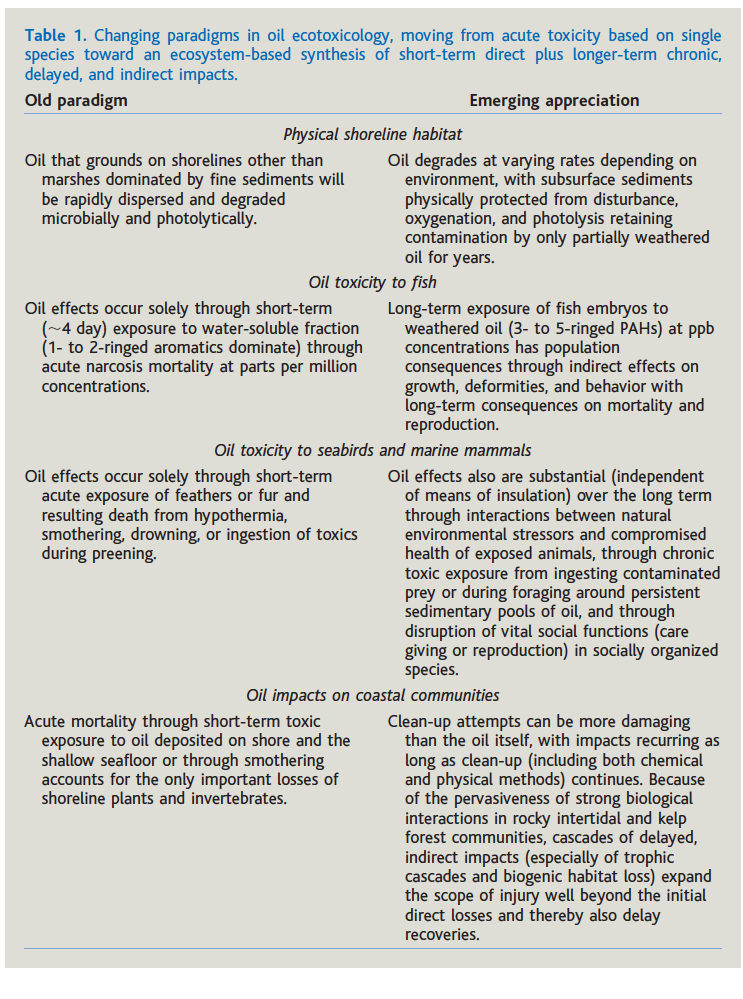
References / Annotated Bibliography about the extent and damage wrought by the Exxon Valdez Oil Spill on fish communities.

(Peterson et al. 2003)

Science summary of information about exxon 15 years later. Provides a few detailed example of detailed studies on physiology

*Cascades of indirect effects.* Indirect effects can be as important as direct trophic interactions in structuring communities (*35*). Cascading indirect effects are delayed in operation because they are mediated through changes in an intermediary. Perhaps the two generally most influential types of indirect interactions are (i) trophic cascades in which predators reduce abundance of their prey, which in turn releases the prey’s food species from control (*36*); and (ii) provision of biogenic habitat by organisms that serve as or create important physical structure in the environment (*37* ).

Expectations of rapid recovery based on short generation times of most intertidal plants and animals are naïve and must be replaced by a generalized concept of how interspecific in- teractions will lead to a sequence of delayed indirect effects over a decade or longer (*7*).



(Sol et al. 2000)

This paper talks about increased exposure to oil near the spill site in three fish (yellowfin sole, dolly varden, Pollock) and how reproductive parameters decline with more exposure. These are physiological indicators of exposure. Also, there appeared to be a geographic cline in insults to the fish (fish down shelikof strait had less problems). This was true even though samples were take 1 or 2 years after the oil spill (90 or 91) suggesting that oil effects can be persistent.

(Collier et al. 1993)

Abstract

“*Our results show a continuing exposure of several fish species, including benthic species, which indicates petroleum contamination of subtidal areas. We have also assessed reproductive function and histopathological alterations in several of these species; and while major effects have not been documented, some suggestion of histopathological alterations of gill exists in one species of benthic fish. Still to be determined are the potential impacts on fishery resources of long-term exposure to petroleum, albeit at moderate to low levels.*”

(Jewett et al. 2002)

masked greenling

Abstract ”In 1999, fishes collected from sites adjacent to intertidal mussel beds containing lingering Exxon Valdez oil had elevated endothelial CYP1A and EROD, and high concentrations of biliary FACs. Fishes from sites near unoiled mussel beds, but within the original spill trajectory, also showed evidence of hydrocarbon exposure, although there were no correlations between sediment petroleum hydrocarbon and any of the biomarkers. Our data show that 10 years after the spill, nearshore fishes within the original spill zone were still exposed to residual EVOS hydrocarbons.”

(Page et al. 1996, 1999)

These seem to be from some guy paid by Exxon. They don’t really make a lot of sense but seem to be arguing for natural oil seeps as the source of subtidal oil.

(Wolfe et al. 1994)

description of where the oil that was spilled ended up. Plenty of evidence that it reached deep water. Although the mass transport from beaches to shallow subtidal sediments was not quantified, the amount (Figure 2) was estimated, along with shoreline dispersion.

(Paine et al. 1996)

The lightest most toxic fraction probably evaporated within the first 10 days and constituted more than 20% of the total amount(172). Degradation of heavier oil fraction takes a great deal longer and is often assumed to follow an exponential decline, as hydrocarbons are broken down by light and by microbial consumers (172). Five years after the spill, about 2% of the oil remained onbeaches and 13% in sediments with onlya tiny fraction still dispersed in water(172)

Ref # 172 is Wolfe et al. 1994.

(Short & Heintz 1997) Some empirical modeling of the dispersal of oil

(Short et al. 2007) There is still oil on the beaches in Alaska from Exxon.

Fish were exposed, even slight exposure can have physiological and fitness effects (Collier et al. 1993, Hicken et al. 2011, Incardona et al. 2012, 2015)

From Incardona et al.: Our findings indicate that embryonic exposure to very low, environmentally relevant levels of crude oil causes permanent structural and functional changes to the fish heart. Crude oil essentially acts as a potent teratogen that produces specific abnormalities in the compact myocardium and outflow tract following exposure during early heart development. These developmental defects initiated during organogenesis in turn led to reduced cardiorespiratory performance much later in juvenile fish. Hence, embryonic injury following crude oil exposure leads to irreversible impairment.

Rockfish were exposed to oil (Marty et al. 2003)

(Feder & Blanchard 1998) This paper does the space comparison between oiled and unoiled spots . Doesn’t find much but then it didn’t have a very good statistical design

(Hicken et al. 2011)

PNAS paper about sublethal effects of oil on experimental zebra fish .

This is a study written up by Exxon paid folk. Seems to have lots of input from Exxon. (Harwell & Gentile 2006)

Thoughts on Armstrong et al. In book (Armstrong et al. 1995)

A lot of these analyses and conclusions stem from the assumption that lethal levels of oil or derivatives need to be present in the water column to cause harm.

E.g. “On a population level, the extent of the negative effect is excess of deined toxic thresholds, is dispersed relative to the distribution of the population and the length of time such toxic levels persist. Ecologically toxic concentrations of water-soluble fractions (WSF) used in modeling impact scenarios for several Alaskan oil and gas pre-lease sales are generally set at a lower limit of 0.01 ppm, considered toxic to eggs and larvae of temperate water species, although adult stages may be 10- to 20- fold less sensitive.

Also tends to frame in whole-population terms: “only a small area of total population in gulf would be affected”

No acute effects were detected

Ole’s summary:

Most useful aspects of the Armstrong et al. paper is that they document oil getting to deep water and in the water column.

Direct evidence: oil showed up in trawls.

Animal evidence: This evidence is from scallops (high in 1989, decline relatively quickly), mussels (high in 1989, decline pretty quickly), Infaunal bivalves had evidence of some petrogenic sources through 1991 though this is somewhat spatially variable. Suggestion that local non-spill sources oil PAHs and the like may be unavailable biologically. Flathead sole had evidence of bile metabolites associated with the spill but it looks like sole are getting the exposure through their diet.

Look up Cabioch et al. 1978 Amoco Cadiz for a reference to 3d dispersal of oil.

Paywall.

Laevastu and Fukuhara 1985 [ pain in the ass grey literature report]

“Oil on the bottom of the sea – a simulation study of oil sedimentation and its effects on the Bristol Bay ecosystem” Final report No. 36 Part 1 (1986) U.S. Department of Commerce, NOAA/ OCSEAP pp. 395-454.

Clark, B.R. 1992. Marine Pollution. 3rd ed Clarendon Press. Oxford, England 172 pp.

(Gundlach et al. 1983) Where oil ended up in France after a big spill.

Santa Barbara spill Squirre 1992

(Squire 1992) Pelagic species spatial distribution relative to oil spill.

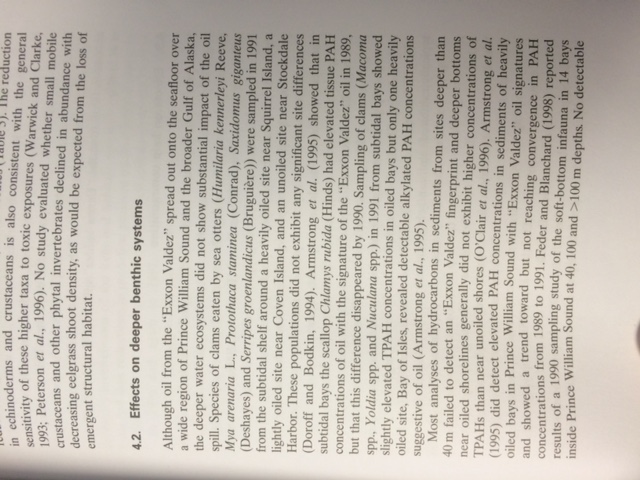
Other spills:

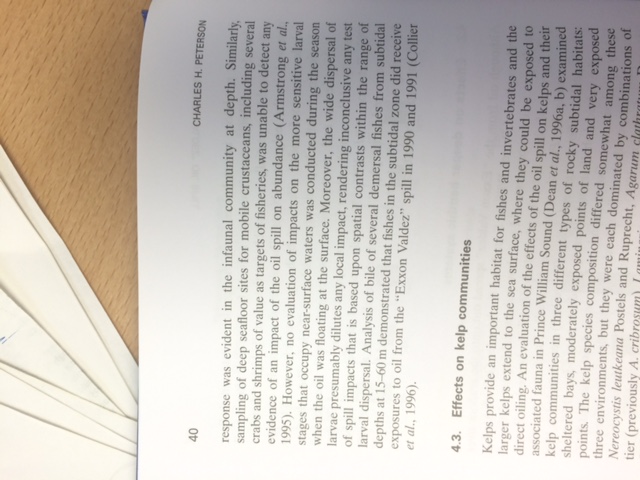
Manen and Pelto 1984

Linden et al. 1979

(Krahn et al. 1992). Demonstrates exposure to oil in pollock and salmon using a mix of experimental and field collections.

(Peterson 2001)





Summary of the Peterson 2001.

Overall synthetic summary of the type and extent of studies conducted about Exxon Valdez.

Study type A is to calculate the toxicological effects in the lab on a few species and then attribute changes to the ecosystem based on uncertain exposures in nature. Study type B is to go into the field and measure stuff even if the exact mechanism is not clearly articulated.

History and fate of oil from Exxon Valdez

Approx. 40-45% was estimated to be deposited on the shore of PWS (Wolfe et al. 1994)

About 25% was transported out of the sound.

About 8-16% was deposited in shallow subtidal sedimentary habitats less than 20m deep.

Water column oil was detectable in 1-5 weeks after the spill (Short and Harris 1996, Neff and Stubblefield 1995), but not detectable in the water by the end of the summer 1989. However, mussels deployed and collected had detectable oil signatures even when the water did not have an oil signature (Short and Harris 1996).

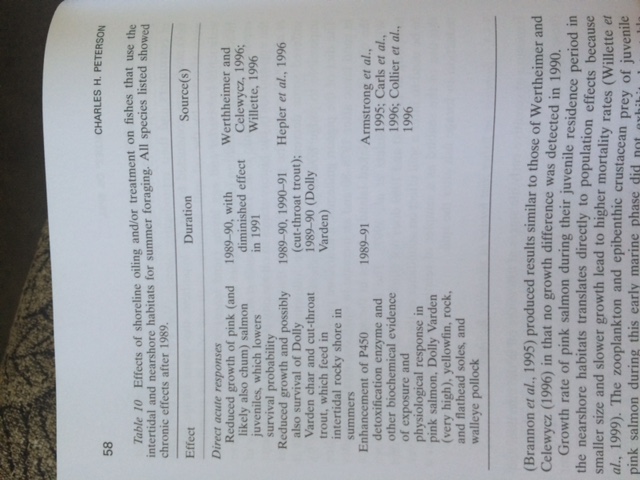
Concentrations of Exxon Valdez oil in subtidal sediments outside of PWS was patchy (O’Clair et al 1996). In eelgrass, low but detectable levels of oil contamination were observed until 1995 when sampling ended (Jewett et al 1999).

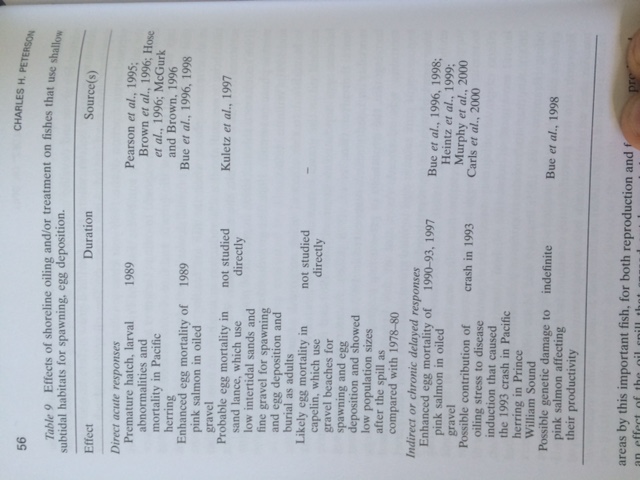
Armstrong found no obvious signal of exxon valdez on abundance of deep water fish or crustaceans. Feder and Blanchard (1998) found no obvious differences in deep water infaunal communities. Collier et al. 1996 found evidence of exposure to oil at depth from Exxon in 1990 and 1991.

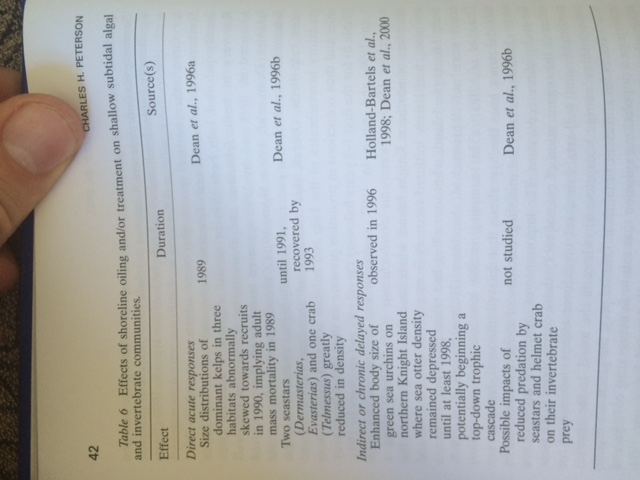
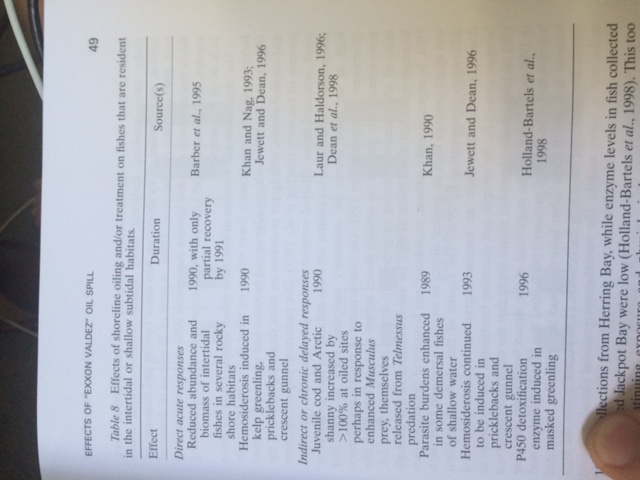
There were no studies of the larval critters during or shortly following the oil spill.

Invert communities appear to have recovered from reduced abundance in kelp beds by 1993 (primarily the big predatory sea stars and a few crabs) Dean et al. 1996.

Fish impacts: Summarized in photos of tables on next page.







From Discussion (pg. 76-77).

Most examples of impact involve bottom up effects moving up the food chain. There have been no studies of deepwater communities with regard to chages in productivity

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