IUU Fishing: Economic Effects of IUU Imports on U.S. Commercial Fishers

Species: American lobster, spiny lobster

Model Release

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This model accompanies the USITC report, *Seafood Obtained via Illegal, Unreported, and Unregulated Fishing: U.S. Imports and Economic Impact on U.S. Commercial Fisheries*, Inv. 332-575. The report includes a quantitative analysis of the economic impact of IUU imports on U.S. commercial fishers and U.S. commercial fishing production, trade, and prices. Economic effects are modeled by species, with each species-level model customized to fit the unique features of the U.S. domestic industry. Consumers of seafood products choose between domestic marine-capture sources, imports, and in some models, domestic aquaculture products. Imports include both legal and IUU sources that enter the U.S. at the same price, so consumers cannot distinguish an IUU from non-IUU product. 2018 data is used to establish an initial equilibrium with imports of IUU products included in the baseline. The model then removes the IUU imports, as estimated in chapter 3, and solves for a new equilibrium absent those products.

In the lobster model, there are domestic and imported varieties of American (true) and spiny (rock) lobster species. The model includes cross-species substitution, so relative price changes in one species affects the other species. Annual catch limits (ACLs) are enforced in the model so modeled increases in domestic landings cannot exceed their legal limits. Catch limits are modeled as a vertical asymptote directly in the supply equation and not as a constraint. Both unprocessed and processed lobster markets are modeled.

Data inputs in the simulation are in the BLUE-shaded cells (with sources for the input data listed in the cell above). Outputs are in the GREEN-shaded cells. The white cells are intermediate calculations.

This PDF is a printout of the Mathematica file “IUU Fishing Model - lobster - model release.nb”.

In[119]:=
```
ClearAll[f];
```

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1. Model Parameters

1.1 Within-Species Elasticity of Substitution

Source: USITC's econometric estimation using the trade cost method in Riker (2020). More information can be found in the technical appendix (appendix I).

Coldwater lobster

In[120]:=
```
sigmac = 3.047522;
```

Warmwater lobster

In[121]:=
```
sigman = 16.64799;
```

1.2 Cross-Species Elasticity of Substitution

Source: USITC Staff Estimate and Interviews with Industry Participants.

Unprocessed products

In[122]:=
```
betau = 1.50;
```

Processed products

In[123]:=
```
betap = 3.0;
```

1.3 Industry Price Elasticity of Demand

Source: USITC Staff Estimate.

Unprocessed products

In[124]:=
```
etau = -1;
```

Processed products

In[125]:=
```
etap = -1;
```

1.4 Illegal Imports Replacement Rates

Source: USITC Staff Estimate. Further discussion on qualitative factors and rate determination can be found in appendix I of the USITC's report.

True lobster imports

In[126]:=
```
replt = 0.3;
```

Rock lobster imports

In[127]:=
```
replr = 0.3;
```

1.5 Price Elasticity of Supply

Source: USITC Staff Estimate and Interviews with Industry Participants.

American lobster

In[128]:=
```
ead = 5.0;
```

Spiny lobster

In[129]:=
```
esd = 5.0;
```

2. Data Inputs

2.1 U.S. Landings Quantities and Prices

Source: National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). Fisheries of the United States 2018. Current Fishery Statistics No. 2018. U.S. Department of Commerce. Silver Spring MD: NOAA, February 2020. https://www.-fisheries.noaa.gov/resource/document/fisheries-united-states-2018-report.

American lobster landings

In[130]:=
```
qadu0 = 66,305,000.00; (*kg*)
```

In[131]:=
```
padu0 = 9.4145; (*$/kg*)
```

Spiny lobster landings

In[132]:=
```
qsdu0 = 3,379,911.00;(*kg*)
```

In[133]:=
```
psdu0 = 18.5898; (*$/kg*)
```

2.2 U.S. Processing Production Quantities and Prices

Sources:
National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). Fisheries of the United States 2018. Current Fishery Statistics No. 2018. U.S. Department of Commerce. Silver Spring MD: NOAA, February 2020. https://www.fisheries.noaa.gov/resource/document/fisheries-united-states-2018-report.

National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). NOAA Processed Products database. Accessed September 1, 2020.https://www.fisheries.noaa.gov/foss/f?p=215:3:5412288074334::NO:::

Processed American lobster

In[134]:=
```
qadp0 = 3,807,745.00; (*kg*)
```

In[135]:=
```
padp0 = 43.8205;(*$/kg*)
```

Processed spiny lobster

In[136]:=
```
qsdp0 = 1,247,109.00;(*kg*)
```

In[137]:=
```
psdp0 = 21.48835; (*$/kg*)
```

2.3 Import Quantities and Prices

Source: IUU Estimate Database as described in Chapter 3 of the report.

Total imports, unprocessed true lobster

In[138]:=
```
qttu0 = 42,154,957;(*kg*)
```

In[139]:=
```
pttu0 = 21.9998;(*$/kg*)
```

Total imports, unprocessed rock lobster

In[140]:=
```
qrtu0 = 6,938,435;(*kg*)
```

In[141]:=
```
prtu0 = 33.2254;(*$/kg*)
```

Total imports, processed true lobster

In[142]:=
```
qttp0 = 7447010; (*kg*)
```

In[143]:=
```
pttp0 = 32.1337; (*$/kg*)
```

Total imports, processed rock lobster

In[144]:=
```
qrtp0 = 115772; (*kg*)
```

In[145]:=
```
prtp0 = 22.2281; (*$/kg*)
```

Total illegal imports, unprocessed

In[146]:=
```
qtiu0 = 1624161; (*kg*)
```

In[147]:=
```
qriu0 = 1512807; (*kg*)
```

Total illegal imports, processed

In[148]:=
```
qtip0 = 287400; (*kg*)
```

In[149]:=
```
qrip0 = 13629; (*kg*)
```

Calculation of legal imports

In[150]:=
```
qtlu0 = qttu0 - qtiu0;
```

In[151]:=
```
qtlp0 = qttp0 - qtip0;
```

In[152]:=
```
qrlu0 = qrtu0 - qriu0;
```

In[153]:=
```
qrlp0 = qrtp0 - qrip0;
```

2.4 Export Quantities

Source:National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). NOAA US Trade in Fishery Products database. Accessed September 1, 2020. https://foss.nmfs.noaa.gov/apexfoss/f?p=215:2:14884747663545::NO

In[154]:=
```
qadue0 = 49445965; (*kg*)
```

In[155]:=
```
qadpe0 = 282882; (*kg*)
```

In[156]:=
```
qsdue0 = 315293; (*kg*)
```

In[157]:=
```
qsdpe0 = 0; (*kg*)
```

2.5 Catch Limits

American lobster

No aggregate ACL available, inserted arbitrarily high limit so it doesn't affect calculation.

In[158]:=
```
qadcap = 400,000,000.00; (*kg*)
```

Spiny lobster

Sources:
NOAA, "Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic Regions; Regulatory Amendment," Federal Register, June 22, 2018, https://www.federalregister.gov/documents/2018/06/22/2018-13400/fisheries-of-the-caribbean-gulf-of-mexico-and-south-atlantic-spiny-lobster-fishery-of-the-gulf-of.

"Annual Catch Limits (ACLs) and Accountability Measures (AMs) for Caribbean Island Management Areas/Caribbean EEZ.," LII / Legal Information Institute, accessed November 19, 2020, https://www.law.cornell.edu/cfr/text/50/622.12.

In[159]:=
```
qsdcap = 4,403,157.00;(*kg*)
```

2.6 Import Market Share Statistics

In[160]:=
```
N[qttu0 / (qttu0 + qadu0 - qadue0)]
```
Out[160]= 0.714321

In[161]:=
```
N[qttp0 / (qttp0 + qadp0 - qadpe0)]
```
Out[161]= 0.678736

In[162]:=
```
N[qrtu0 / (qrtu0 + qsdu0 - qsdue0)]
```
Out[162]= 0.693632

In[163]:=
```
N[qrtp0 / (qrtp0 + qsdp0 - qsdpe0)]
```
Out[163]= 0.0849465

3. Calibration

Baseline values of domestic apparent consumption and imports

In[164]:=
```
vttu0 = qttu0 pttu0;
```

In[165]:=
```
vttp0 = qttp0 pttp0;
```

In[166]:=
```
vrtu0 = qrtu0 prtu0;
```

In[167]:=
```
vrtp0 = qrtp0 prtp0;
```

In[168]:=
```
vadu0 = (qadu0 - qadue0) padu0;
```

In[169]:=
```
vadp0 = (qadp0 - qadpe0) padp0;
```

In[170]:= $vsdu0 = (qsdu0 - qsdue0)\ psdu0;$

In[171]:= $vsdp0 = (qsdp0 - qsdpe0)\ psdp0;$

3.1 Supply Parameters

In[172]:= $eadu = N\left[ead \frac{qadu0}{(qadcap - qadu0)}\right];$

In[173]:= $aadu = (qadcap - qadu0)\ padu0^{eadu};$

In[174]:= $esdu = N\left[esd \frac{qsdu0}{(qsdcap - qsdu0)}\right];$

In[175]:= $asdu = (qsdcap - qsdu0)\ psdu0^{esdu};$

In[176]:= $aadp = qadp0\ padp0^{-ead};$

In[177]:= $asdp = qsdp0\ psdp0^{-esd};$

3.2 Demand Parameters

In[178]:= $btu = \frac{vttu0}{vadu0}\left(\frac{pttu0}{padu0}\right)^{sigmac-1};$

In[179]:= $Pcu0 = \left(padu0^{1-sigmac} + btu\ pttu0^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[180]:= $bru = \frac{vrtu0}{vsdu0}\left(\frac{prtu0}{psdu0}\right)^{sigman-1};$

In[181]:= $Pnu0 = \left(psdu0^{1-sigman} + bru\ prtu0^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[182]:= $bsu = \frac{vrtu0 + vsdu0}{vadu0 + vttu0}\left(\frac{Pnu0}{Pcu0}\right)^{betau-1};$

In[183]:= $Pu0 = \left(Pcu0^{1-betau} + bsu\ Pnu0^{1-betau}\right)^{\frac{1}{1-betau}};$

In[184]:= $btp = \frac{vttp0}{vadp0}\left(\frac{pttp0}{padp0}\right)^{sigmac-1};$

In[185]:= $Pcp0 = \left(padp0^{1-sigmac} + btp\ pttp0^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[186]:= $brp = \frac{vrtp0}{vsdp0}\left(\frac{prtp0}{psdp0}\right)^{sigman-1};$

In[187]:= $Pnp0 = \left(psdp0^{1-sigman} + brp\ prtp0^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[188]:= $bsp = \frac{vrtp0 + vsdp0}{vadp0 + vttp0}\left(\frac{Pnp0}{Pcp0}\right)^{betap-1};$

In[189]:= $Pp0 = \left(Pcp0^{1-betap} + bsp\ Pnp0^{1-betap}\right)^{\frac{1}{1-betap}};$

In[190]:= $ku = \frac{qttu0\ Pu0^{-etau-betau}\ Pcu0^{betau-sigmac}\ pttu0^{sigmac}}{btu};$

In[191]:= $kp = \frac{qttp0\ Pp0^{-etap-betap}\ Pcp0^{betap-sigmac}\ pttp0^{sigmac}}{btp};$

4. New Equilibrium Calculation

In[192]:= $Pcu = \left(padu^{1-sigmac} + btu\ pttu^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[193]:= $Pnu = \left(psdu^{1-sigman} + bru\ prtu^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[194]:= $Pu = \left(Pcu^{1-betau} + bsu\ Pnu^{1-betau}\right)^{\frac{1}{1-betau}};$

In[195]:= $Pcp = \left(padp^{1-sigmac} + btp\ pttp^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[196]:= $Pnp = \left(psdp^{1-sigman} + brp\ prtp^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[197]:= $Pp = \left(Pcp^{1-betap} + bsp\ Pnp^{1-betap}\right)^{\frac{1}{1-betap}};$

Equilibrium equations

Total supply (landings) of wild caught = exports + consumer demand

In[198]:= $E1 = qadcap - aadu\ padu^{-eadu} == qadue0 + ku\ Pu^{etau+betau}\ Pcu^{sigmac-betau}\ padu^{-sigmac};$

In[199]:= $E2 = qsdcap - asdu\ psdu^{-esdu} == qsdue0 + ku\ bsu\ Pu^{etau+betau}\ Pnu^{sigman-betau}\ psdu^{-sigman};$

Supply of imported unprocessed product = Demand for imported unprocessed product

In[200]:= $E4 = qtlu0 + replt\ qtiu0 == ku\ \ btu\ Pu^{etau+betau}\ Pcu^{sigmac-betau}\ \ pttu^{-sigmac};$

In[201]:= $E5 = qrlu0 + replr\ qriu0 == ku\ bru\ bsu\ Pu^{etau+betau}\ Pnu^{sigman-betau}\ \ prtu^{-sigman};$

Supply of imported processed product = Demand for imported processed product

In[202]:= $E7 = qtlp0 + replt\ qtip0 == kp\ btp\ Pp^{etap+betap}\ Pcp^{sigmac-betap}\ pttp^{-sigmac};$

In[203]:= $E8 = qrlp0 + replr\ qrip0 == kp\ brp\ bsp\ Pp^{etap+betap}\ Pnp^{sigman-betap}\ prtp^{-sigman};$

Supply of domestic processed lobster = demand of domestic processed lobster

In[204]:= $E9 = aadp\ padp^{ead} ==\ qadpe0 + kp\ Pp^{etap+betap}\ Pcp^{sigmac-betap}\ padp^{-sigmac};$

In[205]:= $E10 = asdp\ psdp^{esd} ==\ qsdpe0 + bsp\ kp\ Pp^{etap+betap}\ Pnp^{sigman-betap}\ psdp^{-sigman};$

In[206]:=
```
FindRoot[{E1, E2, E4, E5, E7, E8, E9, E10}, {padu, padu0},
 {psdu, psdu0}, {pttu, pttu0}, {prtu, prtu0}, {prtp, prtp0}, {pttp, pttp0},
 {padp, padp0}, {psdp, psdp0}, AccuracyGoal → 6, PrecisionGoal → 6]
```

Out[206]= {padu → 9.43547, psdu → 19.6062, pttu → 22.562, prtu → 35.7736, prtp → 22.4418, pttp → 32.6426, padp → 43.927, psdp → 21.5612}

In[207]:= $padu1 = padu\ /.\ \%;$

In[208]:= $psdu1 = psdu\ /.\ \%\%;$

In[209]:= `pttu1 = pttu /. %%%;`

In[210]:= `prtu1 = prtu /. %%%%;`

In[211]:= `pttp1 = pttp /. %%%%%;`

In[212]:= `prtp1 = prtp /. %%%%%%;`

In[213]:= `padp1 = padp /. %%%%%%%;`

In[214]:= `psdp1 = psdp /. %%%%%%%%;`

In[215]:= $Pcu1 = \left(padu1^{1-sigmac} + btu\ pttu1^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[216]:= $Pnu1 = \left(psdu1^{1-sigman} + bru\ prtu1^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[217]:= $Pu1 = \left(Pcu1^{1-betau} + bsu\ Pnu1^{1-betau}\right)^{\frac{1}{1-betau}};$

In[218]:= $Pcp1 = \left(padp1^{1-sigmac} + btp\ pttp1^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[219]:= $Pnp1 = \left(psdp1^{1-sigman} + brp\ prtp1^{1-sigman}\right)^{\frac{1}{1-sigman}};$

In[220]:= $Pp1 = \left(Pcp1^{1-betap} + bsp\ Pnp1^{1-betap}\right)^{\frac{1}{1-betap}};$

In[221]:= `qadu1 = qadcap - aadu padu1^-eadu;`

In[222]:= `qsdu1 = qsdcap - asdu psdu1^-esdu;`

In[223]:= `qttu1 = qtlu0 + replt qtiu0;`

In[224]:= `qrtu1 = qrlu0 + replr qriu0;`

In[225]:= `qttp1 = qtlp0 + replt qtip0;`

In[226]:= `qrtp1 = qrlp0 + replr qrip0;`

In[227]:= $qadp1 = qadpe0 + kp\ Pp1^{etap+betap}\ Pcp1^{sigmac-betap}\ padp1^{-sigmac};$

In[228]:= $qsdp1 = qsdpe0 + bsp\ kp\ Pp1^{etap+betap}\ Pnp1^{sigman-betap}\ psdp1^{-sigman};$

5. Results

American Lobster

Percent change in price of unprocessed domestic production

In[229]:= $\frac{(padu1 - padu0)\ 100}{padu0}$

Out[229]= `0.222753`

Percent change in quantity of landings

In[230]:=
$$\frac{(\text{qadu1} - \text{qadu0})\ 100}{\text{qadu0}}$$

Out[230]= 1.1113

Percent change in price of processed domestic production

In[231]:=
$$\frac{(\text{padp1} - \text{padp0})\ 100}{\text{padp0}}$$

Out[231]= 0.242963

Percent change in quantity of processed production

In[232]:=
$$\frac{(\text{qadp1} - \text{qadp0})\ 100}{\text{qadp0}}$$

Out[232]= 1.22073

Change ($) in operating income, unprocessed product

In[233]:= `N[ (1 / sigmac) (padu1 (qadu1 - qadue0) - padu0 (qadu0 - qadue0)) ]`

Out[233]= 2.39737×10^6

Change ($) in operating income, processed product

In[234]:= `N[ (1 / sigmac) (padp1 (qadp1 - qadpe0) - padp0 (qadp0 - qadpe0)) ]`

Out[234]= 793,140.

Spiny Lobster

Percent change in price of unprocessed domestic production

In[235]:=
$$\frac{(\text{psdu1} - \text{psdu0})\ 100}{\text{psdu0}}$$

Out[235]= 5.46744

Percent change in quantity of landings

In[236]:=
$$\frac{(\text{qsdu1} - \text{qsdu0})\ 100}{\text{qsdu0}}$$

Out[236]= 17.7065

Percent change in price of processed domestic production

In[237]:=
$$\frac{(\text{psdp1} - \text{psdp0})\ 100}{\text{psdp0}}$$

Out[237]= 0.338998

Percent change in quantity of processed domestic product

In[238]:=
$$\frac{(\text{qsdp1} - \text{qsdp0})\ 100}{\text{qsdp0}}$$

Out[238]= 1.70652

Change ($) in operating income, unprocessed product

In[239]:= `N[(1/sigman) (psdu1 (qsdu1 - qsdue0) - psdu0 (qsdu0 - qsdue0))]`

Out[239]= 891,907.

Change ($) in operating income, processed product

In[240]:= `N[(1/sigman) (psdp1 (qsdp1 - qsdpe0) - psdp0 (qsdp0 - qsdpe0))]`

Out[240]= 33,019.9

True Lobster Imports

Percent change in price of unprocessed imports

In[241]:=
$$\frac{(\text{pttu1} - \text{pttu0})\ 100}{\text{pttu0}}$$

Out[241]= 2.55544

Percent change in quantity of unprocessed imports

In[242]:=
$$\frac{(\text{qttu1} - \text{qttu0})\ 100}{\text{qttu0}}$$

Out[242]= −2.69698

Percent change in price of processed imports

In[243]:=
$$\frac{(\text{pttp1} - \text{pttp0})\ 100}{\text{pttp0}}$$

Out[243]= 1.58361

Percent change in quantity of processed imports

In[244]:=
$$\frac{(\text{qttp1} - \text{qttp0})\ 100}{\text{qttp0}}$$

Out[244]= −2.70149

Rock Lobster Imports

Percent change in price of unprocessed imports

In[245]:=
$$\frac{(\text{prtu1} - \text{prtu0})\ 100}{\text{prtu0}}$$

Out[245]= 7.66935

Percent change in quantity of unprocessed imports

In[246]:=
$$\frac{(\text{qrtu1} - \text{qrtu0})\ 100}{\text{qrtu0}}$$

Out[246]= −15.2623

Percent change in price of processed imports

In[247]:=
$$\frac{(\text{prtp1} - \text{prtp0})\ 100}{\text{prtp0}}$$

Out[247]= 0.961236

Percent change in quantity of processed imports

In[248]:=
$$\frac{(\text{qrtp1} - \text{qrtp0})\ 100}{\text{qrtp0}}$$

Out[248]= −8.24059

Price Indexes

Percent change in unprocessed price index

In[249]:=
$$\frac{(\text{Pu1} - \text{Pu0})\ 100}{\text{Pu0}}$$

Out[249]= 3.21435

Percent change in processed price index

In[250]:=
$$\frac{(\text{Pp1} - \text{Pp0})\ 100}{\text{Pp0}}$$

Out[250]= 1.00498