11,221 |
| Lingcod North of 40°10' N. | | 0% | 1 | | 0% | 1 | 16,123 |
| Lingcod South of 40°10' N. | | 0% | - | | 0% | - | - |
| Longspine thornyheads North of 34°27' N. | $ 0.05 | 45% | 15 | $0.06 | 120% | 20 | 15,004 |
| Minor shelf rockfish North of 40°10' N. | | 0% | - | | 16% | 9 | 3,246 |
| Minor slope rockfish North of 40°10' N. | $ 0.03 | 53% | 3 | $0.02 | 58% | 4 | 10,231 |
| Minor shelf rockfish South of 40°10' N. | $ 0.04 | 19% | 5 | | 48% | 2 | 5,476 |
| Minor slope rockfish South of 40°10' N. | | 13% | 7 | | 0% | - | 8,286 |
| Other flatfish | | 0% | - | | 0% | 1 | 63,881 |
| Pacific cod | | 0% | 1 | | 94% | 4 | 25,791 |
| Pacific halibut (IBQ) North of 40°10' N. | $ 1.76 | 51% | 21 | $0.58 | 64% | 15 | 1,007 |
| Pacific ocean perch North of 40°10' N. | $ 0.75 | 45% | 14 | $0.98 | 44% | 15 | 1,073 |
| Pacific whiting | $ 0.04 | 43% | 54 | $0.03 | 47% | 29 | 179,150 |
| Petrale sole | $ 0.25 | 32% | 50 | $0.28 | 16% | 58 | 10,448 |
| Sablefish North of 36° N. | $ 0.88 | 17% | 66 | $1.00 | 26% | 62 | 10,303 |
| Sablefish South of 36° N. | $ 0.26 | 31% | 8 | $0.16 | 37% | 22 | 6,922 |
| Shortspine thornyheads North of 34°27' N. | $ 0.05 | 46% | 10 | $0.06 | 35% | 9 | 11,090 |
| Shortspine thornyheads South of 34°27' N. | | 15% | 3 | | 48% | 4 | 788 |
| Splitnose rockfish South of 40°10' N. | | 0% | - | | 0% | - | 16,500 |
| Starry flounder | | 0% | - | | 0% | - | - |
| Widow rockfish | $ 0.53 | 45% | 10 | $0.23 | 45% | 34 | 6,933 |
| Yelloweye rockfish | $ 29.58 | 53% | 11 | $27.07 | 10% | 12 | 10 |
| Yellowtail rockfish North of 40°10' N. | $ 0.03 | 10% | 6 | $0.02 | 34% | 21 | 28,301 |

Because NMFS has not published prices from QP sales and would likely not be able to do so for most species until well into the year (due to the small number of trades and confidentiality issues), the only publicly available means of price discovery for QP prices to date is auction closing prices from Jefferson Trading (http://jeffersonstatetradingco.com). Jefferson Trading has been running timed auctions for QP since the IFQ program's inception and has been posting closing prices. The entire history of auction closing prices can be downloaded from their website. Average prices from Jefferson Trading differ, in some cases substantially, from the average of NMFS prices (Table 9). The discrepancies presumably reflect transfers reported to NMFS that were not arranged through Jefferson Trading. Differences may also reflect some transfers facilitated by Jefferson Trading for which prices were not reported to NMFS. For the more frequently traded IFQ stocks, Jefferson Trading average prices are mostly within 20 percent of NMFS average prices, suggesting that they provide a reasonable means of price discovery for the wider cash sale market.

**Table 9 Average Annual QP Prices from Jefferson Trading Auctions, Count of Sales on Jefferson Trading, and Ratio of Jefferson Trading Prices to NMFS Prices from Single-Species Cash Sales.**

| OPTIMAL_YIELD_CATEGORY | 2011 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Price | Count | Ratio | Price | Count | Ratio | Price | Count | Ratio | Price | Count | Ratio |
| Arrowtooth flounder | $ - | - | | $ 0.01 | 1 | | $ 0.01 | 6 | 70% | $ 0.00 | 8 | 83% |
| Bocaccio rockfish South of 40°10' N. | $ 0.23 | 6 | | $ 0.18 | 3 | | $ 0.24 | 5 | 108% | $ 0.31 | 9 | |
| Canary rockfish | $ 1.63 | 6 | | $ 2.09 | 13 | 115% | $ 3.47 | 15 | 101% | $ 2.43 | 19 | 106% |
| Chilipepper rockfish South of 40°10' N. | $ 0.05 | 5 | | $ 0.02 | 6 | 59% | $ 0.02 | 7 | 87% | $ 0.03 | 13 | |
| Cowcod South of 40°10' N. | $ 0.54 | 2 | | $ 1.92 | 2 | | $ 2.19 | 5 | | $ 4.79 | 3 | |
| Darkblotched rockfish | $ 0.48 | 2 | 131% | $ 0.48 | 6 | 108% | $ 0.77 | 15 | 104% | $ 1.30 | 14 | 111% |
| Dover sole | $ 0.03 | 3 | 60% | $ - | - | | $ 0.002 | 2 | 33% | $ 0.01 | 2 | |
| English sole | $ - | - | | $ - | - | | $ - | - | | $ - | - | |
| Lingcod | $ - | - | | $ 0.05 | 4 | 95% | $ 0.04 | 1 | | $ 0.01 | 1 | |
| Lingcod North of 40°10' N. | $ - | - | | $ - | - | | $ - | - | | $ - | - | |
| Lingcod South of 40°10' N. | $ - | - | | $ - | - | | $ - | - | | $ - | - | |
| Longspine thornyheads North of 34°27' N. | $ 0.05 | 6 | 101% | $ 0.05 | 11 | 84% | $ 0.04 | 20 | 83% | $ 0.07 | 18 | 86% |
| Minor shelf rockfish North of 40°10' N. | $ - | - | | $ 0.05 | 2 | | $ - | - | | $ 0.02 | 8 | |
| Minor slope rockfish North of 40°10' N. | $ - | - | | $ 0.03 | 4 | 85% | $ 0.02 | 2 | 78% | $ 0.02 | 2 | 115% |
| Minor shelf rockfish South of 40°10' N. | $ - | - | | $ 0.03 | 2 | | $ 0.04 | 5 | 118% | $ 0.03 | 2 | |
| Minor slope rockfish South of 40°10' N. | $ 0.05 | 6 | 69% | $ 0.03 | 7 | 100% | $ 0.05 | 10 | | $ - | - | |
| Other flatfish | $ - | - | | $ 0.04 | 1 | | $ - | - | | $ 0.00 | 3 | |
| Pacific cod | $ 0.03 | 2 | 66% | $ 0.04 | 2 | 158% | $ - | - | | $ 0.01 | 2 | |
| Pacific halibut (IBQ) North of 40°10' N. | $ 1.41 | 6 | 100% | $ 1.04 | 11 | 93% | $ 1.79 | 22 | 104% | $ 0.98 | 15 | 93% |
| Pacific ocean perch North of 40°10' N. | $ 0.26 | 1 | | $ 0.24 | 4 | | $ 0.84 | 15 | 95% | $ 1.26 | 21 | 111% |
| Pacific whiting | $ 0.02 | 8 | 78% | $ 0.04 | 10 | 101% | $ 0.10 | 14 | 257% | $ 0.05 | 16 | 123% |
| Petrale sole | $ 0.35 | 10 | 100% | $ 0.44 | 7 | 109% | $ 0.28 | 27 | 101% | $ 0.29 | 45 | 101% |
| Sablefish North of 36° N. | $ 1.17 | 19 | 108% | $ 1.17 | 31 | 122% | $ 0.88 | 20 | 103% | $ 1.10 | 30 | 105% |
| Sablefish South of 36° N. | $ 0.76 | 22 | 90% | $ 0.97 | 8 | 97% | $ 0.22 | 4 | 85% | $ 0.10 | 5 | 65% |
| Shortspine thornyheads North of 34°27' N. | $ 0.03 | 1 | | $ 0.05 | 7 | 87% | $ 0.05 | 11 | 107% | $ 0.07 | 12 | 117% |
| Shortspine thornyheads South of 34°27' N. | $ 0.05 | 1 | 33% | $ 0.03 | 1 | | $ 0.04 | 4 | | $ 0.06 | 2 | |
| Splitnose rockfish South of 40°10' N. | $ - | - | | $ - | - | | $ - | - | | $ - | - | |
| Starry flounder | $ - | - | | $ - | - | | $ - | - | | $ - | - | |
| Widow rockfish | $ 0.16 | 3 | 34% | $ 0.52 | 7 | 120% | $ 0.63 | 18 | 89% | $ 0.30 | 26 | 118% |
| Yelloweye rockfish | $ 39.60 | 5 | | $ 17.75 | 11 | 84% | $ 25.44 | 14 | 78% | $ 27.13 | 12 | 101% |
| Yellowtail rockfish North of 40°10' N. | $ 0.04 | 1 | | $ 0.02 | 7 | 154% | $ 0.03 | 8 | 99% | $ 0.02 | 18 | 95% |

It is not clear what number of trades would be required to produce meaningful price estimates that are representative of value.  Price dispersion provides one measure of price reliability and market efficiency.  Newell et al. (2005) suggest that the price dispersion of 25 to 35 percent observed in the New Zealand quota lease[4] market is "reasonable" when compared to price dispersion in commonplace commodities.  Price dispersion for QP sales in the Pacific groundfish fishery is somewhat higher (Table 8). For several species, price dispersion has declined over the 2011–2013 period, but this is not the case for all species. If we consider stocks that had at least two buyers and two sellers in a given year, price dispersion averaged across stocks fell from 61 percent in 2011 to 44 percent in 2012. It fell again slightly to 42 percent in 2013, but increased to 45 percent in 2013.  There is a weak but statistically significant relationship between the number of transfers for a stock in a year and price dispersion (Table 10).  This fitted relationship predicts that price dispersion would fall from 53 percent with five trades to 33 percent with 50 trades and 12 percent with 100 trades.

**Table 10 Regression of Price Dispersion as a Function of Count of Single-species Cash Sales**

| Variable | Coefficients | P-value |
|---|---|---|
| Intercept | 0.548 | 0.00 |
| Transfer Count | -0.0043 | 0.01 |
| R Square | .083 | |

A decline in price dispersion may be an indicator that the market is becoming more efficient (the law of one price prevailing), but high price dispersion may also be the result of changes in prices over the year.  Presumably prices are a function of derived demand (associated with the net value of the catch enabled by the QP), but also a function of supply relative to demand.  For a target species like sablefish, petrale sole, or whiting—for which QP is mostly utilized —we might expect prices to reflect average or marginal profits associated with catches.  However, prices may decline toward the end of the year if it looks like there will be more QP left unutilized than can be carried over (each vessel account can carry over as much as 10 percent of its QP by species). QP prices might also change, however, if ex-vessel prices unexpectedly changed during the year. This could result in either increased or decreased QP prices, but either way it would contribute to higher price dispersion, which cannot really be ascribed to inefficient pricing by the market except to the extent that the market was not able to anticipate the changes. For most species, there are not enough transfers to calculate more than annual prices, but for a few of the more frequently traded species we can calculate at least semi-annual prices. For the Northern sablefish stock, QP prices were lower in the second half of the year than the first, and most of the cash sales also occurred in the second half the year. The same is true for petrale sole in 2013, but there was no difference in prices by semester in 2012 and prices were higher in the second semester in 2011.

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[4] Leasing quota is essentially the same as selling QP.

**Table 11 Bi-annual QP Prices and Price Dispersion from Single-Species Cash Sales**

| Year | Semester | Pacific Whiting | | | Petrale Sole | | | Sablefish (N. of 40'10") | | |
| | | Price | Count | C.V. | Price | Count | C.V. | Price | Count | C.V. |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2011 | 1 | | | | | | | $1.01 | 4 | 25% |
| 2011 | 2 | $0.02 | 29 | 81% | $0.36 | 36 | 24% | $1.10 | 54 | 42% |
| 2012 | 1 | $0.04 | 16 | 34% | $0.40 | 13 | 8% | $1.35 | 12 | 20% |
| 2012 | 2 | $0.04 | 49 | 27% | $0.40 | 7 | 19% | $0.83 | 35 | 32% |
| 2013 | 1 | $0.05 | 9 | 80% | $0.35 | 16 | 17% | $1.00 | 11 | 6% |
| 2013 | 2 | $0.04 | 45 | 14% | $0.24 | 34 | 31% | $0.83 | 55 | 17% |
| 2014 | 1 | $0.05 | 15 | 36% | $0.31 | 23 | 11% | $1.06 | 21 | 9% |
| 2014 | 2 | $0.03 | 14 | 37% | $0.28 | 35 | 17% | $1.04 | 41 | 32% |

One thing that is seemingly in conflict with efficient market pricing is that QP prices are a significant fraction of ex-vessel price for some species for which there is substantial unused QP available. In fact, for some species like canary and yelloweye rockfish, QP prices are well above ex-vessel price even though only a small fraction of total QP was used in any year. If there is substantial excess supply of QP, we might expect these prices to fall, particularly after surpluses persist for a few years. In the case of yelloweye rockfish, the high prices may really reflect transactions costs. Individual transfers are very small and total transfer values are not large, and the high cost per pound may reflect distribution of the transactions costs over a small number of pounds (averaging only 8 pounds).  This explanation is somewhat less likely for canary, for which transfers average more than 245 pounds per transfer. For Pacific halibut, which has a zero ex-vessel value (since it cannot be retained), average QP prices ranging from $1.42 to $1.73 over the 2011–2013 period are quite surprising given that utilization of QP in aggregate has not exceeded 43 percent (Table 1). Average QP trades of Pacific halibut are more than 1,000 pounds, decreasing the likelihood that prices can be ascribed primarily to transactions costs. Regardless of whether these high prices can be ascribed to transactions costs, they suggest inefficiency in the QP market because some individuals are paying substantial amounts for QP while others are simply leaving QP unused.

# Discussion

The role of an efficient QP market is at least three-fold. First, it serves to allocate QP to its highest value use (or at least to those who value it most). Second, it influences behavior. For example, prices for QP should encourage efficient use and discipline inefficient use of QP (i.e., generating the greatest value from its use and forcing inefficient players out of the fishery). In a multispecies fishery, QP prices, through the out-of-pocket cost or the opportunity cost of QP, should induce fishermen to avoid constraining fish stocks for which QP prices are high.  A third important role of QP markets is to provide

information to fishing businesses, fishery managers, and other stakeholder to support business planning and policy decisions. The prices generated by QP markets also provide information to QP market participants on how to set prices in subsequent transactions. This not only lowers negotiation costs, but helps buyers and sellers to decide whether and how much of a commodity to offer to buy or sell on the market. For those decisions to be optimal, with the right amounts of QP going to those who value it most, everyone must have a good idea of what prices others are willing to sell or buy at.

The extent to which the distribution that occurs through the QP market maximizes value, provides the correct behavioral incentives, and provides useful and interpretable information depends on whether the market is operating efficiently. A well-functioning market makes it possible for transacting parties to find each other, determine mutually acceptable quantities of the commodity to trade and negotiate compensation, and carry out the transaction with confidence. An efficient market also implies that the process of carrying out these transactions is easy and inexpensive (i.e., with minimal transactions costs).[5] Furthermore, we would expect prices (or in-kind compensation) in an efficient market to reflect the marginal value of the commodity and that prices would be fairly homogeneous, at least at a given point[6]

An effective and efficient QP market is not automatically created when an IFQ system is created, even if a tool for implementing transfers is in place. The analysis in this report suggests that the QP market for Pacific groundfish IFQ has not been operating efficiently. Price dispersion is high. The market is thin, particularly for species that are not primary targets. High prices for QP of some species with substantial unused QP in aggregate indicate high transactions costs or a failure to match up those with unused QP to those who could use it. Anecdotal evidence suggests this is occurring as a result of "hoarding" driven by the combination of uncertainty about individual QP needs and a lack of confidence that one could acquire QP on the market at a foreseeable price should it be needed unexpectedly. There are some indications that market efficiency is increasing slowly, but the market may take many years to mature into an efficient market.

IFQ markets, particularly in multispecies fisheries with many jointly caught species, pose a number of challenges, so it is perhaps not surprising that an efficient market has not quickly emerged. The value of QP is a function of the value that can be produced with it rather than a consumption or resale value, and that value is generally uncertain until the fish is actually landed and sold. In multispecies fisheries the value of QP for one species is likely to be partly a function of holdings of QP of other species, as a portfolio of QP is needed to balance catch of a mixed bag of species. Even if a fisherman has a good idea of his overall QP needs, it may be difficult to determine what he should pay for a given species and how much he should buy unless he can simultaneously purchase the desired quantities of the other species in the portfolio at acceptable prices. When there are relatively few buyers and sellers, limited information on who has QP to sell, and substantial heterogeneity in the types and locations of fishing operations that result in different relative QP needs and values, it is not surprising that transactions costs remain high.

As our analysis shows, the forms of compensation used in inter-firm QP transactions are quite diverse and transfers are not dominated by cash sales with individual species prices. Rather barter and

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[5] Dahlman (1979 J. Law and Econ 22(1), 141-162) described transactions costs as "search and information costs, bargaining and decision costs, policing and enforcement costs."

[6] Assuming the prices reflect willingness to pay and thus the implicit value of the QP, a lack of price homogeneity for a commodity that is identical suggest that overall benefits would have been increased if more QP had gone to the individual who paid a higher price and less to the one who paid less. Alternatively, if prices do not reflect willingness to pay, they are not sending the right signals to buyers, who thus may be offering too little or too much for sale.

contractual arrangements, including risk pools, are common.  Given that QP of a given species is a straightforward non-differentiable commodity, we might expect to see a higher prevalence of cash sales and the lack of them may suggest an inefficient market. [7] However, these transaction methods may be largely a product of uncertainty about the value of QP to the users that would purchase it. That value depends on whether the QP will actually be needed to balance catch or can be carried forward to the next year, and on the cost of harvesting the fish and the price received for it. A contractual arrangement (e.g., for a percentage of the value of the landed fish) shares the risk between the buyer and seller and, if the seller of the quota pounds is the buyer of the fish, they may be in a better position to bear some of that risk. Barter enables individuals to trade less-valued QP for more valued QP without having to put cash up front, which may be difficult and risky financially for an individual fisherman.  Multispecies cash sales or barter, while they may result in less efficient pricing of particular species, enable fishermen to acquire a balanced portfolio of QP and reduce the risk they will be left holding QP for species they can't catch without more QP of jointly caught species.

Economists tend to trust that competitive markets are the most efficient means of distributing scarce resources (e.g., QP), but this may not be the case when these markets are inherently thin and must distribute multiple goods with jointly determined and highly uncertain values.   As we noted, arm's-length cash sales of QP make up only a fraction of the transfers that occur in the IFQ system, and it seems likely that other means of distributing QP play an important role in the IFQ systems and will continue to. The centralized decision-making of a large firm (whether an owner of vessels or a processor that owns or buys and distributes QP to the vessels that deliver fish to it) that can harness disparate information and/or can mitigate risk associated with uncertainty may actually be able to do a better job of maximizing value. It is notable that, in mature multispecies IFQ systems in New Zealand, Iceland, and British Columbia much of the quota share has been acquired by large firms, often by processors or vertically integrated firms with processing and harvesting capacity. Part of the reason for this is undoubtedly to increase their ability to build stable markets for their products by gaining control of what fish is landed when, but these firms are also able to move QP around to the vessels that fish to them to ensure it is used efficiently. Cooperatives might achieve similar gains, depending on how they are organized and operated. Risk pools also play an important role in managing risk associate with highly uncertain QP needs.

There may be things that regulators can do to facilitate development of an efficient QP market and to nurture or at least not undermine other mechanisms for distributing QP in the fishery. Regulators should make as much information as possible available in a timely and easily accessible manner. Confidentiality rules limit this to some degree, and not providing confidentiality might be counterproductive if it undermined full and honest price reporting. However, it should be possible to provide and regularly update prices once the threshold of three unique parties is reached. Rules that at face value appear to be designed to make the market more competitive (e.g., aggregation limits, prohibiting subtracting quota cost from ex-vessel price) may actually constrain useful distribution mechanisms (e.g., risk pools and cooperatives), though they may also be necessary to avoid abuses of market power. There are likely to be trade-offs in terms of allowing useful organizational mechanisms for quota distribution and abuses that can occur as a result of centralized control and "market power."

Most multispecies IFQ fisheries include a number of catch balancing mechanisms that provide flexibility and thereby reduce the uncertainty and risk fishermen face if their catches turn out to be different than expected.  The provisions that allow carry-forward of 10 percent of QP are an example of this, though they are less flexible that some other IFQ systems (e.g., vessels in British Columbia can carry

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[7] Both because more sales would occur if transactions costs were low and because there is little reason to believe that distribution is optimal, as individual users are unlikely to by paying the same for QP.

forward or back up to 30 percent of QP).  Iceland allows conversion of QP from one species to another to cover overages. New Zealand allows individuals to land catch for which they do not hold QP and pay a "deemed value" in lieu of balancing in with QP. The deemed value can be refunded up through the end of the year if the individual acquired QP to balance the catch. Deemed values effectively provide fishermen with a known maximum price for QP and also provide some guidance for the market (i.e., an upper bound for price).  The Pacific groundfish fishery is highly complex and has relatively rigid catch balancing rules, which make an efficient market doubly important but may also undermine its operations.  Although it may not be legal or desirable to implement approaches used elsewhere, it may be possible to increase flexibility. For example regulators could operate a limited deemed value scheme, perhaps designed primarily to give individuals time to acquire QP on the market without being forced to tie up.[8]  Fishermen might also simply be given more time to balance QP deficits before being forced to tie up.

# Acknowledgements

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[8] This might be accomplished by setting very high deemed values that would incentivize fishermen to look for QP on the market and seek a refund of QP, thereby limiting the net use of deemed value of balanced catch and the pool of QP required to support the system.