H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

APPENDICES

for

Framework for Identifying Key Environmental Concerns in Marine Renewable Energy Projects

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Appendix A. Potential generic effects of wave and tidal energy conversion devices.

Potential generic effects of wave and tidal energy conversion devices on marine species.

Action	Organisms affected and description of potential effect						
	Marine birds	**Cetaceans**	**Pinnipeds**	**Fish**	**Invertebrates**	**Mustelids**	**Sea turtles**
Noise and vibration	Disrupt movement, behavior	Disrupt movement, behavior	Disrupt movement, behavior	Disrupt movement, behavior	Effects unlikely	Disrupt movement, behavior	?
Seabed disturbance	Affect food resources	Affect food resources	Affect food resources	Affect food and habitat resources	Affect habitat	Affect food resources	Effects unlikely
Structure	Provide rest sites, foraging, collision and entanglement	Collision and entanglement	Provide rest sites, foraging, entanglement	Acts as attractant, provides habitat, foraging	Provide habitat	Provide rest sites, foraging	Effects unlikely
Moving parts	Strike or impact	Strike or impact	Strike or impact	Strike or impact	Effects unlikely	Strike or impact	Strike or impact
Water circulation changes	Affect food resources	Affect food resources	Affect food resources, behavior	Affect food resources, behavior	Change community composition	Affect food resources, behavior	Effects unlikely
Electromag-netic field (EMF)	?	Disrupt movement, behavior	Disrupt movement, behavior	Disrupt movement, behavior	Disrupt movement, behavior	?	Disrupt movement, behavior
Lights	Disorientation, collision	?	?	Affect behavior for some fish species	Attract some species of pelagic invertebrates	?	Effects unlikely
Chemical releases	Hypothermia, toxicity to individuals and prey	Toxicity to individuals and prey	Toxicity to individuals and prey	Toxicity to individuals and prey	Toxicity to individuals	Toxicity to individuals and prey	Toxicity to individuals and prey

Potential generic effects of wave and tidal energy conversion devices on site physical characteristics (NA= not affected)

Action	Substrate Dynamics	Hydrodynamic regime (tidal only)	Sediment chemistry	Water chemistry	Acoustic environment	Visual environment	Electromagnetic environment
Seabed disturbance	Increases in substrate size if fine-grained or unconsolidated substrates disturbed/ eroded	NA	Releases pollutants from contaminated sediments or causes reduction-oxidation	Increased suspended sediment	NA	NA	NA
Structure	Localized current velocity reduction; contribution to sediments from biofouling organisms on structures	Localized current velocity reduction	Biological contribution to sediments from biofouling organisms on structures	NA	Increased noise, vibrations	Introduces visual stimuli	Effects unlikely
Moving parts	Effects unlikely	Effects unlikely	Effects unlikely	Effects unlikely	Increased noise, vibrations	NA	Effects unlikely
Water circulation changes	Altered substrate size, sediment transport, and/or littoral cells	Reduced downstream current velocities, may affect sediment transport, water quality in inlets and estuaries	Sediment transport and deposition changes alters chemistry	Changes in mixing and stratification	NA	NA	NA
Electromagnetic field (EMF)	Effects unlikely	Effects unlikely	Effects unlikely	Effects unlikely	NA	NA	Alters local geomagnetic fields
Lights	NA	NA	NA	NA	NA	Introduces artificial light sources	NA
Chemical releases	NA	NA	Addition of contaminants to sediment	Addition of contaminants to water column	NA	NA	NA

Appendix B. Raptools Methodology

1 Raptools Description

Raptools is a spreadsheet application that uses multidimensional scaling (MDS), leveraging analyses, and graphical representations so that one can evaluate the interactions and effects of numerous attributes of many scenarios. These statistical techniques are readily accepted and well-vetted but complex, and a simplified and conceptual description is given here.

1.1 MDS Mechanics

MDS is a set of statistical techniques that has recently been applied to aid in the relatively new field of information visualization (Kruskal and Wish 1978). MDS enables objective comparison between complex entities—in this case the "entities" are wave and tidal energy development scenarios; MDS allows identification of clusters or "more similar" entities. MDS was selected because we needed a way to evaluate and visualize the relationships between many site attributes (e.g., beach slope, numbers of special status species, or cost of energy per kilowatt), three potential project locations (Makapu'u, Hawaii; Humboldt, California, and Tacoma, Washington), and three project scales (pilot, small commercial, and large commercial).

Most people can easily evaluate and visualize relationships between 2 or 3 attributes or dimensions. An example of analysis in 2 dimensions would be evaluating whether the project generates any noise or vibrations in frequencies that affect whale behavior; the first dimension is noise, the second is whale behavior. A third dimension could be project size. We can visualize 3 dimensions as an x-y-z graph, but more than 3 dimensions are difficult to visualize.

"The purpose of multidimensional scaling (MDS) is to provide a visual representation of the pattern of proximities (i.e., similarities or distances) among a set of objects" (Kruskal and Wish 1978). For MDS to be applied to resource management and evaluation, Kruskal and Wish's "similarities or distances" are the distances between two attributes if they were measured, scored, and compared. The scoring of the attributes is standardized to simple valuations of "few effects" to "most effects" so that the attributes may be compared against each other. In our 2 dimensional example above, whales could be scored 1 for very disturbed or affected, to a 3 for no behavioral changes observed; the noise generated during project construction could be scored 1 for that noise associated with a pilot project, to a 3 for power associated with a large commercial scale project.

If the relationship between whales and noise during construction is weak, then no behavioral changes (that is a "good" effect, 3 on the x axis) would be observed during construction of a large commercial project (a large commercial project would create the most construction noise, 3 on the y axis), and one can imagine a line or vector on an x-y graph, from the origin (0,0) to a point (3,3) (Figure B-1).

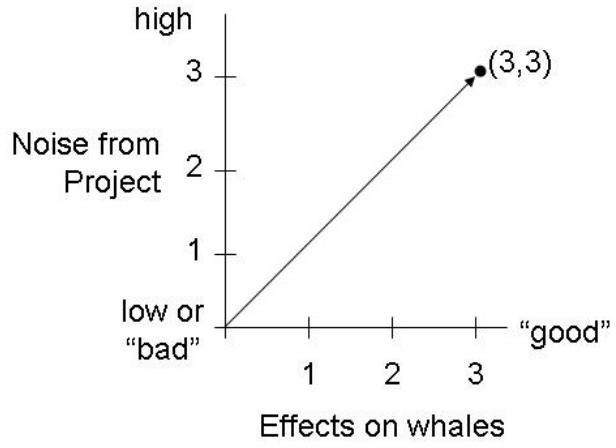


Figure B-1. High levels of noise that do not affect whales are represented by a vector from the origin (0,0) to (3,3).

If the relationship is very strong (whales are highly affected by noise from a pilot project), then the vector would be from (0,0) to (1,1); this second vector would be shorter than the first one (Figure B-2). In this way, relationships between attributes can be represented by distances; the MDS algorithms are performed on the distances between scored attributes.

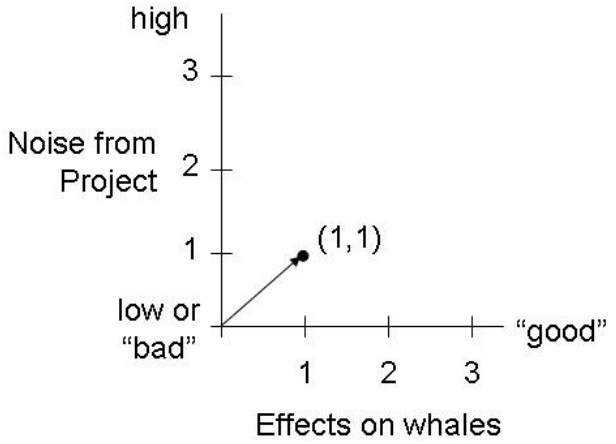


Figure B-2. Low levels of noise that do affect whales are represented by a vector from the origin (0,0) to (1,1).

We have identified 4 sets of attributes and 8 attributes within each set. (The statistics literature calls these sets of attributes "evaluation fields".) When distances between the many standardized attributes are obtained, the attributes can be put in order. MDS is considered an "ordination method" by statisticians.

MDS techniques have been applied to a variety of complex, multivariate problems from a variety of disciplines (Schiffman et al. 1981; Jongman et al. 1995; McCune and Grace 2002). This MDS methodology has been used as the center piece for a suite of analyses to examine the

multidisciplinary task of evaluating the relative sustainability of commercial fisheries; this approach is called "Rapfish" (Pitcher et al. 1998; Pitcher 1999; Pitcher and Preikshot 2001). With Raptools, we have adapted the Rapfish software with the expectation that this approach offers suitable means for the objective assessment of diverse attributes (personal communication, T. Pitcher, 12 February 2009).

1.2 Running Raptools

In Raptools, we selected these evaluation fields:

1. Siting attributes, which are measurable site characteristics
2. Technology attributes, which are characteristics of a project's technology
3. Ecological attributes, which are environmental attributes that could be affected
4. Human environment attributes, which are attributes that are defined by society

In applying MDS to a resource management evaluation, the exercise depends on 1) the selection of the individual attributes, and 2) their scorings.

Within each attribute set, we selected 8 attributes. The ideal number of attributes is between 8 to 12 (Kavanagh and Pitcher 2004), which are enough to capture the complexity of an evaluation field, but not so many that the ordinations become too difficult to interpret visually. Kavanagh (2004) found that the resultant level of detail was a good match between the diversity of factors at play in complex scenarios, and the amount of information available to inform the evaluation of each attribute.)

The scoring of each attribute, on a coarse "few effects" to "more effects" scale, was assigned based on the literature and professional judgment. The range of scores is based on how well we can discern potential effects. For example, if our understanding of an effect on an attribute can only be judged to be "high", "medium," or "low", the scores would be 0, 1, or 2 and the range would be 0 to 2; however if we have a better understanding and can discern the effects better, the score range would be greater, say from 0 to 4, representing "no effect", "minor", "moderate", "moderately high" and "very high."

However, another approach--one that is sometimes used in the Rapfish protocol--is to have stakeholders and experts come to a consensus on the attributes and their scorings. Rapfish uses expert opinion to evaluate the probable importance of a broad range of physical, biological and sociological attributes. Rapfish creates 'best case' and 'worst case' scenarios, using the same attributes; these extreme scenarios allow multiple ordinations[1] to be oriented consistently for direct comparison. Rapfish is unusual, however, in its capacity to compare multiple situations and compares favorably to other less inclusive (and often less quantitative) methods for evaluating complex systems (Leadbitter and Ward 2007). By adopting the Rapfish approach and methods in Raptools, we have also adopted its capabilities and advantages.

In this application of Raptools, we generated scores for wave energy and tidal energy development projects. The scores were entered into a spreadsheet. We downloaded the Rapfish spreadsheet from the University of British Columbia website[2] and followed the instructions for

[1] Ordination is a technique of multivariate statistics that maps multiple measures from multiple factors, enabling the user to compare the relative importance of these factors.
[2] http://www2.fisheries.com/archive/projects/rapfish.php

performing the calculations with our new attributes. After obtaining the x, y ordinations, we used graphing software to produce the X-Y ordination plots, the leveraging bar graphs, and the kite diagrams.

Jongman RHG, Ter Braak CJF, van Tongeren OFR (1995) Data Analysis in Community and Landscape Ecology. Cambridge University Press 321 pp.

Kavanagh P, Pitcher TJ (2004) Implementing Microsoft Excel software for Rapfish: A technique for the rapid appraisal of fisheries status. Fisheries Centre Research Reports 12: 1-75

Kruskal JB, Wish M (1978) Multidimensional Scaling. Sage University 96 pp.

Leadbitter D, Ward TJ (2007) An evaluation of systems for the integrated assessment of capture fisheries. Marine Policy 31: 458-469

McCune B, Grace JB (2002) Analysis of Ecological Communities. MjM Software Design, Gleneden Beach, Oregon, 300 pp.

Pitcher T, Bundy A, Preikshot D, Hutton T, Pauly D (1998) Measuring the unmeasurable: a multivariate and interdisciplinary method for rapid appraisal of the health of fisheries. In: Pitcher T, Hart PJB, Pauly D (eds) Reinventing Fisheries Management. Kluwer Academic Publishers, London, pp 31-54

Pitcher TJ (1999) Rapfish, a rapid appraisal technique for fisheries, and its application to the code of conduct for responsible fisheries. Food and Agricultural Organization of the United Nations, Rome, pp 52

Pitcher TJ, Preikshot D (2001) RAPFISH: A rapid appraisal technique to evaluate the sustainability status of fisheries. Fisheries Research 49: 255-270

Schiffman SS, Reynolds ML, Young FW (1981) Introduction to Multidimensional Scaling, Theory, Methods and Applications. Elsevier 440 pp.

Attributes and scoring ranges for trial run of the Raptools analysis, as applied to evaluating effects of siting wave energy technology

Attributes	Fewest adverse effects	Most adverse effects	Explanation
SITING			
distance from shore	0	3	Although shorter distance reduces installation and maintenance costs, greater distances present fewer effects due to greater wave attenuation and lower biodiversity.
water depth	4	0	Greater depth presents fewer effects; higher biodiversity in shallow water.
estuarine distance	0	2	The farther away an estuary (or rivermouth) is, the fewer effects because change in sediment transport will be less, with less effect on estuary closure and opening.
proximity to natural reef	2	0	The farther away a natural reef is, the fewer adverse effects because reefs are associated with high diversity and species attracted to artificial habitat presented by devices.
beach slope	2	0	The steeper the slope, the fewer adverse effects expected, because the width of the intertidal zone would be narrower, so less of this important zone would be affected.
biological hot spot	0	2	Ecologically important areas ideally would be avoided; increasing number or magnitude is assumed to be detrimental.
Sea surface temperature (SST) predictability	0	3	SST is associated with biological predictability; greater predictability would create fewer effects because ecological effects could be avoided or minimized if they can be predicted.
distance to port	0	2	The shorter the distance to port, the fewer effects because vessel transit distances are reduced; accident probabilities would be lower.
PROJECT/TECHNOLOGY			
Project size (MW generated)	0	2	Smaller projects translate to fewer environmental effects, however, the relationship is almost certainly nonlinear.
energy extraction	0	2	Less energy extraction would create the fewest adverse effects. Technologies' extraction efficiencies are a function of device design and siting, so this attribute was scored primarily on scale.
impingement/entrainment/moving parts	0	2	The fewer moving parts, the fewer effects created.
# of vertical cables	0	3	The fewer cables, the smaller the risk of seabird or marine mammal strike.
anchoring system	0	2	Anchoring/foundation system designs vary, as would their potential effects through displacement or adding substrate.
operations and maintenance	0	2	The less O&M activity, the fewer effects because risk of accidents through vessel traffic is also reduced.
noise and vibration generated	0	2	Device noise and vibration is generally unknown, but many taxa are potentially affected; must consider frequency (Hz), amplitude, duration as well as longer temporal patterns

Attributes	Fewest adverse effects	Most adverse effects	Explanation
hydraulic fluid	0	3	Least volumes used create the fewest effects.
operational/navigational lighting	0	2	Lighting strength and patterns create effects. Efforts or projects with designs explicitly intended to mitigate effects on seabird behavior recognized in the scoring.
ECOLOGICAL			
de facto marine reserve	2	0	Protection results in fewer effects. Fishing access restrictions likely to result in protected subpopulation; scale effects are likely; assumes some degree of compliance.
artificial reef effect	2	0	Attraction is detrimental and production is beneficial. This attribute combines distance to nearest existing reefs with presence and swimming ability of local fishes. A lower redistribution is preferable for causing the fewest adverse effects. Artificial reef effect + project scale may combine to result in local production (increased regional biomass through larval/juvenile recruitment). Smaller projects may result in attraction and migration from existing reefs.
local concentration of piscivores	0	1	Fewer piscivores is preferable because concentrating potential predators may affect species of special concern (e.g., salmon smolts, sea turtle hatchlings) near known/suspected migration routes.
species of special concern	0	2	Fewer species of special concern is better.
EMF-responsive species	0	3	Fewer EMF-responsive species is better.
Marine mammal strike	0	3	Fewer vulnerable species is better. Presence determined by siting of project with a migration corridor, and prior experience with local strike or entanglement (e.g., crab pot lines).
noise-responsive species	0	2	The fewer species known to be noise-responsive is better.
light-responsive birds	0	2	The fewer species known to be light-responsive is better.
HUMAN ENVIRONMENT			
local population size	4	0	The greater the population size, the fewer the adverse effects because any negative impact would be spread across a greater population size (ecological footprint concept).
# of temporary jobs	3	0	The greater number of temporary jobs created, the fewer adverse (greater beneficial) impacts to the human environment.
# of permanent jobs	3	0	The greater number of permanent jobs created, the fewer adverse (greater beneficial) impacts to the human environment.
lost fishing grounds	0	2	The lower the area of lost fishing grounds, the fewer effects.
existing vessel traffic	0	2	The lower the existing traffic, the fewer effects because the probability of vessel collision is lower.
cost of energy ($/kwhr)	2	0	The higher the local cost of energy, the greater the positive effect of the project.
energy output (MWh/year)	2	0	The greater the energy output, the greater the contribution to reduction in greenhouse gas

Attributes	Fewest adverse effects	Most adverse effects	Explanation
			emissions.
indirect economic effects	2	0	Indirect economic development assumed to occur with energy development.

Attributes > Ocean Energy Projects V	Abbreviation	**SITING**	distance from shore	water depth	estuarine factor	proximity to natural reef	beach slope	biological hot spot	SSTemp predictability	distance to port		**PROJECT/TECHNOLOGY**	size (MW generated)	energy extraction	impingement/entrainment/moving parts	# of vertical cables	anchoring system	operations & maintenance	noise and vibration generated
Hawaii Pelamis sml	HI_Pel_sml		2	3	0	0	2	2	0	2			0	0	0	1	0	1	1
Hawaii Pelamis mec	HI_Pel_med		2	3	0	0	2	2	0	2			1	1	0	1	0	1	1
Hawaii Pelamis lrg	HI_Pel_lrg		2	3	0	0	2	2	0	2			2	2	0	2	0	1	1
Hawaii OPT sml	HI_OPT_sml		2	3	0	0	2	2	0	2			0	0	0	2	3	1	1
Hawaii OPT med	HI_OPT_med		2	3	0	0	2	2	0	2			1	1	0	2	3	1	1
Hawaii OPT lrg	HI_OPT_lrg		2	3	0	0	2	2	0	2			2	2	0	3	3	1	1
Hawaii Wdragon sml	HI_WD_sml		2	3	0	0	2	2	0	2			0	0	2	1	2	1	2
Hawaii Wdragon med	HI_WD_med		2	3	0	0	2	2	0	2			1	1	2	1	2	1	2
Hawaii Wdragon lrg	HI_WD_lrg		2	3	0	0	2	2	0	2			2	2	2	2	2	1	2
Hawaii Oyster sml	HI_Oys_sml		0	1	0	0	2	2	0	2			0	0	1	0	1	1	0
Hawaii Oyster med	HI_Oys_med		0	1	0	0	2	2	0	2			1	1	1	0	1	1	0
Hawaii Oyster lrg	HI_Oys_lrg		0	1	0	0	2	2	0	2			2	2	1	0	1	1	0
California Pelamis sml	CA_Pel_sml		2	2	1	2	1	1	2	0			0	0	0	1	0	1	1
California Pelamis med	CA_Pel_med		2	2	1	2	1	1	2	0			1	1	0	1	0	1	1
California Pelamis lrg	CA_Pel_lrg		2	2	2	2	1	1	2	0			2	2	0	2	0	1	1
California OPT sml	CA_OPT_sml		2	2	1	2	1	1	2	0			0	0	0	2	3	1	1
California OPT med	CA_OPT_med		2	2	1	2	1	1	2	0			1	1	0	2	3	1	1
California OPT lrg	CA_OPT_lrg		2	2	2	2	1	1	2	0			2	2	0	3	3	1	1
California Wdragon sml	CA_WD_sml		2	2	1	2	1	1	2	0			0	0	2	1	2	1	2
California Wdragon med	CA_WD_med		2	2	1	2	1	1	2	0			1	1	2	1	2	1	2
California Wdragon lrg	CA_WD_lrg		2	2	2	2	1	1	2	0			2	2	2	2	2	1	2
California Oyster sml	CA_Oys_sml		0	1	1	2	1	1	2	0			0	0	1	0	1	1	0
California Oyster med	CA_Oys_med		0	1	1	2	1	1	2	0			1	1	1	0	1	1	0
California Oyster lrg	CA_Oys_lrg		0	1	2	2	1	1	2	0			2	2	1	0	1	1	0
Washington MCT sml	WA_MCT_sml		1	3	2	1	2	1	1	0			0	0	2	0	1	1	0
Washington MCT med	WA_MCT_med		1	3	2	1	2	1	1	0			1	1	2	0	1	1	0
Washington MCT lrg	WA_MCT_lrg		1	3	2	1	2	1	1	0			2	2	2	1	1	1	0
Washington Lunar E sml	WA_LuE_sml		1	3	2	1	2	1	1	0			0	0	1	0	0	1	1
Washington Lunar E me	WA_LuE_med		1	3	2	1	2	1	1	0			1	1	1	0	0	1	1
Washington Lunary E lrg	WA_LuE_lrg		1	3	2	1	2	1	1	0			2	2	1	1	0	1	1
Washington SMD sml	WA_SMD_sml		1	3	2	1	2	1	1	0			0	0	2	0	1	1	2
Washington SMD med	WA_SMD_med		1	3	2	1	2	1	1	0			1	1	2	0	1	1	2
Washington SMD lrg	WA_SMD_lrg		1	3	2	1	2	1	1	0			2	2	2	1	1	1	2

hydraulic fluid	operational/navigational lighting		ECOLOGICAL	de facto marine reserve	artificial reef effect	local concentration of piscivores	spp of special concern	EMF-responsive spp	whale strike	light-responsive birds	noise-responsive spp			HUMAN ENVIRONMENT	local population size	# of temporary jobs	# of permanent jobs	lost fishing grounds	existing vessel traffic	cost of E ($/kwhr)	E (output, MW)	indirect economic effects
3	1			1	0	0	1	1	1	1	2				3	1	0	0	0	2	0	0
3	1			1	0	1	1	1	1	1	2				3	1	0	0	0	2	1	0
4	2			2	0	1	1	2	2	2	2				2	1	1	0	0	2	2	1
2	1			1	1	0	1	1	1	1	2				3	2	0	0	0	2	0	0
2	1			1	1	1	1	1	2	1	2				3	2	0	0	0	2	1	0
3	2			2	1	1	1	2	2	2	2				2	2	1	0	0	2	2	1
3	1			1	1	0	1	1	0	1	2				3	1	0	0	0	2	0	0
3	1			1	1	0	1	1	1	1	2				3	1	0	0	0	2	1	0
4	2			2	1	1	1	2	2	2	2				2	1	1	1	0	2	2	1
0	0			0	1	0	0	1	1	0	1				3	1	0	0	0	2	0	0
0	0			0	1	0	0	1	1	0	1				3	1	0	0	0	2	1	0
0	0			1	1	0	0	2	1	0	2				2	1	1	0	0	2	2	1
3	1			1	0	0	2	2	2	1	1				1	1	0	0	0	1	0	0
3	1			1	0	1	2	2	2	1	1				1	1	0	1	1	1	1	0
4	2			2	0	1	2	3	3	2	2				0	1	1	2	1	1	2	1
2	1			1	1	0	2	2	2	1	1				1	2	0	0	0	1	0	0
2	1			1	1	1	2	2	3	1	1				1	2	1	1	1	1	1	0
3	2			2	1	1	2	3	3	2	2				0	2	1	2	1	1	2	1
3	1			1	1	0	2	2	0	1	1				1	1	0	0	0	1	0	0
3	1			1	1	0	2	2	1	1	1				1	1	0	1	1	1	1	0
4	2			2	1	1	2	3	2	2	2				0	1	0	2	1	1	2	1
0	0			0	1	0	1	2	0	0	0				1	1	0	0	0	1	0	0
0	0			0	1	1	1	2	0	0	0				1	1	0	0	0	1	1	0
0	0			1	1	1	1	3	0	0	1				0	1	1	0	0	1	2	1
0	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	0	0
0	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	1	1
1	0			1	1	1	1	3	2	0	1				3	1	1	1	1	0	2	1
1	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	0	0
1	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	1	1
2	0			1	1	1	1	3	2	0	1				3	1	1	1	1	0	2	1
2	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	0	0
2	0			0	1	0	1	2	1	0	0				4	1	0	0	0	0	1	1
3	0			1	1	1	1	3	2	0	1				3	1	1	1	1	0	2	1

Appendix D. Effects of a Small Commercial OPT Power Buoy Project at Humboldt on physical and biological indicators

Included in Appendix D are 1) a project description of the small commercial OPT Power Buoy project at the Humboldt project site; 2) the marine indicators selection process based on species' distribution, behavior, and biology; 3) an effects analysis of the project on site physical and biological indicators in tabular format; and 4) a list of references used to complete the effects analysis.

Project description for construction, operations and maintenance, and decommissioning phases for Small Commercial OPT Power Buoy project at the Humboldt project site.

Project phase	Project activity or characteristic	Technology and site specific information
Construction	Location and deployment depths	Off Humboldt Bay, 50m water depth, 3 NM from shore
	Footprint	67 devices, 3.3 km x 0.8 km (2.6 km^2).
	Loading ports and dock locations	Humboldt Bay
	Shipping routes for delivery and installation	Assumed in and out of Humboldt Bay docks
	Ship types and sizes	2 tug boats, 1 barge
	Installation and assembly procedures	Cable directionally drilled from land to subsea opening, the subsea cable installation is from the subsea opening to turbine site. Tug boats bring barge, anchor from barge lowered via strand jacks, and mooring buoys deployed. Repeat until each OPT buoy gets 3 mooring buoys, but some share buoys. OPT buoy is towed to mooring sites with a tug boat, then connected to mooring buoys.
	Installation equipment	Barge, tug boats, strand jacks, directional drilling rig
	Temporary structures	N/A
	Types, composition, locations, and numbers of anchoring and mooring systems	3 anchors and subsurface mooring buoys for each device, 67 devices. Anchors are 6 x 6 x 3.1 m concrete blocks.
	Installation schedule and phasing	~ 4 months, could be over 2 summers. Construction assumed to occur 24 hrs/day.
	Chemicals and fuels used	Hydraulic fluids, boat fuel, paints, anti-fouling agents
	Sources and levels of noise	Ship engines, drilling rig for directional drilling
	Sources, levels, and characteristics of light	Navigational lights on boats and on devices as they are installed. Construction and deck lights will be brighter than navigation lights
	Number of vessel trips	Unknown
Operations and Maintenance	General description of technology	The OPT Buoy is a heaving point absorber, reacting against a subsea reaction plate. The relative movement between the absorber buoy and the reaction mass is converted into electricity using a hydraulic power conversion system. The device is "slack-moored" to the seabed; the wires are under tension.
	O&M procedures and schedule	Routine O&M is assumed to be annually; devices will likely be towed to pier.
	Operating equipment other than wave device(s)	Mooring lines and anchors, maintenance boats, electrical collector system, subsea cable
	Listing of all moving parts	OPT buoys

Project phase	Project activity or characteristic	Technology and site specific information
	Listing of all structures on surface and below	67 OPT buoys. Each OPT buoy extends 8 m above surface and 34 m below surface, and is 11m diameter. 3 subsurface mooring buoys (at depths 9 to 15 m below surface) are moored to anchor on bottom.
	Vessel routes and schedule for operation and maintenance	Assumed from Humboldt Bay docks to project site
	Ship types and sizes	Tug boat if device towed to pier
	Potential emergency conditions and procedures	Unknown
	Chemicals used by devices, e.g., hydraulic fluids, antifouling paints.	Antifouling paint, hydraulic fluid
	Sources and levels of noise	Unknown. Possibly splash sound of waves on devices. Assume no audio navigational warnings on devices. Maintenance vessel noise.
	Sources and levels of light	Navigational lights on devices, surface piercing mooring buoys, and on maintenance vessels.
Decommissioning	Description of equipment or structures removed	Assumed all buoys, devices, mooring lines, anchors, subsea cable, and other electrical collection removed with custom vessel, tug boats, and barges
	Description of equipment or structures to be left in place	None.
	Monitoring procedure and schedule for equipment left in place	None.
	Shipping routes for equipment removed	Assumed project site to Humboldt dock
	Ship types and size	Assumed same as construction , 2 tug boats, 1 barge plus a cable handling vessel
	Decommissioning and disassembly procedures	Assumed similar but reverse of construction procedures
	Decommissioning equipment	Barges, tug boats, supply boat, cable handling vessel
	Temporary structures	None
	Decommissioning schedule and phasing	Assumed over 1 summer season
	Chemicals and fuels used	Boat fuels, hydraulic fluids
	Sources and levels of noise	Shipping noise, subsea cable removal, dismantling of mooring cables and device
	Vessels required, number of trips	Unknown
	Best management practices planned	Assumed to follow BMPs for marine construction and decommissioning

Selection of biological indicators for the Humboldt project effects analysis

1. Selection of pinnipeds and cetacean indicators for Humboldt project

Cetacean and pinniped indicator species were selected for the Humboldt wave energy project effects analysis by considering their temporal distribution, habitat and abundance, for all pinnipeds and cetacean species that could occur in the project area.

Cetaceans. Many baleen whales (Order Mysticeti) and toothed whales (Order Odontoceti) could occur in the continental shelf waters off the Humboldt coast (Table 1). However, the only two baleen whale species that regularly occur within the Humboldt wave energy project area are the humpback whale and the gray whale. The remaining baleen whales either occur further offshore along the continental slope and beyond, and/or are very rare in the area. Although not selected as indicator species, blue whales and minke whales also occasionally occur in the project area. If they do occur in the project area, the effects on the blue whales are likely similar to effects on the humpback whales, and effects on the minke whales are likely similar to effects on the gray whales.

The toothed whale species that regularly occur within the project area are the killer whale, harbor porpoise, and three smaller species: Pacific white-sided dolphin, Dall's porpoise, and Risso's dolphin. The remaining odontocetes occur farther offshore, along the continental slope and beyond. The harbor porpoise is the most common toothed whale species in the project area with its preference for nearshore sandy bottom habitats. Killer whales are infrequently sighted but are known to appear closer to shore, including inside Humboldt Bay. Dall's porpoise, Risso's dolphin, and Pacific white-sided dolphin regularly occur in the area, but tend to prefer more offshore waters.

The following cetaceans were selected as indicator species to assess the effects of a Humboldt wave energy project: 1) humpback whale; 2) gray whale; 3) killer whale; 4) harbor porpoise; and 5) "small odontocetes" (Pacific white-sided dolphin, Dall's porpoise, and Risso's dolphin). All cetaceans have highly developed acoustic abilities capable of detecting sounds at great distances; therefore, the acoustic zone of influence of project activities (i.e., noise emitted from construction equipment or device structures) extends far beyond the project area. Types of potential impacts on these species include collision and injury with boats; toxicity from oil or chemical spills/ releases, noise disturbance from turbines, moorings, boats or construction/ decommissioning activities; and entanglement or collision with moorings and wave structures.

Table 1. Cetaceans species that could occur in the Humboldt wave energy project area

Common Name	Scientific Name	Habitat	Temporal Distribution	Life Stage	Federal/ State Status	References
Baleen whales						
Blue whale	*Balaenoptera musculus*	Offshore, occasionally nearshore	Spring to fall	Adult, calf	FE 1970	1
Humpback whale	*Megaptera novaeangliae*	Nearshore	Spring to fall	Adult, calf	FE 1970	1
Fin whale	*Balaenoptera physalus*	Nearshore	Spring to fall	Adult, calf	FE 1970	1
Gray whale	*Eschrichtius robustus*	Nearshore	Spring to fall	Adult, calf	Recovered	2

Table 1. Cetaceans species that could occur in the Humboldt wave energy project area

Common Name	Scientific Name	Habitat	Temporal Distribution	Life Stage	Federal/ State Status	References
Sei Whale	*Balaenoptera borealis*	Nearshore and offshore	Rare	Adult, calf	FE 1970	1
Minke Whale	*Balaenoptera acutorostrata*	Nearshore and offshore	Rare	Adult, calf	MMPA	5, 6
Bryde's Whale	*Balaenoptera edeni*	Tropical offshore	Rare	Adult, calf	MMPA	5, 6
Northern Right Whale	*Eubalaena japonica*	Nearshore and offshore	Rare	Adult, calf?	FE, MMPA	3
Toothed whales						
Sperm Whale	*Physeter macrocephalus*	Shelf, slope, offshore	Year-round	Adult, calf	FE, MMPA	1
Killer whale Southern Resident	*Orcinus orca*	Nearshore	Winter	Adult, calf	FE, MMPA	4
Killer whale Offshore	*Orcinus orca*	Nearshore and offshore	Year-round	Adult, calf	MMPA	5, 6
Killer whale Transient	*Orcinus orca*	Nearshore and offshore	Year-round	Adult, calf	MMPA	5, 6
Harbor Porpoise	*Phocoena phocoena*	Nearshore	Year-round	All	MMPA	5, 6
Dall's Porpoise	*Phocoenoides dalli*	Nearshore and offshore	Year-round	All	MMPA	5, 6
Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	Nearshore and offshore	Year-round	All	MMPA	5, 6
Risso's Dolphin	*Grampus griseus*	Nearshore and offshore	Year-round	All	MMPA	5, 6
Short-beaked Common Dolphin	*Delphinus delphis*	Offshore	Rare	All	MMPA	5, 6
Long-beaked Common Dolphin	*Delphinus capensis*	Offshore	Rare	All	MMPA	5, 6
Striped Dolphin	*Stenella coeruleoalba*	Offshore	Rare	All	MMPA	5, 6
Northern Right Whale Dolphin	*Lissodelphis borealis*	Offshore	Rare	All	MMPA	5, 6
Bottlenose Dolphin (offshore)	*Tursiops truncatus*	Offshore	Rare	All	MMPA	5, 6
Short-finned Pilot Whale	*Globicephala macrorhynchus*	Offshore	Rare	All	MMPA	5, 6
Baird's Beaked Whale	*Berardius bairdii*	Offshore	Rare	All	MMPA	5, 6
Cuvier's Beaked Whale	*Ziphius cavirostris*	Offshore	Rare	All	MMPA	5, 6

Table 1. Cetaceans species that could occur in the Humboldt wave energy project area

Common Name	Scientific Name	Habitat	Temporal Distribution	Life Stage	Federal/ State Status	References
Blainville's Beaked Whale	*Mesoplodon densirostris*	Offshore	Rare	All	MMPA	5, 6
Perrin's Beaked Whale	*Mesoplodon perrini*	Offshore	Rare	All	MMPA	5, 6
Lesser Beaked Whale	*Mesoplodon peruvianus*	Offshore	Rare	All	MMPA	5, 6
Gingko-toothed Beaked Whale	*Mesoplodon gingkodens*	Offshore	Rare	All	MMPA	5, 6
Hubbs' Beaked Whale	*Mesoplodon carlhubbsi*	Offshore	Rare	All	MMPA	5, 6
Stejneger's Beaked Whale	*Mesoplodon stejnergeri*	Offshore	Rare	All	MMPA	5, 6
Pygmy Sperm Whale	*Kogia breviceps*	Offshore	Rare	All	MMPA	5, 6
Dwarf Sperm Whale	*Kogia sima*	Offshore	Rare	All	MMPA	5, 6

MMPA = Marine Mammal Protection Act; FE = Federally endangered

References: [1]USFWS 1970, [2]USFWS 1994, [3]NMFS 2008, [4]NMFS 2005c, [5]Carretta et al. 2009, [6]NOAA 2009a

Pinnipeds. Six species of pinnipeds could occur along the Humboldt coast (Table 2). However, harbor seals and Steller sea lions are the only pinnipeds that breed along the Humboldt coast and inhabit the area throughout the year. The other species of pinnipeds breed on beaches along the central and southern California mainland, on central and southern California islands, or on islands off of Alaska, and their presence in the project area would be rare and infrequent. Therefore, harbor seals and Steller sea lions were selected as indicator pinniped species for the Humboldt wave energy project effects analysis. Steller sea lions are listed as federally endangered. Potential impacts of the project on these species include collision and injury with boats; toxicity from oil or chemical spills/releases; noise disturbance from turbines, moorings, boats or construction and decommissioning activities; attraction to the wave energy structures because they aggregate prey or provide haul-out structures; and disorientation from construction lights. If any other pinniped species occur in the project area, the effects of the project are likely similar to effects on harbor seals and Steller sea lions.

Table 2. Pinniped species that could occur in the Humboldt wave energy project area

Common Name	Scientific Name	Habitat	Temporal Distribution	Life Stage	Federal/ State Status	References
California sea lion	*Zalophus californianus*	Coastal, Cont. shelf	Fall and Spring peaks	Adult, juvenile	MMPA	1, 2
Harbor seal	*Phoca vitulina*	Coastal, Cont. shelf	Year-round	Adult, pup	MMPA	1, 2
Steller sea lion	*Eumetopias jubatus*	Coastal, Cont. shelf	April-October Few in winter	Adult, pup	FT, MMPA	3, 4, 5
Elephant seal	*Mirounga angustirostris*	Oceanic, Cont. slope	Year-round	Adult, juvenile	MMPA	1, 2
Northern fur seal	*Callorhinus ursinus*	Oceanic, Cont. slope	Year-round	Adult, juvenile	MMPA	6, 7
Guadalupe fur seal	*Arctocephalus townsendi*	Oceanic, Cont. slope	Summer, rare	Adult, juvenile	FT, ST, MMPA	6, 7

MMPA = Marine Mammal Protection Act; FE = Federally endangered; FT = Federally threatened; ST = California State threatened

References: [1]Carretta et al. 2009, [2]NOAA 2009b, [3]NMFS 1990, [4]NMFS 1993, [5]Angliss and Allen 2009, [6]NMFS 1988, [7]NMFS 1985

2. Selection of fish indicators for Humboldt wave energy project

Fish indicator species were selected for the Humboldt wave energy project effects analysis if they are known to occur in northern California coastal waters, suitable habitat either occurs in the project area or would be created by the project, and aspects of their behavior and/or biology makes it likely that they would be affected by the project. Fish species were also selected if the project area is located within designated Essential Fish Habitat (EFH), and/or if they are designated as federally threatened or endangered and could occur in the project area. The following indicator species groups were selected for the Humboldt wave energy project effects analysis: 1) sharks, skates, and rays (elasmobranchs), 2) flatfishes, 3) rockfishes, 4) pelagic schooling fishes, 5) juvenile salmonids, and 6) adult salmonids.

Sharks, skates and rays — There are eight sharks, skates and ray species that could occur in the project area (Table 3). Other elasmobranchs could be in the vicinity of the project site; however, these eight species were selected as indicators because they are present in significant numbers year-round or seasonally, they have special conservation or management status, their behavioral ecology lends itself to a high probability of interaction with electromagnetic fields associated with the wave energy project, or some combination of these factors. Some other locally abundant species were not included (i.e., blue sharks (*Prionace glauca*) and salmon sharks (*Lamna ditropis*), because their behavioral ecology is such that the likelihood of interaction is very low.

Most of these species prey on benthic invertebrates and fishes; however, larger, more open water sharks are frequent visitors or transients and feed on pelagic organisms (Klimley et al. 2001). The wave structures could affect sharks by aggregating fishes, which could then attract sharks to the area. Marine

mammals are also important prey for white sharks (Klimley et al. 2001), and sea lions could haul out on the wave buoys and attract white sharks. These are not necessarily negative effects; however, they could change the community composition of the project area and result in changes in shark behavior. The more concerning potential effect to these species is from electromagnetic fields (EMF) associated with the wave energy project. Sharks, rays, and skates have highly sensitive electroreceptive sense organs for predation, mate detection and, possibly orientation and navigation (Bodznick et al. 2003). Electromagnetic fields (EMF) could result in disorientation and behavioral changes (Nelson 2008).

Table 3. Elasmobranchs associated with Nearshore, Soft-Bottom Habitat Off Humboldt County, California

Common Name	Species	Life Stage	Seasonal Presence	Locally Abundant	Reference
Sevengill shark	*Notorynchus cepedianus*	juvenile & adult	?*		1, 2, 3, 4
Spiny dogfish	*Squalus acanthias*	juvenile & adult	?	X	2, 3
White shark	*Carcharodon carcharias*	adult	Aug-Jan		2, 3
Brown smoothhound shark	*Mustelus henlei*	juvenile & adult	?	X	1, 2, 3, 4
Leopard shark	*Triakis semifasciata*	adult	All year*	X	1, 2, 3
Soupfin shark	*Galeorhinus zyopterus*	adult	Annual N/S migrations	?	3, 4, 5
Big skate	*Raja binoculata*	juvenile & adult	All year	X	1, 2, 6
Bat ray	*Myliobatis californica*	juvenile & adult	All year*	X	1, 2, 3

* Seasonally abundant in Humboldt Bay. References: [1]Allen et al. 2006, [2]Fritzsche and Cavanagh 1995, [3]Love 1996, [4]Miller and Lea 1976, [5]Ebert 2001, [6]Pequegnat et al. 1995

Flatfishes- Species most likely to occur in the project area include sand sole (*Psettichthys melanostictus*), starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*), Pacific sanddab (*Citharichthys sordidas*), Dover sole (*Microstomus pacificus*), Pacific halibut (*Hippoglossus stenolepis*), and Rex sole (*Errex zachirus*) (Allen 2006, Pequegnat et al. 1990). Most of these flatfishes spawn in the winter, with juveniles settling to demersal habitats in the summer (Brodeur et al. 2004). Flatfishes are associated with the sand/mud bottom habitats that occur within the project area (Allen 2006). They feed on or near the bottom on crustaceans, copepods, polychaetes, squid, octopus and small fishes, and are preyed upon by larger marine fishes, diving birds and marine mammals (Allen 2006, Allen and Leos 2001). Underwater structures associated with the wave energy project could attract new species (i.e., rockfish, sharks) to the project area, which could affect flatfishes through increased predation or other species interactions (Nelson 2008).

Rockfish, lingcod, cabezon- The typical habitat for rockfishes (*Sebastes* spp.), cabezon (*Scorpaenichthys marmoratus*), and lingcod (*Ophiodon elongatus*) in the adult life stage is rocky substrate with some relief, although some species (e.g., lingcod) make extensive use of other habitats, including sand bottom habitats (Allen 2006, Lea et al. 1999, Love et al. 1991). These species are pelagic during their early life history stages (larval through pre-settlement; Allen and Cross 2006), therefore, these species could occur in the project area during their early life history prior to construction of the wave energy project. After construction of the wave energy project, adults of these species could be attracted to the underwater wave energy structures (i.e., anchors, mooring devices, and chains) that become an artificial reef, resulting in changes to species composition and distribution in the project area (Nelson 2008).

Pelagic schooling fishes- Species that could occur in the project area include small- to medium-sized species that occur in coastal waters, including Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and true smelts such as eulachon (*Thaleichthys pacificus*), whitebait smelt (*Allosmerus elngates*), longfin smelt (*Spirinchus thaleichthys*), and surf smelt (*Hypomesus pretiosus*), and night smelt (*Spirinchus starksi*). Collectively, these species are the largest marine fisheries in California in terms of biomass (California Department of Fish and Game 2008). Populations tend to be very dynamic; for example, sardines tend to be more abundant during "warm" regimes and anchovies more abundant during "cool" regimes (Horn and Stephens Jr. 2006). They are also highly mobile and migratory in coastal waters. Schooling in these species occurs can vary from well-defined compact aggregations to widespread, scattering layers, and some species are in deeper waters during the day and closer to the surface and more scattered at night (Allen and Cross 2006). Because of their mobility and patchy distribution, there may be a low likelihood of effects on these species from the wave energy project. However, some species are known to be attracted to lights; therefore, they could be attracted to bright construction lights, making them more vulnerable to predation. They could also be attracted to underwater or surface structures associated with the project, resulting in increased predation, or other changes in community composition.

Salmonids – Salmonid species that could occur in the project area include coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), and cutthroat trout (*O. clarki*). Pacific salmonids spawn in streams and tributaries along the Pacific coast and occur in northern California ocean waters during their oceanic stage. They migrate to the ocean mostly in spring and early summer, coinciding with the greatest availability of prey, and grow rapidly by feeding on small fishes, crustaceans, and squid. They occur in the epipelagic zone in offshore and coastal nearshore waters, and are more abundant in the subarctic and northern Pacific waters, decreasing in abundance towards subtropic waters. They are known to migrate long distances in oceanic waters, although some species and individuals remain in coastal waters near their natal rivers.

Salmonids as a group were selected as indicator species because there are several Evolutionarily Significant Units (ESU) and Distinct Population Segments (DPS) that are federally listed as threatened or endangered that could occur in the project area (Table 4). The effects of the Humboldt wave energy project would be different for juvenile and adult salmonids and were analyzed separately. Bright construction lights or lights on the wave structures could result in behavioral changes (i.e., attraction or reduced movements) of juvenile salmonids, making them more vulnerable to predation. Changes in community composition around the underwater wave structures (i.e., aggregating fish and fish predators) could make juvenile or adult salmonids more vulnerable to predation. Both juvenile and adult salmonids are not likely to be affected by noise and vibration, seabed disturbance, and oil/chemical releases associated with the project because they are highly motile.

Table 4. Salmonids that could occur in the Humboldt wave energy project area.

Common Name	Scientific Name	Federal/ State Status	References
Central California Coast coho salmon ESU	*Oncorhynchus kisutch*	FE, ST	NMFS 2005b
S. OR/N. CA Coast Coho salmon ESU	*Oncorhynchus kisutch*	FT, ST	NMFS 1997, 1999
Sacramento River winter-run Chinook salmon ESU	*Oncorhynchus tshawytscha*	FE, SE	NMFS 2005b

Table 4. Salmonids that could occur in the Humboldt wave energy project area.

Common Name	Scientific Name	Federal/ State Status	References
California Coast Chinook salmon ESU	*Oncorhynchus tshawytscha*	FT	NMFS 2005b
Central Valley spring-run Chinook salmon ESU	*Oncorhynchus tshawytscha*	FT, ST	NMFS 2005b
Northern CA Steelhead DPS	*Oncorhynchus mykiss*	FT	NMFS 2000, 2005a
Central Valley steelhead DPS	*Oncorhynchus mykiss*	FT	NMFS 2006
Central California Coast steelhead DPS	*Oncorhynchus mykiss*	FT	NMFS 2006

FE= federally endangered; FT= federally threatened; SE= California State endangered; ST= California State threatened

Green Sturgeon- Green sturgeon (*Acipenser medirostris*) spend the majority of their lives in coastal marine waters, coastal bays, and estuaries along the Pacific coast, and Humboldt Bay provides habitat for large numbers of adult and subadult green sturgeon. Juveniles inhabit bays and estuaries for 1 to 4 years before traveling to the ocean. They spend about 15 years at sea before returning to spawn in their natal habitat, and spawn every two to four years thereafter (Moyle 2002). They spend summers in coastal waters up to 110 m deep along California, Oregon, and Washington, migrate north in the fall to as far as southeast Alaska, and then return in the spring (Erickson and Hightower 2007, Lindley et al. 2008). They occur on the bottom and feed on benthic invertebrates and small fishes.

There are two DPSs of the North American green sturgeon that could occur in the project area, the Northern DPS and Southern DPS. The Northern and Southern DPS populations are distinguished only by their spawning locations; otherwise they are identical and their ranges overlap (Adams et al. 2002, NMFS 2005d, USFWS 2006, USFWS 2009). The Northern DPS breeds north of the Eel River and is not listed as threatened or endangered, and the Southern DPS breeds only in the Sacramento River and is listed as federally threatened (USFWS 2006). Critical habitat for the Southern DPS was proposed in 2008, and all of Humboldt Bay, its coastal estuaries and river mouths, and coastal waters along the Pacific coast outside of Humboldt Bay are included in proposed critical habitat (USFWS 2008). Sturgeon have highly sensitive electroreceptive sense organs for predation, mate detection and, orientation and navigation (Bodznick et al. 2003). Electromagnetic fields (EMF) could result in disorientation and behavioral changes (Nelson 2008). Sturgeon could also be attracted to the wave energy structures if they aggregate prey, and they could be impacted by seabed disturbance because they occur in benthic habitats. Sturgeons are not likely to be affected by noise and vibration and oil/chemical releases associated with the project because they are highly migratory and motile.

3. Selection of marine bird indicators for Humboldt wave energy project

Marine bird indicators were selected for the Humboldt wave energy project effects analysis by determining the foraging mode, foraging habitat and diurnal rhythms of all marine bird species that could occur in the project area (Table 5). This information was used to evaluate whether the species could be affected by the project. Of the below groups of marine birds, the following species or species groups were selected as indicators for the Humboldt wave energy project effects analysis: 1) diving ducks, loons and

grebes; 2) shearwaters and storm-petrels; 3) pelicans and gulls; 4) cormorants; and 5) alcids. These species were selected because they fit one or more of the following criteria: 1) marine birds that exhibit nocturnal behaviors and are known to be attracted to or disoriented by lights, 2) marine birds that are known to roost on buoys or other at-sea structures, and 3) diving marine birds that could strike underwater structures. All surface-feeding and plunge-diving diurnal marine birds were excluded as indicators, unless they exhibit nocturnal behaviors or are known to roost on at-sea structures. Occurrence of the selected marine bird indicators in the project area was used for effects analysis (Table 6).

Table 5. Marine birds that are known to, or are likely to, regularly occur in the project area and the area between the Humboldt project site and shore.

Group	Common name	Scientific name	Foraging mode[1]	Foraging habitat[2]	Diurnal rhythm[3]	Federal /state status[4]
Ducks, geese, swans	Brant	*Branta bernicla*	S	N	D	None
	Canada goose	*Branta canadensis*	S	N	D	None
	Snow goose	*Chen caerulescens*	S	N	D	None
	Cackling goose	*Branta hutchinsii*	S	N	D	None
	Greater scaup	*Aythya marila*	D	N	D	None
	Lesser scaup	*Aythya affinis*	D	N	D	None
	Harlequin duck	*Histrionicus histrionicus*	D	N	D	None
	Surf scoter	*Melanitta perspicillata*	D	N	D	None
	White-winged scoter	*Melanitta fusca*	D	N	D	None
	Black scoter	*Melanitta nigra*	D	N	D	None
	Long-tailed duck	*Clangula hyemalis*	D	N	D	None
	Bufflehead	*Bucephala albeola*	D	N	D	None
	Common goldeneye	*Bucephala clangula*	D	N	D	None
	Red-breasted merganser	*Mergus serrator*	D	N	D	None
	Ruddy duck	*Oxyura jamaicensis*	D	N	D	None
Loons and grebes	Red-throated loon	*Gavia stellata*	D	N	D	None
	Pacific loon	*Gavia pacifica*	D	N	D	None
	Common loon	*Gavia immer*	D	N	D	None
	Horned grebe	*Podiceps auritus*	D	N	D	None
	Red-necked grebe	*Podiceps grisegena*	D	N	D	None
	Eared grebe	*Podiceps nigricollis*	D	N	D	None
	Western grebe	*Aechmophorus occidentalis*	D	N	D	None
	Clark's grebe	*Aechmophorus clarkii*	D	N	D	None
Albatrosses	Laysan albatross	*Phoebastria immutabilis*	S	P	D, N	None
	Black-footed albatross	*Phoebastria nigripes*	S	P	D, N	None
Shearwaters	Northern fulmar	*Fulmarus glacialis*	S	P	D, N	None
	Pink-footed shearwater	*Puffinus creatopus*	S	P	D, N	None
	Flesh-footed shearwater	*Puffinus carneipes*	S	P	D, N	None
	Buller's shearwater	*Puffinus bulleri*	S	P	D, N	None
	Sooty shearwater	*Puffinus griseus*	S	P	D, N	None
	Short-tailed shearwater	*Puffinus tenuirostris*	S	P	D, N	None
Storm-petrels	Fork-tailed storm-petrel	*Oceanodroma furcata*	S	P	D, N	None
	Leach's storm-petrel	*Oceanodroma leucorhoa*	S	P	D, N	None

	Ashy storm-petrel	*Oceanodroma homochroa*	S	P	D, N	None
	Black storm-petrel	*Oceanodroma melania*	S	P	D, N	None
Pelicans	Brown pelican	*Pelecanus occidentalis*	P	N	D	FE
Cormorants	Brandt's cormorant	*Phalacrocorax penicillatus*	D	N	D	None
	Double-crested cormorant	*Phalacrocorax auritus*	D	N	D	None
	Pelagic cormorant	*Phalacrocorax pelagicus*	D	N	D	None
Birds of prey	Osprey	*Pandion haliaetus*	S	N	D	None
	Peregrine falcon	*Falco peregrinus*	S	N	D	SE
Phalaropes	Red-necked phalarope	*Phalaropus lobatus*	S	P	D, N	None
	Red phalarope	*Phalaropus fulicarius*	S	P	D, N	None
Gulls	Black-legged kittiwake	*Rissa tridactyla*	S, P	N	D	None
	Sabine's gull	*Xema sabini*	S, P	N	D	None
	Bonaparte's gull	*Larus philadephia*	S, P	N	D	None
	Heerman's gull	*Larus heermanni*	S, P	N	D	None
	Mew gull	*Larus canus*	S, P	N	D	None
	Ring-billed gull	*Larus delawarensis*	S, P	N	D	None
	California gull	*Larus californicus*	S, P	N	D	None
	Herring gull	*Larus argentatus*	S, P	N	D	None
	Thayer's gull	*Larus thayeri*	S, P	N	D	None
	Western gull	*Larus occidentalis*	S, P	N	D	None
	Glaucous-winged gull	*Larus glaucescens*	S, P	N	D	None
	Glaucous gull	*Larus hyperboreus*	S, P	N	D	None
Terns	Caspian tern	*Hydroprogne caspia*	P	N	D	None
	Common tern	*Sterna hirundo*	P	N	D	None
	Arctic tern	*Sterna paradisaea*	P	N	D	None
	Forster's tern	*Sterna forsteri*	P	N	D	None
	Elegant tern	*Thalasseus elegans*	P	N	D	None
Jaegers	South polar skua	*Stercorarius maccormicki*	S	N	D	None
	Pomarine jaeger	*Stercorarius pomarinus*	S	N	D	None
	Parasitic jaeger	*Stercorarius parasiticus*	S	N	D	None
	Long-tailed jaeger	*Stercorarius longicaudus*	S	N	D	None
Alcids	Common murre	*Uria aalge*	D	P	D	None
	Thick-billed murre	*Uria lomvia*	D	P	D	None
	Pigeon guillemot	*Cepphus columba*	D	P	D	None
	Marbled murrelet	*Brachyramphus marmoratus*	D	P	D, N	FT, SE
	Xantus's murrelet	*Synthliboramphus hypoleucus*	D	P	D, N	FC, ST
	Ancient murrelet	*Synthliboramphus antiquus*	D	P	D, N	None
	Rhinoceros auklet	*Cerorhinca monocerata*	D	P	D, N	None
	Cassin's auklet	*Ptychoramphus aleuticus*	D	P	D, N	None
	Horned puffin	*Fratercula corniculata*	D	P	D, N	None
	Tufted puffin	*Fratercula cirrhata*	D	P	D, N	None
Kingfishers	Belted kingfisher	*Ceryle alcylon*	S	N	D	None

[1] S= surface feeder, dabbler; P= shallow diver/plunger; D= deep diver

[2] N= nearshore; P= pelagic

[3] D= foraging or return to nests diurnal only; N= some nocturnal foraging and/or return to nests

[4] FE= Federally endangered; FT= Federally threatened; FC= Federal candidate; SE= California State endangered; ST= California State threatened

There are a large number of marine bird species that could occur in the project area, however, not all of them are likely to be affected by the Humboldt wave energy project. The sensitivity of a group of marine birds to the project is dependent on factors such as foraging mode, habitat, and timing of activity (diurnal or nocturnal) and is examined below:

Ducks, geese, and swans— Members of this group are either foot-propelled surface feeders or divers that feed in a variety of nearshore habitats including above tideflats, reefs, eelgrass beds, and kelp forests over a variety of substrates (sand, rock, and mud). They feed on small mollusks, crustaceans, benthic invertebrates, small fish and roe, vegetable matter such as sea lettuce and eelgrass, and some species are known to pry mussels from reefs and ledges (Angell 1982). Surface feeding ducks, and geese and swans are unlikely to be affected by the project. However, diving ducks could be affected by the project if they strike underwater structures while diving, especially if these structures serve as prey habitat and become an attractant to ducks. If present in the project area, they could also be affected by chemical releases or oil spills. Ducks, geese, and swans are not known to roost on at-sea structures, or be attracted to lights at night.

Loons and Grebes— Loons and grebes are wing-propelled pursuit divers that feed on small fishes and crustaceans in a variety of habitats, including in open water or nearshore, and over mudflats, estuaries, reefs, and eelgrass beds (Angell 1982). Loons are known to dive up to 60 m to capture prey (Angell 1982). Diving depths for grebes are not well-known; however, one study found that great crested grebes in the Netherlands dove up to 10 m (Wiersma et al. 1995). Loons and grebes could be affected by the project if they strike underwater structures while diving, especially if these structures aggregate prey and become an attractant to loons and grebes. If present in the project area, they could also be affected by chemical releases or oil spills. Loons and grebes are not known to roost on at-sea structures, or be attracted to lights at night.

Albatrosses— Members of this group are nocturnal and diurnal surface-feeders and feed on shrimp, squid, fish, crustaceans, and zooplankton that can be picked off the surface of the water. Many species follow fishing boats and scavenge ship offal (USFWS 2005). Albatrosses are unlikely to be affected by the project because they are highly pelagic and would not be expected to occur in the project area (Harris 2006).

Shearwaters— Members of this group are nocturnal and diurnal surface-feeders and feed on shrimp, squid, fish, crustaceans, and zooplankton that can be picked off the surface of the water. Many species follow fishing boats and scavenge ship offal (USFWS 2005). They are known to be attracted by lights and could become disoriented and/or vulnerable to predation by construction lights or by lights on the wave energy structures. If present in the project area, they could also be affected by chemical releases or oil spills. Shearwaters are not known to roost on at-sea structures.

Storm-petrels— Storm-petrel are surface-feeders and feed on crustaceans, squid, jellyfish, zooplankton, fish, and animal detritus picked off the surface of the water. They often feed near ocean fronts, tide-rips, eddies, and large floating objects where prey is available near the water's surface. They are generally diurnal feeders, although some species also forage at night (USFWS 2005). Storm-petrels are known to be attracted by lights and could become disoriented and/or vulnerable to predation by construction lights or by lights on the wave energy structures. If present in the project area, they could also be affected by chemical releases or oil spills. Storm-petrels are not known to roost on at-sea structures.

Pelicans— Pelicans feed by plunge-diving on small schooling fishes (USFWS 2005). Pelicans are known to roost on at-sea structures and could roost on the wave energy structures. If present in the project area,

they could also be affected by chemical releases or oil spills. They are not known to be attracted to lights at night.

Cormorants— Cormorants are foot-propelled pursuit divers known to dive up to 100 m to capture prey. They feed on small fish and crustaceans at or near the bottom in nearshore waters and in intertidal waters over rocky substrates (USFWS 2005). Cormorants could be affected by the project if they strike underwater structures while diving, especially if these structures aggregate prey and become an attractant to cormorants. If present in the project area, they could also be affected by chemical releases or oil spills. Cormorants are also known to roost on at-sea structures and could roost on the wave energy structures. They are not known to be attracted to lights at night.

Birds of prey— Birds of prey feed on birds, small mammals, and fish, capturing prey items from the surface of the water, or from the ground with their talons (Poole et al. 2002, White et al. 2002). They are unlikely to be affected by the project because they are not known to roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

Phalaropes— Phalaropes are pelagic surface-feeders, and forage by picking prey items off the surface of the water. They feed on aquatic insects, crustaceans, and zooplankton, often at upwelling and convergence zones where prey is available near the surface of the water (Colwell and Jehl Jr. 1994, Rubega et al. 2000). When swimming, they will spin in tight circles and create upwellings of food, and pick up small bits of food from the water's surface. They are generally diurnal feeders, although they are also known to forage at night (Colwell and Jehl Jr. 1994, Rubega et al. 2000). They are unlikely to be affected by the project because they do not roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

Small gulls— Members of this group include kittiwakes and small gulls such as Bonaparte's gulls. They often feed in mixed flocks with other seabird species in offshore waters. They feed opportunistically on small schooling fishes, euphausids, amphipods, and insects using a variety of foraging methods including plunge-diving, surface-dipping, surface-seizing, and jump-plunging (Burger and Gochfeld 2002, Hatch et al. 2009). They are unlikely to be affected by the project because they do not roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

Gulls— Gulls are generalist predators and scavengers, feeding on pelagic and intertidal marine invertebrates and fish, eggs, chicks, and adults of other seabirds, and human refuse, carrion, and ship offal. They join multi-species feeding aggregations and use a variety of foraging methods including surface-dipping, shallow plunge-diving, surface-seizing, walking or swimming along shore at low tide, or by kleptoparasitism (Hayward and Verbeek 2008, Pierotti and Annett 1995). Gulls could be affected by the project because they are known to roost on at-sea structures and could roost on the wave energy structures. If present in the project area, they could also be affected by chemical releases or oil spills. They are not known to be attracted to lights at night.

Terns— Terns generally feed close to shore or close to their island nesting colonies, mostly on small fishes, although arthropods, crustaceans, and insects are sometimes taken (Cuthbert and Wires 1999, Mcnicholl et al. 2001, Nisbet 2002). They capture prey by plunge-diving but will also steal prey items from conspecifics. They are unlikely to be affected by the project because they do not roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

Jaegers— Jaegers feed on birds, eggs, rodents, insects, and berries, and also often forage by chasing other seabirds and forcing them to drop their prey. They are unlikely to be affected by the project because they

do not roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

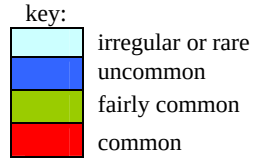
Alcids— Alcids are wing-propelled pursuit divers that feed on small schooling fishes, crustaceans, squid, zooplankton, and other benthic and pelagic invertebrates in a variety of nearshore and offshore habitats. Diving depths vary widely by species; common murres dive up to 180 m, other smaller alcids have maximum dive depths of 30-60 m (USFWS 2005). Alcids could be affected by the project if they strike underwater structures while diving, especially if these structures serve as prey habitat and become an attractant to alcids. If present in the project area, they could also be affected by chemical releases or oil spills. Some alcids are also known to be attracted by lights and could become disoriented and/or vulnerable to predation by construction lights or by lights on the wave energy structures. Alcids are not known to roost on at-sea structures. The marbled murrelet is listed as federally threatened; this alcid species could be affected by the project and effects were analyzed separately.

Kingfishers— Kingfishers feed on small fish, crayfish, frogs, and tadpoles. They will hover or perch over open water to locate prey, and then take prey items near the surface of the water. They are unlikely to be affected by the project because they do not roost on at-sea structures, are not known to be attracted to lights at night, and do not dive under the water's surface for prey.

Table 6. Occurrence of marine birds that may be affected by the Humboldt wave energy project.

Group	Common name	Foraging mode	Diurnal rhythm	Temporal distribution											
				Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Diving ducks	Greater scaup	D	D												
	Harlequin duck	D	D												
	Surf scoter	D	D												
	White-winged scoter	D	D												
	Black scoter	D	D												
	Long-tailed duck	D	D												
	Bufflehead	D	D												
	Common goldeneye	D	D												
	Red-breasted merganser	D	D												
	Ruddy duck	D	D												
Loons and grebes	Red-throated loon	D	D												
	Pacific loon	D	D												
	Common loon	D	D												
	Horned grebe	D	D												
	Red-necked grebe	D	D												
	Eared grebe	D	D												
	Western grebe	D	D												
	Clark's grebe	D	D												
Shearwaters	Northern fulmar	P	D, N												
	Pink-footed shearwater	P	D, N												
	Sooty shearwater	P	D, N												
	Short-tailed shearwater	P	D, N												
Storm-petrels	Fork-tailed storm petrel	S	D, N												
Pelicans	Brown Pelican	P	D												
Cormorants	Brandt's cormorant	D	D												

	Double-crested cormorant	D	D	
	Pelagic cormorant	D	D	
Gulls	Bonaparte's Gull	S, P	D	
	Heermann's Gull	S, P	D	
	Mew Gull	S, P	D	
	California Gull	S, P	D	
	Herring Gull	S, P	D	
	Thayer's Gull	S, P	D	
	Western Gull	S, P	D	
	Glaucous-winged Gull	S, P	D	
	Black-legged Kittiwake	P	D	
Alcids	Common murre	D	D	
	Pigeon guillemot	D	D	
	Marbled murrelet	D	D, N	
	Ancientmurrelet	D	D, N	
	Cassin's auklet	D	D, N	
	Rhinoceros auklet	D	D, N	



Potential effects on acoustic environment due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high or unknown)	Source(s)
Construction						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic will occur over 1 to 2 years during the summer	Med, noise could be elevated but would be short-term	Austin et al. 2009
Construction and installation of electrical collector system, mooring cables, anchors or footings, devices	Noise and vibration	Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, construction noise will occur over 1 to 2 years during the summer	Med, noise could be elevated but would be short-term	Austin et al. 2009
Directional drilling, and laying cable under/on seabed	Noise and vibration	Vibration of immediate area being drilled	Low, vibration could be localized, assuming similar to directional drilling on land	Low, drilling will occur for 1-2 weeks	Low, effect expected to be localized and short-term	CPUC 2009
Operation and maintenance						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic infrequent during O&M	Low, elevated noise would occur infrequently	Austin et al. 2009
Operation of turbines or other moving parts of devices	Noise and vibration	Adds to existing natural and man-made noise in project area	Unknown levels generated; site specific attenuation and ambient noise also unknown	High, noise would occur over life of the project	Unknown	Study warranted
Decommissioning						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic will occur over 1 to 2 years during the summer	Med, noise could be elevated but would be short-term	Austin et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, noise will occur over 1 to 2 years during the summer	Med, noise could be elevated but would be short-term	Austin et al. 2009

Potential effects on visual environment due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high)	Source(s)
Construction						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Humboldt Bay docks to the project site	Low, visibility varies with atmospheric conditions, will be seen from docks and shore	Low, construction vessel traffic will occur over 1 to 2 years during the summer	Low, lights visible when boats in shipping lanes in and near Humboldt Bay but existing traffic ameliorates effect	CSLC 2008
Construction of electrical collector system, moorings and foundations; device installation	Construction and deck lights	Construction lights much brighter than vessel lights, depending on sea and weather conditions, could be visible from shore.	High, construction lights brighter than navigation lights and may be visible 2 to 5 nm.	Low, construction will occur over 1 to 2 years during the summer	Med, lights may be visible from shore	IALA 2008, NOAA 2007
Operation and maintenance						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Humboldt Bay docks to the project site	Med, visibility varies with atmospheric conditions, will be seen from docks and shore	Med, construction vessel traffic will occur over life of project but at reduced frequency compared to construction	Low, lights visible when boats in shipping lanes in and near bay but existing traffic ameliorates effect	CSLC 2008
Structures on water's surface	Structure	Multiple devices 8 m above water's surface and clustered	Low, devices 3 nm from shore and unlikely to be visible from shore	High, will be present through life of project	Med, device profiles are low and "facilities will probably have little visual impact" (NOAA 2007)	NOAA 2007
	Navigation lights	Devices will have navigational lights visible from 2 to 5 nm.	Med, device lights will be visible from 2 to 5 nm.	High, device lights will be required throughout the life of the project	Low, device lights will have a low profile and will be 3 nm from shore	CSLC 2008
Decommissioning						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Humboldt Bay docks to the project site	Med, visibility varies with atmospheric conditions, will be seen from docks and shore	Low, decommissioning vessel traffic will occur over 1 to 2 years during the summer	Low, lights visible when boats in shipping lanes in and near bay but existing traffic ameliorates effect	CSLC 2008
Decommissioning of structures on water's surface or seabed	Deconstruction lights	Deconstruction lights much brighter than vessel lights, depending on sea and weather conditions, could be visible from shore	High, deconstruction lights brighter than navigation lights and may be visible 2 to 5 nm.	Low, deconstruction will occur over 1 to 2 years during the summer	Med, lights may be visible from shore	IALA 2008, NOAA 2007

Potential effects on sediment and water chemistry due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high)	Source(s)
Construction						
Boat traffic	Oil/chemical release, assumed seepage from exhaust and general use, not a spill from collision or other release	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	High, traffic and boat frequency will be the highest during construction	Low, given low spatial extent but high boat traffic	HBHRCD 2006
Construction of electrical collector system, anchors and foundations; installation of devices	Oil/chemical release		Low, seepage will have a small spatial and areal extent relative to the project	Low, construction will be 1 to 2 years over the 15 to 25 year project life	Low, given low spatial and temporal extent	HBHRCD 2006
Directional drilling, and laying cable under/on seabed (assume normal conditions, not a drilling mud "blow out" scenario)	Seabed disturbance	Sediment would be introduced into water column; deeper sediments with different chemistry brought to seabed surface	Med, cable length approx 3 nm; project area approximately 2.9 km^2 or 1.1 mi^2	Low, increased sediment in water column would mix or dilute quickly.	Low, due to quick dilution of sediment in water column	Previsic 2009
Operation and Maintenance						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	Low, O&M vessel traffic will be much less than during construction	Low, due to low seepage spatial extent, and low volume of vessel traffic during O&M	HBHRCD 2006
Structures in water column and on seabed, such as devices and anchors	Structure	Concrete anchors are sources of alkaline elements (sodium, potassium) that could leach into water column	Low, effect would be localized to vicinity of concrete anchors	High, any leaching would occur throughout life of project	Low, effects would be diluted and may not be measurable	Substructure [date unknown]
	Water circulation changes affecting sediment transport	Concrete anchors could change sediment transport dynamics	Low, effect would likely be localized	High, any changes to water circulation would be throughout the life of the project	Low, effect is localized although occurring over life of project	Largier et al. 2008

Project activity	**Project action**	**Description of action's effect on attribute**	**Spatial exposure of attribute (low, med, high)**	**Temporal exposure of attribute (low, med, high)**	**Overall risk to attribute (low, med, high)**	**Source(s)**
Presence of structures on water's surface	Structure	Biofouling organisms slough off on to the seabed surface	Low, effect localized to seabed directly under devices	Low, antifouling paint and maintenance likely to remove organisms before sloughing	Low, effect is localized to immediate vicinity of seabed under devices	MMS 2007
		Reduction in wave height to beaches	Low, project offshore and small	Medium, effects to beaches depends on wave size, larger waves affecting beach dynamics probably less affected.	Low, may not be measurable	Largier et al. 2008
Decommissioning						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	High, traffic and boat frequency will be the high during decommissioning	Low, given low spatial extent but high boat traffic	HBHRCD 2006
Decommissioning of structures on water's surface or seabed	Oil/chemical release			Low, decommissioning will be 1 to 2 years over the 15 to 25 year project life	Low, given low spatial and temporal extent	HBHRCD 2006
	Seabed disturbance	Sediment would be introduced into water column when removing anchors and/or subsea cable	Med, cable length approx 3 nm; project area approximately 2.9 km^2 or 1.1 mi^2	Low, increased sediment in water column would mix or dilute quickly.	Low, due to quick dilution of sediment in water column	Previsic 2009

Potential effects on Gray Whales due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	High, boat traffic crosses migration path along the coast	Low, occurring during the summer months for 1 to 2 years	Low; most of population not present during construction; Med for Pacific Coast Feeding Aggregation (PCFA) whales in region over summer.	Med-high; could affect large segment of popn if overlaps with north migration; PCFA whales present; gray whale-boat collision not uncommon	Calambokidis et al. 2002, Sullivan et al. 1983, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Med to high, sound travels far, animals will hear outside project area, but affects small portion of migration range as they travel through	Low, occurring during the summer months for 1 to 2 years	Low, PCFA gray whales likely to tolerate background vessel noise although masking cues still likely to occur.	Med-high; see above	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but the volume released low;	Low, occurring during the summer months for 1 to 2 years	Low for migratory gray whales; medium for PCFA whales due to potentially increased ambient contamination levels	Low; area of exposure small relative to range; additional inputs may compound effects of elevated levels for PCFA whales	Le Boeuf et al. 2002, Richardson and Wursig 1997
Construction of electrical collector system, moorings and foundations; device installation	Noise and vibration	Migratory and PCFA whales displaced from project area;	Med to high; migratory whales use nearshore areas, PCFA whales could be displaced over large area of resident range	Low, occurring over 1 summer	Med to high, may affect large portion of the gray whale population on northward migration; potential large area effect for resident PCFA whales	Med-high; could affect large segment of popn if overlaps with north migration; PCFA whales may be displaced	
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, significant increase in use of chemicals; volume of fluids released low, pre-existing levels elevated	Low, occurring over 1 to 2 summers	Low for migratory gray whales; medium for PCFA whales due to potentially increased ambient contamination levels	Low; area of exposure small relative to range; inputs may compound elevated levels for PCFA whales in area	Le Boeuf et al. 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction and deck lights	Avoidance	Low, not likely to be attracted to lighted areas	Low, occurring over 1 to 2 summers	Low for migratory whales. Spatial extent effects low compared to animal's range	Low, effects likely to be very localized around project area	
Directional drilling, and laying cable under/on seabed	Noise and vibration	Migratory whales displaced from routes around	Med to high; migratory whales use nearshore areas, and PCFA whales' risks of collision increase with operations	Low, occurring over 1 summer	Med to high, may affect large portion of the gray whale population during northward migration.	Med-high; High if overlaps with migration; med due to displacement of PCFA whales in summer	Calambokidis et al. 2002, Sullivan et al. 1983
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	High, boat traffic crosses migration path along the coast	Low, occurring during the summer months for 1 to 2 years	Med for PCFA whales in region over summer; med for large portion of population if overlaps with northward migration along coast	Low; may affect large portion of popn if overlaps with north migration; gray whale-boat collisions not uncommon	Calambokidis et al. 2002, Sullivan et al. 1983, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Low, increase in traffic but volume of fluids released low; could increase contamination levels for PCFA whales	Med, occurring throughout project duration but not likely to be year round action	Low for migratory gray whales; potentially increased ambient contamination levels for PCFA whales	Low; area of exposure small relative to range; inputs may compound elevated levels for PCFA whales	Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masks environmental cues, communication signals	Low, limited traffic; sound travels far, animals will hear outside project area, but affects small part of large range	Low, maintenance via boats occurring infrequently but during summer months	Low; PCFA whales likely to tolerate moderate increase in vessel noise. Med if overlaps with northward migration along coast	Low; may affect large portion of popn if overlaps with north migration; likely to cause avoidance of transport corridor	Richardson and Wursig 1997
Operation of turbines or other moving parts of devices	Moving device parts	Movement of heaving point absorber and mooring lines could injure animals	Low, area of potential contact between moving parts and whales small, whales not likely to approach	High, movement will be continuous throughout the duration of the project	Low, although moving throughout the project life, likelihood of interaction between animals and devices low.	Low; unlikely to approach moving parts close enough to be at risk	

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Unknown, sound travels far and animals will hear it outside project area, but affects small part of large range as they travel through area	Med, occurring throughout the duration of the project	Low; PCFA whales likely to acclimate to noise, may overlap with the end of the northward migration if actions occur in early summer/late spring	Low; likely to affect migratory and PCFA whales; sound levels not likely higher than levels during migration along coast; may cause avoidance of area by PCFA whales	Richardson and Wursig 1997
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collisions, entanglement with derelict gear caught on moorings; artificial reef could attract fish	Low, home range is large compared to project area	High, occurring throughout project duration.	Med for PCFA resident whales; low for whales that migrate along coast	Unknown; risk of entanglement in derelict gear, loose cables or loose mooring lines unknown	
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect because electricity generated over life of the project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, project area is small compared to range	High, occurring throughout project duration	Low, for both migrants and PCFA whales because range is large compared to project area	Low; whales readily avoid buoys; gray whales encounter large number of mobile and stationary structures during migration	
	Navigation lights	Low intensity; likelihood of impacts low to none	Low, associated with navigation lights on devices	High, occurring throughout project duration	Low to no effect for migrants and low effect for PCFA whales	Low; navigation lights relatively dim, area of effect very limited	
Decommissioning							

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Direct impact	Collision injuries	High, boat traffic crosses migration path along the coast	Low, occurring during the summer months for 1 to 2 years	Low; for most of the population is not present in the region during time of deconstruction; Med for PCFA whales in region over summer.	Med-high; could affect large segment of popn if overlaps with north migration; PCFA whales present, gray whale-boat collision not uncommon	Calambokidis et al. 2002, Sullivan et al. 1983, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Med to high, sound travel far, animals will hear outside project area, but affects small portion of migration range	Low, occurring during the summer months for 1 to 2 years	Low, PCFA gray whales likely to tolerate background vessel noise although masking cues still likely to occur.	Med-high; could affect large segment of population if overlaps with northward migration; likely to displace PCFA whales	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, increase in traffic but low volume of fluids released; medium for PCFA whales due to potentially increased contamination levels	Low, occurring during 1 to 2 summers	Low for migratory gray whales; medium for PCFA whales due to potentially increased ambient contamination levels	Low; area of exposure small relative to range; inputs may compound elevated levels for PCFA whales in area for extended periods	Le Boeuf et al. 2002
Decommissioning of structures on water's surface or seabed	Noise and vibration	Migratory and PCFA whales displaced from project area;	Med; migratory whales use nearshore areas, PCFA whales displaced over potentially large area of resident range	Low, occurring over 1 summer	Med to high, may affect large portion of the gray whale population on northward migration; potential large area effect for resident PCFA whales	Med-high; could affect large segment of popn if overlaps with migration; PCFA whales may be displaced	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, significant increase in use of chemicals; volume of fluids released low-med, existing levels elevated	Low, occurring over 1 to 2 summers	Low for migratory gray whales; medium for PCFA whales due to potentially increased ambient contamination levels	Low-med; area exposure small relative to range; additional inputs may compound effects of elevated levels for PCFA whales	Le Boeuf et al. 2002
	Deconstruction and deck lights	Avoidance	Low, not likely to be attracted to lighted areas	Low, occurring over 1 to 2 summers	Low for migratory whales. Spatial extent effects low compared to animal's range	Low, effects likely to be very localized around project area	

Potential effects on harbor porpoise due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on species or group	Spatial extent of effect (low, med, high) relative to project	Temporal extent of effect (low, med, high) relative to project	Effect's overlap with critical life stage, behavior, habitat (low, med, high) relative to species/group	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	High, significant increase in traffic (esp in bay and jetties); present inshore and at harbor entrance where porpoises move in and out	Low, occurs over 1 to 2 summers	Low for adults; med for calves foraging and travel in construction, transport zones; area of exposure small relative to home range;	Low; risk at harbor opening where boat traffic and porpoises both occur; boat-porpoise collisions infrequent	Stroud and Roffe 1979
	Noise and vibration	Avoidance, masking of environmental cues. Reduction of hearing sensitivity (Temporary Threshold Shift), could increase in predation	High, increase existing traffic (esp in bay and jetties); present inshore and at harbor entrance where porpoises move in and out	Low, occurs over 1 to 2 summers	Low; may affect adults and calves while foraging and traveling parallel to shore	Med; effects greater in bay near jetties and project area; but short duration	Erbe and Farmer 2000
	Oil/chemical release	Ingestion while feeding or breathing, breathing exhaust fumes, accumulation of toxins. Assuming no catastrophic spills.	Med, significant increase in existing traffic but the volume released low and dispersed	Low, occurs over 1 to 2 summers	Low-med for all age classes; potential for exposure while foraging and while resting in Bay	Low; area of exposure small relative to home range; inputs compound elevated levels	Brookens et al. 2007, Le Boeuf et al. 2002
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Avoidance of area, affects foraging and travel, masks environmental cues, echolocation and communication signals	Med; sound likely to be detected over large area (several 10s of km^2)	Low, only 1 summer	Med, potential temporary impacts on hearing if porpoises are attracted to fish aggregates	Low; harbor porpoises forage successfully around similar industrial activities	Todd et al. 2009
	Oil/chemical release	Ingestion while feeding or nursing; breathing exhaust fumes; accumulation of toxins. Assuming no catastrophic spills.	Med, increase in use of chemicals; volume of fluids released low-med, and pre-existing ambient levels high	Low, only 1 to 2 summers	Low for all age classes; potential for exposure while foraging around structures	Low; area of exposure small relative to home range; inputs compound elevated contaminant levels	Brookens et al. 2007, Le Boeuf et al. 2002

Project activity	Action	Description of action's effect on species or group	Spatial extent of effect (low, med, high) relative to project	Temporal extent of effect (low, med, high) relative to project	Effect's overlap with critical life stage, behavior, habitat (low, med, high) relative to species/group	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction and deck lights	May attract porpoise prey, and indirectly porpoise increasing potential for impacts related to other actions	Low to med; project site small relative to range of porpoises; lights may attract prey and concentrate porpoises	Low, only 1 to 2 summers	Low; area affected by lights small relative to home range	Low due to high levels of pre-existing boat traffic	Todd et al. 2009
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, affects foraging and travel, masks environmental cues, echolocation and communication signals	Med; relatively small footprint may affect along shore movement	Low, only 1 summer	Low, but unknown effects on calves	Med; risk with concentrating impacts in nearshore envir.; potential for propeller strike; disruption of movement along shore	Kastak et al. 2005, Koschinski et al. 2003, Tougaard et al. 2009
Operation and Maintenance							
Boat traffic	Direct impact	Collision; behavioral disruption vessels may disrupt rest, foraging, travel, and socialization around area.	Low-med, moderate increase over existing traffic (esp in bay and jetties); porpoises inshore and concentrate at narrow harbor entrance	Low-med, annual maintenance assumed during 3 months of summer (2-3 round trips/day)	Low for adults; med for calves due to foraging and travel in and near construction and transport zones	Low; area of exposure small relative to home range; risk at harbor opening where boat traffic and porpoises occur; boat-porpoise collisions infrequent	Stroud and Roffe 1979
	Noise and vibration	Avoidance of area, affects foraging and travel, masks environmental cues, echolocation and communication signals	Low-med, increase in traffic (esp in bay and jetties); present inshore and at harbor entrance where porpoises move in and out	Low-med, annual maintenance assumed during 3 months of summer (2-3 round trips/day)	Low for adults; med for calves due to foraging and travel in and near construction and transport zones	Low; could mask cues over long distance; effects greater in bay near jetties and around project area; short duration and few vessels	Erbe and Farmer 2000
	Oil/chemical release	Ingestion while feeding or breathing, breathing exhaust fumes, accumulation of toxins. Assuming no catastrophic spills.	Low-med; increase in existing traffic but the volume released low and dispersed	Low, occurs over 1 to 2 summers	Low-med for all age classes; potential for exposure while foraging and while resting in Bay	Low; area of exposure small relative to home range; inputs compound elevated contaminant levels	Brookens et al. 2007, Le Boeuf et al. 2002

Project activity	Action	Description of action's effect on species or group	Spatial extent of effect (low, med, high) relative to project	Temporal extent of effect (low, med, high) relative to project	Effect's overlap with critical life stage, behavior, habitat (low, med, high) relative to species/group	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Noise and vibration	Avoidance of area, affects foraging and travel, masks environmental cues, echolocation and communication signals	Medium, increase in traffic (esp in bay and jetties); present inshore and at harbor entrance where porpoises move in and out.	Low, annual maintenance assumed during 3 months of summer (2-3 round trips/day)	Low for adults; med for calves due to foraging and travel in area around turbines	Low; could mask cues near turbine (<70m); porpoise less sensitive to low-freq sounds and sound likely inaudible at >100m	Erbe and Farmer 2000
	Moving device parts	Movement of the heaving point absorber and mooring lines could injure animals	Low, the areas of movement are small compared to project area	High, the movement occurs over the life of the project	Low for all age classes	Low; porpoise highly sensitive to surroundings, unlikely to approach regularly moving parts	Koschinski et al. 2003, Stroud and Roffe 1979
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collision, entanglement with derelict gear caught on moorings; artificial reef could attract fish and increase porpoise foraging	Low, home range large (210 – 51,000km^2); may create new habitat, depends on strength of attraction	High, any effects would occur over the life of the project.	Low; may incrementally increase foraging on prey attracted to structure	Low, structure unlikely to present risk to porpoise	Todd et al. 2009
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if there is an effect, it would occur over life of the project	Unknown; any effects would likely impact all age classes	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Artificial reef effects could attract fish and increase porpoise foraging	Low, reef effect area is small compared to home range (210 – 51,000km^2)	High, any effects would occur over life of project.	Low, may incrementally increase forage as de facto marine reserve.	Low	Goodwin 2008
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, increase over traffic (esp in bay and jetties); inshore and concentrated at harbor entrance where porpoises move in and out	Low, occurs over 1 to 2 summers	Low adults; med for calves due to foraging and travel in and near construction and transport zones	Low; exposure area small relative to home range; risk at harbor opening where boat traffic and porpoises occur; boat-porpoise collisions infrequent	Stroud and Roffe 1979

Project activity	Action	Description of action's effect on species or group	Spatial extent of effect (low, med, high) relative to project	Temporal extent of effect (low, med, high) relative to project	Effect's overlap with critical life stage, behavior, habitat (low, med, high) relative to species/group	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion orally while feeding or breathing, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase in existing traffic but the volume released low and dispersed	Low, occurs over 1 to 2 summers	Low for all age classes; potential for exposure while foraging and while resting in Bay	Low; potential exposure area small relative to home range; additional inputs compound elevated contaminant levels	Brookens et al. 2007, Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masking of environmental cues. TTS, resulting in potential increase in predation	High, significant increase in traffic (esp in bay and jetties); inshore and at harbor entrance where porpoises move in and out	Low, occurs over 1 to 2 summers	Low, may affect adults and calves while foraging and traveling parallel to shore;	Med; could mask envir. cues over long distance; effects greater in bay and around project area; but short duration	Erbe and Farmer 2000
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance of area, affects foraging and travel, masks environmental cues, echolocation and communication signals	Med; sound likely to be detected over large area (several 10s of km^2)	Low, only 1 summer	Med, potential temporary impacts on hearing if porpoises attracted to buoys to forage on fish aggregates	Low; harbor porpoises do not appear to forage around industrial activities	Todd et al. 2009
	Oil/chemical release	Ingestion orally while feeding; breathing exhaust fumes; accumulation of toxins. Assuming no catastrophic spills.	Med, significant increase in use of chemicals; volume of fluids released low-med, and pre-existing ambient levels high	Low, only 1 to 2 summers	Low for all age classes; potential for exposure while foraging around structures	Low; potential exposure area small relative to home range; additional inputs compound elevated contaminant levels	Brookens et al. 2007, Le Boeuf et al. 2002
	Deconstruction and deck lights	May attract porpoise prey, and indirectly porpoise increasing potential for impacts related to other actions	Low to med; project site small relative to range of porpoises; lights may attract prey and concentrate porpoises	Low, only 1 to 2 summers	Area affected by lights small relative to home range	Low due to high levels of pre-existing boat traffic	Todd et al. 2009

Potential effects on harbor seal due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase existing traffic (esp in bay and jetties)	Low, occurring over 1 to 2 summers	Low for adults; med for pups foraging and travel in construction, transport zones; High for pups in bay.	Low; vessels similar to existing fleet(s) and do not represent new types of impact	Stroud and Roffe 1979
	Noise and vibration	Avoidance, masks environmental cues. Reduced hearing sensitivity Temporary Threshold Shift (TTS) could increase predation	Med, significant increase in boat traffic, noise travels well beyond project area	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in and near construction and transport zones; High for pups in bay.	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; potential contamination in Humboldt Bay and near offshore site, contaminants passed to pups	Low; low volume of contaminants expected and not significantly greater then background	Brookens et al. 2007
Construction and installation of electrical collector system, mooring cables, anchors or footings, devices	Noise and vibration	Avoidance of area, masking of environmental cues, TTS could increase predation.	High, sound likely to be detectable up to ~3 km from project site	Low, occurring over 1 to 2 summers	Low-med for adults med for pups due to foraging and travel in and near construction zones;	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low for all age classes in Humboldt Bay and offshore, foraging and pupping	Low; low volume of contaminants expected and not significantly greater then existing background levels	Brookens et al. 2007

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, enhance foraging on species attracted to light	Low-high dependant on how many buoys are installed simultaneously, and the required light levels	Low, occurring over 1 to 2 summers	Low for all age classes	Low; effect highly localized; may enhance foraging of prey attracted to lights; may increase exposure if attracted to project activities	Yurk and Trites 2000
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, masks environmental cues, TTS could increase predation	Med, seals likely to avoid areas occupied by cable and support vessels	Low, occurring over 1 summer	Low for all age classes; avoidance of construction area occupied by vessels	Low; activities highly localized and short term; seals likely to acclimate and tolerate noise	Blackwell et al. 2004
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Medium, increase in existing traffic (esp in bay and jetties)	Med, annual maintenance assumed during 3 months of summer over project duration	Low for adults; med for pups foraging and travel in construction and transport zones; High for pups in bay.	Low; possible sig. increase in boat traffic; vessels similar to existing and do not represent new type of impact	Stroud and Roffe 1979
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low, slight increase existing traffic but the volume of fluids released low	Med, routine maintenance occurs over life of the project during summer	Low to med; potential contamination in Bay and offshore, contaminants passed to pups	Low; low volume of contaminants expected and not significantly greater than background levels	Brookens et al. 2007
	Noise and vibration	Avoidance of area, masking of environmental cues, TTS could increase predation	Med, slight increase in boat traffic, noise travels beyond project boundaries	Med, boat traffic limited to summers but for life of the project	Low for adults; med for pups foraging and travel in construction and transport zones; med-high for pups in bay.	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004; Kastak et al. 2005; Tougaard et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	Movement of the heaving point absorber and mooring lines could injure animals	Low, the areas of movement are small compared to project area	High, the movement occurs over the life of the project	Low for all age classes, seals sensitive to water movement, unlikely to be near moving parts	Low; seals unlikely to approach moving devices close enough to be at significant risk	Dehnhardt et al. 1998, Stroud and Roffe 1979

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Avoidance of area, masking of environmental cues, TTS possible which could increase predation	Sound propagated over significant distance (~3 km); likely to produce behavioral reaction at close range (<15M)	High, any effect would be constant over project duration	Low; structure readily avoidable; may exclude seals from immediate area of devices	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Artificial reef effects could attract fish and increase foraging; collisions, entanglement with derelict gear caught on moorings	Low, not much structure nearby but home ranges large. pup home range 10.4 km^2 and adults travel range is 30-45 km.	High, structure present over life of project	Med, structure readily avoided; could increase foraging on prey attracted to structure	Low; effect on population likely insignificant; possible risk to individuals if they approach device closely	Herder 1986, Loughlin 1974, Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect, it would occur over life of the project	Unknown; any effects would likely impact all age classes	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, harbor seals do not haul out, structure occupies very small portion of home range.	High, structure present over life of project	Low for all age classes; harbor seals do no haul out on such structures	Low, structure easily avoided visually; similar to existing navigation buoys;	Schusterman and Balliet 1970
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over life of the project	Low; may have effect on adults and pups foraging and traveling	Low; effects not expected to be significant; lights similar to existing navigation buoy lights	Yurk and Trites 2000
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase existing traffic (esp in bay and jetties)	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in construction and transport zones; High for pups in bay.	Low; possible significant increase in boat traffic; vessels similar to existing and do not represent new types of impact	Stroud and Roffe 1979

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; for all age classes potential contamination in Humboldt Bay and near offshore site, contaminants passed to pups	Low; low volume of contaminants expected and not significantly greater than background levels	Brookens et al. 2007
	Noise and vibration	Avoidance, masks environmental cues, TTS possible which could increase predation.	Med, significant increase in boat traffic, noise travels well beyond project area	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in construction and transport zones; High for pups in bay.	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance, masks environmental cues, TTS possible which could increase predation.	High, sound likely to be detectable up to ~3 km from project site	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in and near de-construction zones	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Low-high dependant on how many buoys are installed simultaneously, and the required light levels	Low, occurring over 1 to 2 summers	Low for all age classes, could be adverse and beneficial effects as it may enhance foraging on prey attracted to lights	Low; overall effect localized; may enhance foraging of prey attracted to lights; may increase exposure if attracted to project activities	Yurk and Trites 2000
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low for all age classes in Humboldt Bay and offshore, foraging and pupping	Low; low volume of contaminants expected and not significantly greater than background levels	Brookens et al. 2007

Potential effects on Humpback Whales due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	Med-high, increase in existing traffic but in small area of their large range	Low, occurring over 1 to 2 summers	Med-high; especially for summer foraging	High; overlap in use of coastal waters; humpback-boat collision rate one of highest for cetaceans	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masks envir. cues, communication signals	Med to high, sound travels far, animals will hear it outside of the project area	Low, occurring over 1 to 2 summers	Med, especially for summer foraging in coastal waters	Med-high; overlap in use of coastal waters foraging and travel	
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low for whales foraging in project transport corridors; increased contamination levels	Low; area of potential exposure small relative to range; inputs may compound effects of elevated levels	Le Boeuf et al. 2002
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masks envir. cues, communication signals	Med to high, sound travels far, animals will hear it outside project area	Low, occurring over 1 to 2 summers	Med, especially for summer foraging	Med-high; overlap in use of coastal waters; may cause avoidance of project area	
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, enhance foraging on species attracted to light	Low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; limited spatial impact; relatively short duration	
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, increase in use of chemicals; volume of fluids released low	Low, occurring over 1 to 2 summers	Low; due to potentially increased ambient contamination levels	Low; area of exposure small relative to range; inputs may compound elevated contaminant levels	Le Boeuf et al. 2002
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masks environmental cues, communication signals	Med to high, sound travels far, animals will hear it outside of the project area	Low, occurring over 1 summer	Med, especially for summer foraging	Low; most activity is near shore; whales will readily avoid cable vessel as it moves offshore at low speed	
Operation and Maintenance							

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Direct impact	Collision injuries	Low, increase in existing traffic but in small area of large range.	High, traffic will occur during summer over life of project	Low; especially for summer foraging	Low; overlap in use of coastal waters; humpback-boat collision rate one of highest for cetaceans	Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, slight increase existing traffic but the volume of fluids released low	High, traffic increase will occur in summer over life of project	Low, boat frequency low and limited to summer, and effects cover a small part of large range	Low; area of exposure small relative to range; inputs may compound effects of elevated levels	
	Noise and vibration	Avoidance, masks of envir. cues, communication signals	Med, sound travels far, animals will hear it outside of the project area	High, occurring mostly during summers over life of project	Med, especially for summer foraging	Med; project area within summer foraging area; increase in background noise level	
Operation of turbines or other moving parts of devices	Moving device parts	Movement could injure animals	Low, area of devices small relative to project area	High, movement continuous throughout life of the project	Low, interaction between animals and device movement low.	Low; unlikely to approach close enough to mechanical movements to be at risk	
	Noise and vibration	Avoidance, masks of envir. cues, communication signals	Unknown, attenuation over large area and ambient noise unknown	High, noise will be continuous throughout life of the project	Low; may cause avoidance of project area; site in small area of home range	Unknown; project area within summer foraging area; potential increase in background noise	
Structures in water column and on seabed, such as devices, moorings and footings	Structure	Collisions, entanglement with derelict gear caught on moorings, reef effects may increase foraging	Low, home range large compared to project area; may create new habitat	High, any effects would occur over life of the project.	Low, overall project area covers a small part of their large range	Low; humpbacks readily avoid structures; low risk of entanglement	
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect electricity generated over life of project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures on water's surface	Structure	Collision, entrapment, artificial reef may attract krill and increase foraging	Low, home range large compared to project area; may create new habitat	High, positive or negative effects would occur over life of project.	Low, effects occur in tiny part of large range	Low; structure readily avoided	
	Navigation lights	Visual disorientation could lead to collision, enhance foraging	Low, device lights are low intensity, and shielded.	High, lights shining over life of the project	Low, limited area of effect similar to existing structures along coast	Low; lights relatively dim; spatial extent of effect limited	
Decommissioning							
Boat traffic	Direct impact	Collision injuries	Med, significant increase in existing traffic in small area	Low, occurs over 1 summer	Med-high; especially for summer foraging	High; overlap in use of coastal waters; humpback-boat collision rate one of highest for cetaceans	Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low for whales foraging in or near project transport corridors; increased contamination levels	Low; area of potential exposure small relative to range; inputs may compound elevated levels	Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masking of envir. cues, communication signals	Med to high, sound travels far, animals will hear it outside of the project area	Low, occurring over 1 to 2 summers	Med, especially for summer foraging	Med-high; overlap in use of coastal waters; foraging and travel; increase in background noise levels	
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance, masking of envir. cues, communication signals	Med to high, sound travels far, animals will hear it outside of the project area	Low, occurring over 1 to 2 summers	Med, especially for summer foraging	Med-high; overlap in use of coastal waters foraging and travel; may cause avoidance of project area	
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, increase in use of chemicals; volume of fluids released low	Low, occurring over 1 to 2 summers	Low-med; due to potentially increased ambient contamination levels	Low; area of potential exposure small relative to range; inputs may compound elevated levels	Le Boeuf et al. 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, enhance foraging	Low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; limited spatial impact; relatively short duration	

Potential effects on Killer Whales due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	Low, significant increase in existing traffic but in a small area of large range.	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; increase in boat traffic; killer whale-boat collisions not uncommon	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear outside project area, but affects a small part of large range	Low, occurring over 1 to 2 summers	Low, small part of large range.	Low; species may be displaced from transport zones by high amplitude sound	Morton and Symonds 2002
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; area of exposure small relative to home range; inputs may compound elevated contaminant levels	Le Boeuf et al. 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, animals will hear noise outside project area, but affects small part of large range	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; species may be displaced by high amplitude noise; affects small portion of range	Morton and Symonds 2002
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, significant increase in use of chemicals; volume released low-med, and ambient levels elevated	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; area of potential exposure small relative to range; inputs may compound elevated contaminant levels	Le Boeuf et al. 2002
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, enhance foraging on species attracted to light	Low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; limited special and temporal effect	
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear outside of project area, but affects a small part of large range	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; likely displaced from area but small portion of range and short time period	Morton and Symonds 2002
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Low, slight increase in existing traffic in small area of their large range.	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; area of effect small relative to home range; killer whale-boat collisions not uncommon	Van Waerebeek and Leaper 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, increase in existing traffic but the volume of fluids released low	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; area of exposure small relative to home range; inputs may compound elevated contaminant levels	Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; species sensitive to noise; transport corridor may be avoided but small area compared to range	Morton and Symonds 2002
Operation of turbines or other moving parts of devices	Movement of the heaving point absorber and mooring lines	Collision, entrapment.	Low, area of devices small	High, movement will be continuous throughout the life of the project	Low, low interaction between animals and device movement	Low; unlikely to approach close enough to be affected by movements	
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Unknown, site occupies small area of home range; attenuation over large area and ambient noise unknown	High, any noise will be continuous throughout the life of the project	Medium, avoidance and masking of environmental cues	Unknown; significant risk if noise produced sufficient to permanently displace killer whales from region	Morton and Symonds 2002
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collisions, entanglement with derelict gear caught on moorings; artificial reef could attract prey	Low, home range large compared to project area; may create new habitat	High, any positive or negative effects would occur over the life of the project.	Low, structure readily avoided; loose or unattached cables possible entanglement risk	Low; may attract killer whales if the structures concentrate pinnipeds	Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if there is an effect because electricity generated over life of the project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures on water's surface	Structure	Collision, artificial reef effects could attract fish, sea lions, small odontocetes	Low, reef effect area is small compared to home range	High, any positive or negative effects would occur over the life of the project.	Low, may incrementally increase forage as marine reserve	Low; may attract killer whales if pinnipeds use the structure as a haul-out	
	Navigation lights	Visual disorientation could lead to collision, enhance foraging on species attracted	Low, device lights are low intensity and shielded	High, lights shining over life of the project	Low, effects' spatial extent small compared to animal's range	Low	
Decommissioning							
Boat traffic	Direct impact	Collision injuries	Low, significant increase existing traffic in small area of their large range.	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; area of effect small relative to home range; killer whale-boat collisions not uncommon	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	Low, occurring over 1 summer	Low, small part of large range.	Low; species may be displaced from transport zones by high amplitude noise	Morton and Symonds 2002
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; inputs may compound elevated existing levels	Le Boeuf et al. 2002
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance, masks envir. cues, communication signals, echolocation	Low-Med, sound travels far, will hear it even if they never approach	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; species may be displaced from project area noise	Morton and Symonds 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med, significant increase in use of chemicals, volume released low-med, and pre-existing levels elevated	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; area of exposure small relative to home range; inputs compound elevated contaminant levels	Le Boeuf et al. 2002
	Deconstruction lights (deck work lights, spotlights, vessel navigation lights)	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Unknown how many buoys installed which would increase number of lights	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; limited spatial and temporal effect	

Potential effects on Steller sea lion due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase in existing traffic (especially in bay and jetties)	Low, occurring over 1 to 2 summers	Med for adults/subadults, high for juveniles due to foraging and travel	Med-high; significant increase in boat traffic and potential for take of pups and juveniles	Stroud and Roffe 1979
	Noise and vibration	Reduction of hearing sensitivity TSS (Temporary Threshold Shift), resulting in potential increase in predation	Med, significant increase in boat traffic between Humboldt Bay and project area, and within project area. Noise will travel beyond project area.	Low, occurring over 1 to 2 summers	Low for adults/subadults, and juveniles related to foraging, travel and predation	Low; noise detectable over sign. distance (~3km); not likely a threat unless animals approach near vessels	Kastak et al. 2005, Kastelein et al. 2009, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; could contaminate Humboldt Bay and offshore, contaminants passed to pups	Low; volume of contaminants low and not greater than background levels	Brookens et al. 2007, Le Boeuf et al. 2002
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance of area, affects foraging and travel, resting onshore in Bay; TSS resulting in potential increase in predation	High, sound likely to be detectable up to ~3 km from project site	Low, occurring over 1 to 2 summers	Low for adults; med for juveniles and pups due to foraging and travel in and near construction zones;	Low; potential for noises to impact hearing if sea lions approach and remain in immediate proximity	Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med; significant increase in use of chemicals but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low; for all age classes, could contaminate Humboldt Bay and offshore site, contaminants passed to pups	Low; low volume of contaminants expected and not greater than background levels	Brookens et al. 2007, Le Boeuf et al. 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights (bright deck lights and spotlights)	May be attracted to construction area increasing likelihood of other impacts, could also enhance foraging on prey species attracted to light	Med to high; number of buoys installed simultaneously would affect number of lights and spatial extent	Low, occurring over 2 summers	Low; dependent on scale of construction operations affecting travel and foraging at night	Low; exposure low relative to home ranges and short duration of construction; may enhance nocturnal foraging on prey attracted to lights	Yurk and Trites 2000
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, affects foraging and travel, resting onshore in Bay	Low, activities focused nearshore; localized around support vessels when offshore	Low, occurring over 1 summer	Low, activities focused nearshore; localized around support vessels when offshore	Low, because exposure is low relative to individual home range	Kastak et al. 2005, Tougaard et al. 2009
Operation and Maintenance							
Boat traffic.	Direct impact	Collision injuries	Medium, increase in existing traffic (especially in bay and jetties)	Medium, occurring during summer for life of the project	Low for adults/subadults, med-high for juveniles due to foraging and travel	Med; moderate increase in boat traffic during summer lasting project duration	Stroud and Roffe 1979
	Oil/chemical release	Bioaccumulation, fur fouling, breathing exhaust fumes, Assumes no catastrophic spills.	Low, slight increase in existing traffic but the volume of fluids released low	Med, routine maintenance occurs over life of the project during summer	Low; for all age classes, could contaminate Humboldt Bay and offshore site, contaminants passed to pups	Low; low volume of contaminants expected and not significantly greater then background levels	Brookens et al. 2007, Le Boeuf et al. 2002
	Noise and vibration	Reduction of hearing sensitivity (TSS), resulting in potential increases in predation	Med, noise will be heard past project area boundaries (~3km) but increase in traffic slight.	High, occurs during summer months over project duration	Low for adults/subadults related to effects on foraging and travel; med for juveniles may increase predation	Low; noise detectable over sign. distance; not likely a threat unless animals approach near moving vessels	Kastak et al. 2005, Kastelein et al. 2009, Tougaard et al. 2009

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Movement of the heaving point absorber and mooring lines could injure animals	Low, the areas of movement are small compared to project area	High, the movement occurs over the life of the project	Low for all age classes;	Low, unlikely to approach close enough to be at risk; small area of effect compared to home range	Merrick 1996
	Noise and vibration	Reduction of hearing sensitivity resulting in potential increase in predation, avoidance, masking environmental cues	Likely to extend well be project area; other pinnipeds should auditory response at distances of ~3km.	High, if effect occurs, mechanical movement occurs over the life of the project	Low for adults/subadults related to effects on foraging and travel; med for juveniles may increase predation	Low; noise detectable over sig. distance; not likely a threat unless animals remain near structures	Kastak et al. 2005, Koschinski et al. 2003, Tougaard et al. 2009
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collisions, entanglement; artificial reef effects could attract fish, increase forage,	Low, currently not much structure nearby but home ranges are large.	High, structure present over life of project	Med, possibly beneficial effect by increasing forage, although entanglement risk increases	Low; structure easily avoided	Schusterman and Balliet 1970, Todd et al. 2009
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding provides some attenuation	High if there is an effect, it would occur over life of the project	Unknown; any effects would likely impact all age classes	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	May provide haul out structure; attract sea lions and increase potential for other impacts	Limited to above surface structures	High, structure present over life of project	Low; may focus sea lion aggregations at new offshore location;	Med; may increase foraging on fish attracted to structure	Relini et al. 2000
	Navigation lights	Visual disorientation could lead to collision, enhance foraging	Low, lights associated with devices and buoys are low intensity, affecting a small area	High, lights would be on over the life of the project	Low; may attract adult/subadults attracted to prey; may attract curious juveniles	Low; exposure low relative to home range	Yurk and Trites 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase existing traffic (especially in bay and jetties)	Low, occurring over 1 to 2 summers	Med for adults/subadults, high for juveniles due to foraging and travel	Med-high; increase in boat traffic, potential for take esp. for pups and juveniles	Stroud and Roffe 1979
	Noise and vibration	Reduction of hearing sensitivity (Temporary Threshold Shift); may increase predation	Med, sign, increase in boat traffic between Humboldt Bay and project area, and within project area. Noise beyond project area.	Low, occurring over 1 to 2 summers	Med for adults/subadults, high for juveniles related to foraging, travel and predation	Low; noise detectable over ~3km; not likely a threat unless animals approach moving vessels	Kastak et al. 2005, Kastelein et al. 2009
	Oil/chemical release, assuming no catastrophic spills.	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; could contaminate bay and offshore site, contaminants passed to pups	Low; contaminants not significantly greater than background levels	Brookens et al. 2007, Le Boeuf et al. 2002
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance of area, affects foraging and travel, rest onshore in Bay; (TSS) could increase predation	High, sound likely to be detectable up to ~3 km from project site	Low, occurring over 1 to 2 summers	Low for adults; med for juveniles/ pups due to foraging and travel in construction zones;	Low; noises could impact hearing if sea lions approach and remain; may cause avoidance	Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release, assuming no catastrophic spills.	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med; increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; could contaminate Bay and offshore, contaminants passed to pups	Low; low volume of contaminants expected and not more than background levels	Brookens et al. 2007, Le Boeuf et al. 2002
	Deconstruction and deck lights	Could be attracted to area increasing likelihood of other impacts, enhance foraging on prey attracted to light	Med to high; number of buoys installed simultaneously would affect number of lights and spatial extent	Low, occurring over 2 summers	Low; operations affecting travel and foraging at night	Low; exposure low relative to home range; short duration of construction	Yurk and Trites 2000

Potential effects on small odontocetes (Pacific White-sided dolphin, Risso's dolphin, Dall's porpoise) due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries, bow riding	Low, significant increase in existing traffic in small area of their large range	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	Low, occurring during 1 to 2 summers	Low, small part of large range.	Low; may be displaced from transport zones by high ampl. sound; effect area small relative to range	
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Med, significant increase in existing traffic but the volume of fluids released low	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Le Boeuf et al. 2002
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Med to high, sound travels far, animals will hear noise even if they never approach	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but the volume of fluids released low	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Le Boeuf et al. 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Unknown area would be small relative to range	Low, occurring during 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low, because exposure is low relative to indicator's range	
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Med to high, sound travels far, animals will hear noise even if they never approach, but sea state can attenuate	Low, limited to 1 summer	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries, bow riding	Low, slight increase in existing traffic in a small area of their large range.	High, traffic increase occurs over life of the project	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, slight increase in existing traffic but the volume of fluids released low	High, traffic increase occurs over life of the project	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	High, traffic increase occurs over life of the project but vessel frequency is less than during construction	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	
Operation of turbines or other moving parts of devices	Movement of the heaving point absorber and mooring lines	Collision, entrapment.	Low, the area of the devices is small relative to the project area, and interaction with animals at movement area is low	High, movement will be continuous throughout the life of the project	Low, although moving throughout the project life, interaction between animals and device movement is low.	Low, because exposure is low relative to indicator's range	Van Waerebeek and Leaper 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Unknown, but physical site occupies small area of total home range; attenuation over large area and ambient noise unknown	High, any noise will be continuous throughout the life of the project	Unknown because animals will likely acclimate over time, however they could still miss environmental cues	Unknown, noise from devices unknown,	
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collisions, entanglement, artificial reef effects could increase forage	Low-Med, home range is large compared to project area; may create new habitat, depends on strength of attraction	High, any positive or negative effects would occur over the life of the project.	Med, entanglement could increase if animals attracted by prey; structure may incrementally increase forage as marine reserve	Unknown, entanglement is not well understood for odontocetes	Cox and Read 2004
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding provides some attenuation	High if an effect because electricity generated over life of the project	Unknown	Unknown	
Structures on water's surface	Structure	Collision, artificial reef effects could attract fish	Low, fish aggregation device (FAD) effect is small compared to indicator's home range	High, any positive or negative effects would occur over the life of the project.	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Van Waerebeek and Leaper 2008
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, device lights are low intensity and shielded.	High, lights shining over life of the project	Low, both adverse and beneficial effects are possible	Low, because exposure is low relative to indicator's range	
Decommissioning							
Boat traffic	Direct impact	Collision injuries, bow riding	Low, significant increase existing traffic in small area of their large range.	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Van Waerebeek and Leaper 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low, because exposure is low relative to indicator's range	Le Boeuf et al. 2002
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low to med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low; may be displaced from transport zones; effect area small relative to range	
Decommissioning of structures on water's surface and seabed	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Med to high, sound travels far, animals will hear noise even if they never approach	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly farther offshore	Low; may be displaced from transport zones by high ampl. sound; effect area small relative to range	
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Med, significant increase in existing traffic but the volume of fluids released low	Low, occurring during 1 to 2 summers	Low, effects occur in small part of large range that is mostly offshore	Low, exposure is low relative to indicator's range	Le Boeuf et al. 2002
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Low, small relative to range	Low, occurring during 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low, exposure is low relative to indicator's range	

Potential effects on sharks, skates, and rays due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Cada 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Nelson 2008
	Construction lights	Sharks may be attracted due to prey aggregation	Low, see above	Low, occurs over 1 to 2 summers	Med, if sharks attracted to project area	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, see above	Low, occurs over a short time period	Low, species present but able to avoid disturbance area	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over a short time period	Low, species present but able to avoid disturbance area	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species present but able to avoid disturbance area	Low	Cada 2008
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species present but able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, prey of these species not attracted to subsurface structures	N/A	N/A	N/A	Low	Boehlert et al. 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible changes in orientation, behavior	Low, see above	High, would be continuous for life of project	Med, species present in project area	Unknown	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, pinniped haul-out which attracts sharks	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, sharks present in project area	Unknown	Nelson 2008
	Navigation lights	Sharks may be attracted to lights due to prey aggregation	Low, see above	High, would be continuous for life of project	Med, sharks present in project area	Unknown	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Cada 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Nelson 2008
	Deconstruction lights	Sharks may be attracted due to prey aggregation	Low, see above	Low, occurs over 1 to 2 summers	Med, sharks present in project area	Low	Nightingale et al. 2006

Potential effects on flatfishes due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	None, see above	N/A	N/A	N/A	Low	Nedwell et al. 2004
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, flatfishes present but able to avoid disturbance area	Low	Nelson 2008
	Construction lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, flatfishes present but able to avoid disturbance area	Low	Nelson 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, changes in predator/prey interactions	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, flatfishes in sand/mud bottom habitat where project located	Unknown	Boehlert et al. 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects to flatfishes unlikely, not known to have sensitive electroreceptive sense organs	N/A	N/A	N/A	Low	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, changes in predator/prey interactions	Low, see above	High, would be continuous for life of project	Low, flatfishes on bottom while effects on surface	Low	Nelson 2008
	Navigation lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Decommissioning of structures on water's surface or seabed	Noise and vibration	None, see above	N/A	N/A	N/A	Low	Nedwell et al. 2004
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, flatfishes present but able to avoid disturbance area	Low	Nelson 2008
	Deconstruction lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006

Potential effects on rockfishes, lingcod, and cabezon due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	None, species not present in sand/mud bottom habitat where project located	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	None (see above)	N/A	N/A	N/A	Low	N/A
	Seabed disturbance	None (see above)	N/A	N/A	N/A	Low	N/A
	Construction lights	None (see above)	N/A	N/A	N/A	Low	N/A
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None (see above)	N/A	N/A	N/A	Low	N/A
	Noise and vibration	None (see above)	N/A	N/A	N/A	Low	N/A
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Operation of turbines or other moving parts of	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
devices	Noise and vibration	Possible altered behavior	Med, project area could occupy individual ranges	High, would persist for life of project	Med, wave structures may attract species to project area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Attraction to artificial reef, changes in fish community	Med, project area could occupy individual ranges	High, would be continuous for life of project	Med, wave structures may attract species to project area	Med	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Med, project area could occupy individual ranges	Low, wouldn't persist long-term	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects unlikely, species not known to have sensitive electroreceptive sense organs	N/A	N/A	N/A	Low	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, changes in predator/prey interactions	Med, project area could occupy individual ranges	High, would be continuous for life of project	Low, species in water column or bottom	Low	N/A
	Navigation lights	None, species don't occur at surface	N/A	N/A	N/A	Low	N/A
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Decommissioning of structures on water's surface or	Noise and vibration	Possible altered behavior	Med, project area could occupy individual ranges	Low, occurs over 1 to 2 summers	Med, species may be present due to attraction to wave structures	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
seabed	Oil/chemical release	Toxicity to individuals and prey	Med, volume released could occupy individual ranges	Low, occurs over 1 to 2 summers	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Habitat loss, changes in prey resources	Med, project area could occupy individual ranges	Low, occurs over 1 to 2 summers	Med, species may be present due to attraction to wave structures	Med	Nelson 2008
	Deconstruction lights	None, species don't occur at surface	N/A	N/A	N/A	Low	N/A

Potential effects on pelagic schooling fishes (mackerel, sardine, anchovy) due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, fish have patchy and wide-ranging distribution	Low, occurs over 1 to 2 summers	Low, fish are able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, fish have patchy and wide-ranging distribution	Low, occurs over 1 to 2 summers	Low, fish are able to avoid disturbance area	Low	
	Construction lights	Aggregation, more vulnerable to predation	Low, fish have patchy and wide-ranging distribution	Low, occurs over 1 to 2 summers	Med, species could be attracted to area	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, see above	Low, occurs over 1 to 2 summers	Low, fish are able to avoid disturbance area	Low	
	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over a short time period	Low, see above	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, fish have patchy and wide-ranging distribution	High, would be continuous for life of project	Low, fish patchy and able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, more vulnerable to predation	Low, see above	High, would be continuous for life of project	Low, see above	Low	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, fish have patchy and wide-ranging distribution	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects unlikely, species not known to have sensitive electroreceptive sense organs	N/A	N/A	N/A	Low	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, changes in predator/prey interactions	Low, see above	High, would be continuous for life of project	Low, species distribution patchy	Low	Nelson 2008
	Navigation lights	Aggregation, more vulnerable to predation	Low, see above	High, would be continuous for life of project	Low, species distribution patchy	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, fish have patchy and wide-ranging distribution	Low, occurs over 1 to 2 summers	Low, fish are able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction lights	Aggregation, more vulnerable to predation	Low, fish have patchy and wide-ranging distribution	Low, occurs over 1 to 2 summers	Med, species could be attracted to area	Low	Nightingale et al. 2006

Potential effects on juvenile salmonids due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Construction lights	Behavioral changes, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, species could be attracted to area	Med	Nelson 2008, Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, these species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Operation and Maintenance							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Nelson 2008
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, attraction of predators (e.g., rockfish)	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible behavior, orientation changes	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, attraction of predators	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Navigation lights	Behavioral changes, more vulnerable to predation	Low, see above	High, would be continuous for life of project	Med, species could be attracted to area	Med	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction lights	Behavioral changes, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, species could be attracted to area	Low	Nightingale et al. 2006

Potential effects on adult salmonids due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Construction lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, species able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species able to avoid disturbance area	Low	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, attraction of predators	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible behavior, orientation changes	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, attraction of predators	Low, see above	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Navigation lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006

Potential effects on green sturgeon due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species motile and able to avoid disturbance area	Low	Cada 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, possible changes to benthic prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species motile and able to avoid disturbance area	Low	Nelson 2008
	Construction lights	None, this species not known to be attracted to lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, possible changes to benthic prey resources	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, species motile and able to avoid disturbance area	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, see above	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species motile and able to avoid disturbance area	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, occurs in critical habitat for species	Unknown	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, attraction of predators	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, occurs in critical habitat for species	Unknown	Boehlert et al. 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible changes in orientation, behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, occurs in critical habitat for species	Unknown	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, attraction of predators	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, occurs in critical habitat for species	Unknown	Nelson 2008
	Navigation lights	None, this species not known to be attracted to lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species motile and able to avoid disturbance area	Low	Cada 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species on bottom but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, species motile and able to avoid disturbance area	Low	Nelson 2008
	Deconstruction and deck lights	None, species not known to be attracted to lights	N/A	N/A	N/A	Low	Nightingale et al. 2006

Effects on diving ducks, and loons and grebes for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, won't occur in winter when birds most abundant	Low	Harris 2006, LGL Limited et al. 2009
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over a short time period	Low, won't occur in winter when birds most abundant	Low	Boehlert et al. 2008, Harris 2006
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over a short time period	Low, see above	Low	Harris 2006, Michel et al. 2007
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, only from periodic trips in summer	Low, see above	Low	Harris 2006, Michel et al. 2007

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Low, see above	Low	Harris 2006, LGL Limited et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, would occur in winter when birds most abundant	Low	Harris 2006, Michel et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear/ moorings, collisions with structures while diving	Low, see above	Med, tangled gear would be removed periodically	Med, birds could be attracted to structure	Unknown	Harris 2006, Michel et al. 2007
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Low, likely sporadic or intermittent for life of project	Low, could occur in winter when birds most abundant	Low	Harris 2006, Michel et al. 2007
Structures on water's surface	Structure	Possible attraction to increased prey (FAD effect), collision while flying	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, birds could be attracted to structure	Unknown	Harris 2006, LGL Limited et al. 2009
	Navigation lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Decommissioning							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, won't occur in winter when birds most abundant	Low	Harris 2006, Michel et al. 2007
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, LGL Limited et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006

Effects on shearwaters and storm-petrels for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, some species common in summer but most farther offshore	Low	Harris 2006, LGL Limited et al. 2009
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	Attraction/ disorientation, collisions	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, some species common in summer but most farther offshore	Low	Harris 2006, Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, some species common in summer but most farther offshore	Low	Harris 2006, Michel et al. 2007
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, only from periodic trips in summer	Low, see above	Low	Harris 2006, Michel et al. 2007

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Low, see above	Low	Harris 2006, LGL Limited et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, continuous for life of project	Low, most species farther offshore	Low	Harris 2006, Michel et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, these species feed on surface and do not dive	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, continuous and intermittent for life of project	Low, most species farther offshore	Low	Harris 2006, Michel et al. 2007
Structures on water's surface	Structure	Possible collision while flying	Low, would occur in small area relative to species' range	High, continuous for life of project	Low, see above	Low	Harris 2006, LGL Limited et al. 2009
	Navigation lights	Attraction/ disorientation, collisions	Low, see above	High, continuous for life of project	Low, see above	Low	Harris 2006, Montevecchi 2006
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, LGL Limited et al. 2009

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	Attraction/ disorientation, collisions	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, some species common in summer but most farther offshore	Low	Harris 2006, Montevecchi 2006

Effects on gulls and pelicans for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	None, gulls and pelicans follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	Harris 2006
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	None, gulls and pelicans not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
Operation and Maintenance							
Boat traffic	Noise and vibration	None, gulls and pelicans follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	Harris 2006

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, these species do not dive deep enough	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, could be continuous and intermittent for life of project	Med, species common in area and could be attracted to structures	Low	Harris 2006, Michel et al. 2007
Structures on water's surface	Structure	Possible roosting habitat, attraction to increased prey (FAD effect), collision while flying	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, see above	Unknown	Harris 2006, LGL Limited et al. 2009, Michel et al. 2007
	Navigation lights	None, gulls and pelicans not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007
	Noise and vibration	None, gulls and pelicans follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	Harris 2006

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	None, gulls and pelicans not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006

Effects on cormorants for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, LGL Limited et al. 2009
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, see above	Low	Harris 2006, Michel et al. 2007
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, project not near nesting colony or known foraging area	Low	Boehlert et al. 2008, Harris 2006
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over a short time period	Low, see above	Low	Harris 2006, Michel et al. 2007
Operation and Maintenance							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, see above	Low, only from periodic trips in summer	Med, boats could pass through foraging areas	Low	Harris 2006, LGL Limited et al. 2009

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, see above	Low	Harris 2006, Michel et al. 2007
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear/ moorings, collisions with structures while diving	Low, see above	Med, tangled gear would be removed periodically	Med, cormorants common in area and could be attracted to structures	Unknown	Harris 2006, Michel et al. 2007
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, could be continuous and intermittent for life of project	Med, cormorants common in area and could be attracted to structures	Low	Harris 2006, Michel et al. 2007
Structures on water's surface	Structure	Possible roosting habitat, attraction to increased prey (FAD effect), collision while flying	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, see above	Unknown	Boehlert et al. 2008, Harris 2006, Michel et al. 2007
	Navigation lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Decommissioning							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, see above	Low	Harris 2006, LGL Limited et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006

Effects on alcids for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, LGL Limited et al. 2009
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, see above	Low	Harris 2006, Michel et al. 2007
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	Attraction/ disorientation, collisions	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over a short time period	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over a short time period	Low, see above	Low	Harris 2006, Michel et al. 2007
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Med, see above	Low	Harris 2006, LGL Limited et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear/ moorings while diving	Low, see above	Med, tangled gear would be removed periodically	Low, see above	Unknown	Harris 2006, Michel et al. 2007
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, continuous and intermittent for life of project	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
Structures on water's surface	Navigation lights	Attraction/ disorientation, collisions	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, alcids present in area year-round and could be attracted to lights	Med	Harris 2006, Montevecchi 2006
	Structure	Possible collision while flying, attraction to increased prey (FAD effect)	Low, see above	High, continuous for life of project	Med, see above	Unknown	Boehlert et al. 2008, Harris 2006
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, boats could pass through foraging areas	Low	Harris 2006, Michel et al. 2007

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, see above	Low	Harris 2006, LGL Limited et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 1 to 2 summers	Low, project not near nesting colony or known foraging area	Low	Harris 2006, Michel et al. 2007
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008, Harris 2006
	Construction lights	Attraction/ disorientation, collisions	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Harris 2006, Montevecchi 2006

Effects on Marbled Murrelets for a Small Commercial OPT Power Buoy Project at the Humboldt site.

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, boats will pass through murrelet foraging areas	Low	Hébert and Golightly 2006, LGL Limited et al. 2009, Ralph and Miller 1995
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, see above	Low	Michel et al. 2007
Construction of electrical collector system, moorings/foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, 90% of murrelet locations closer to shore than project site	Low	Hébert and Golightly 2006, Michel et al. 2007, Ralph and Miller 1995
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, see above	Low	Michel et al. 2007
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008
	Construction lights	Attraction/ disorientation, collisions	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over very short time period	High, would occur in murrelet foraging zone (<2 km from shore)	Med	Boehlert et al. 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over very short time period	High, see above	Med	Michel et al. 2007
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, boats will pass through murrelet foraging areas	Low	Hébert and Golightly 2006, Michel et al. 2007, Ralph and Miller 1995
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Med, see above	Low	LGL Limited et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	None, no underwater moving parts	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	High, continuous for life of project	Low, 90% of murrelet locations closer to shore than project site	Low	Hébert and Golightly 2006, Michel et al. 2007, Ralph and Miller 1995
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear/ moorings, collisions with structures while diving	Low, would occur in small area relative to species' range	Med, tangled gear would be removed periodically	Low, see above	Low	Michel et al. 2007

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, continuous and intermittent for life of project	Low, 90% of murrelet locations closer to shore than project site	Low	Hébert and Golightly 2006, Michel et al. 2007, Ralph and Miller 1995
Structures on water's surface	Navigation lights	Attraction/ disorientation, collisions	Low, would occur in small area relative to species' range	High, continuous for life of project	Low, see above	Low	Montevecchi 2006
	Structure	Possible collision while flying, attraction to increased prey (FAD effect)	Low, would occur in small area relative to species' range	High, continuous for life of project	Low, see above	Low	Boehlert et al. 2008
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Med, boats will pass through murrelet at-sea areas	Low	Hébert and Golightly 2006, Michel et al. 2007, Ralph and Miller 1995
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, see above	Low	LGL Limited et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 1 to 2 summers	Low, 90% of murrelet locations closer to shore than project site	Low	Hébert and Golightly 2006, Ralph and Miller 1995

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low, see above	Low	Michel et al. 2007
	Construction lights	Attraction/ disorientation, collisions	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Low, see above	Low	Montevecchi 2006
	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over 1 to 2 summers	Low, see above	Low	Boehlert et al. 2008

Potential effects on Dungeness crab due to Small Commercial OPT Power Buoy Project at Humboldt site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low for adults on bottom. High for megalopae on surface at night, since oil floats on surface	Low	Nelson and Woo 2008
Construction of electrical collector system, moorings and foundations, and device installation	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 1 to 2 summers	Low for adults, High for megalopae (see above)	Low	Emmett et al. 1991, Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, possible changes to benthic prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, crabs occur on bottom in project area	Low	Nelson 2008
	Construction lights	Adult crabs not known to be affected by lights; megalopae attracted to light	Low, see above	Low, occurs over 1 to 2 summers	Low for adults on bottom. High for megalopae on surface at night.	Low	Miller and Shanks 2005, Moore et al. 2006, Porter et al. 2008
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, possible changes to benthic prey resources	Low, see above	Low, occurs over a short time period	Med, crabs occur on bottom in project area	Low	Nelson 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low for adults on bottom. High for megalopae on surface at night, since oil floats on surface	Low	Nelson and Woo 2008
Operation of turbines or other moving parts of devices	None expected that would affect crabs	N/A	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible changes in predator/prey abundance, interactions (reef effect)	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med for adult crabs on bottom in project area, Low for megalopae on surface	Unknown	Boehlert et al. 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low for adults on bottom. High for megalopae on surface at night, since oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Unknown, could include behavior, orientation changes	Low, see above	High, would be continuous for life of project	Med, crabs occur on bottom in project area	Unknown	Nelson 2008
Structures on water's surface	Structure	Possible changes in predator/prey abundance, interactions (FAD effect)	Low, see above	High, would be continuous for life of project	Med, see above	Unknown	Nelson 2008
	Navigation lights	Adult crabs not known to be affected by lights; megalopae attracted to light	Low, see above	High, would be continuous for life of project	Low for adults on bottom. High for megalopae on surface at night.	Med	Miller and Shanks 2005, Moore et al. 2006, Porter et al. 2008
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 1 to 2 summers	Low for adults on bottom. High for megalopae on surface at night, since oil floats on surface	Low	Nelson and Woo 2008
Decommissioning of structures on water's surface or	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 1 to 2 summers	Low for adults, High for megalopae (see above)	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 1 to 2 summers	Med, crabs occur on bottom in project area	Low	Nelson 2008
	Deconstruction lights	Adult crabs not known to be affected by lights; megalopae attracted to light	Low, see above	Low, occurs over 1 to 2 summers	Low for adults on bottom. High for megalopae on surface at night.	Low	Miller and Shanks 2005, Moore et al. 2006, Porter et al. 2008

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Appendix E. Effects of Small Commercial Pelamis at Makapu'u

Included in Appendix E are 1) a project description of the small commercial Pelamis at Makapu'u project site; 2) an effects analysis of the project on site physical and biological indicators in tabular format; and 3) a list of references used to complete the effects analysis.

Project description for construction, operations and maintenance, and decommissioning phases for Small Commercial Pelamis P-2 project at the Makapu'u site.

Project phase	Project activity or characteristic	Description
Construction	Location and deployment depths	Makapu'u Point, Oahu. In 50 m water depth, 1 to 2 mi from shore
	Footprint	13 devices would be in organized in 2 rows, with an array length of 2.5 km. Width is 0.5 m.
	Loading ports and dock locations	Honolulu Harbor; smaller vessels could use Makai pier near Makapu'u Point and Waimanalo Bay.
	Shipping routes for delivery and installation	Unknown, assume from Honolulu to the project site
	Ship types and sizes	Drill rig, cable installation vessel, supply boat, derrick barge, tug boats
	Installation and assembly procedures	Subsea cable bolted to sea floor (rock bottom). Caternary mooring system installed by barge, with devices towed to site
	Installation equipment	Directional drill rig, cable installation vessel, supply boat, derrick barge, tug boats
	Temporary structures	None
	Types, composition, locations, and numbers of anchoring and mooring systems	Caternary mooring configuration with slack to allow device to move so it points into the waves. Design of embedment anchors on seabed unknown. Each device requires 4 anchors and 4 cables
	Installation schedule and phasing	1 to 2 years, in May through early September. For the 10 devices, which is close to small commercial project scale, installation is assumed to occur day and night, 7 days/week
	Chemicals and fuels used	Hydraulic fluids, gearbox oil, bearing grease, boat fuel, antifouling paint
	Sources and levels of noise	Boat and barge traffic noise, drilling, construction/installation of subsea cable, moorings, anchors, and devices
	Sources, levels, and characteristics of light	Navigational lights (lower intensity) on boats and devices, construction lights (bright, higher intensity) on barges
	Number of vessel trips	Unknown
Operations and Maintenance	General description of technology	Each unit has 4 steel tubes connected in series by a heave and sway joint. Steel tubes contain hydraulic motors that capture energy.
	O&M procedures and schedule	Annual inspections and maintenance: detach devices from mooring, tow devices to pier and inspect and repair.
	Operating equipment other than wave/tidal device(s)	Custom vessel for annual recovery and re-deployment, ROV for visual inspection of underwater components every 4 to 5 years.

Project phase	Project activity or characteristic	Description
	Listing of all moving parts	Heave and sway joints between 4 steel tubes, for each device, approximately 13 devices
	Listing of all structures on surface and below	13 (each 180 x 6 m) on surface, moored via multiple underwater cables and anchors
	Vessel routes and schedule for operation and maintenance	Unknown, assumed from Honolulu
	Ship types and sizes	Types include custom vessel, derrick barge, tugboats, supply boat. Size unknown
	Potential emergency conditions and procedures	Oil/chemical spills or releases from boats, equipment, or devices. Device becomes lose from moorings
	Chemicals used by devices, e.g., hydraulic fluids, antifouling paints.	Hydraulic fluids, bearing grease, gearbox oil, anti-fouling paint, boat fuel. 12,800 liters hydraulic fluid in each device.
	Sources and levels of noise	Noise and vibration associated with movement of devices, sound of vessels servicing the devices
	Sources and levels of light	Navigational lights on boats, navigational lights on devices
Decommissioning	Description of equipment or structures removed	Devices, mooring cables and anchors, transmission cable on seabed surface
	Description of equipment or structures to be left in place	None
	Monitoring procedure and schedule for equipment left in place	None
	Shipping routes for equipment removed	Unknown, assumed from Honolulu
	Ship types and size	Supply boat, custom vessel for devices, derrick barge, tug boats, cable handling vessel
	Decommissioning and disassembly procedures	Recover devices, mooring cables and anchors, and remove collector system and subsea cable.
	Decommissioning equipment	Supply boat, custom vessel for devices, derrick barge, tug boats, cable handling vessel
	Temporary structures	None
	Decommissioning schedule and phasing	Would likely take place over 1 to 2 summer seasons, 6 to 8 weeks total, after a project life of 15 to 25 years
	Chemicals and fuels used	Hydraulic fluids, gearbox oil, bearing grease, boat fuel
	Sources and levels of noise	Boat and barge traffic noise, removal and recovery of subsea cable, moorings, anchors, and devices
	Vessels required, number of trips	See decommissioning equipment, numbers of trips unknown
	Sources, levels, and characteristics of light	Navigational lights (lower intensity) on boats and devices, deconstruction lights (bright, higher intensity) on barges

Effects of Small Commercial Pelamis at Makapu'u on physical and biological indicators

Potential effects on the visual environment due to Small Commercial Pelamis at Makapu'u site

Project activity	Project action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high or unknown)	Source(s)
Construction						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Honolulu Harbor and Makai pier to the project site	Low, visibility varies with atmospheric conditions, will be seen from docks and shore	Low, boat traffic will occur during May-Sept. for 1-2 years	Low, increase may not be noticeable with existing boat traffic	MMS 2007
Construction of electrical collector system, moorings and foundations; device installation	Construction lights	Construction lights much brighter than vessel lights, depending on sea and weather conditions, could be visible from shore.	High, construction lights may be visible 2 to 5 nm.	Low, construction will occur during May-Sept. for 1-2 years	Med, lights may be visible from shore	IALA 2008
Operation and Maintenance						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lines from Honolulu Harbor and Makai pier to the project site	Low, visibility varies with atmospheric conditions, will be seen from docks and shore	Med, vessel traffic will occur over life of project but at reduced frequency compared to construction	Low, increase may not be noticeable with existing boat traffic	MMS 2007
Structures on water's surface	Structure	Devices may be visible from shore	Low, devices 0.5 km from shore but profiles very low	High, devices will be present 15-25 years	Low, device profiles are low and "facilities will probably have little visual impact"	NOAA 2007
	Navigation lights	Devices will have lights for navigational safety visible from 2 to 5 nm.	Med, device lights will be visible from 2 to 5 nm.	High, device lights will be required throughout the life of the project	Med, device lights will have a low profile and visible 1 to 2 mi from shore	IALA 2008
Decommissioning						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lines from Honolulu Harbor and Makai pier to the project site	Low, visibility varies with atmospheric conditions, will be seen from docks and shore	Low, boat traffic will occur during May-Sept. for 1-2 years	Low, increase may not be noticeable within existing boat traffic	MMS 2007
Decommissioning of structures on water's surface or seabed	Deconstruction lights	Deconstruction lights brighter than vessel lights, depending on sea and weather conditions, could be visible from shore.	High, deconstruction may be visible 2 to 5 nm.	Low, deconstruction will occur will occur during May-Sept. for 1-2 years	Med, lights may be visible from shore	IALA 2008, NOAA 2007

Potential effects on acoustic environment due to Small Commercial Pelamis Project at Makapu'u Point, Hawaii

Project activity	Project action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high or unknown)	Source(s)
Construction						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, boat traffic will occur during May-Sept. for 1-2 years	Med, noise could be elevated but short-term and attenuated by sea conditions and ambient noise	Austin et al. 2009, USN 2007
Construction of electrical collector system, moorings and foundations; device installation		Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, construction will occur during May-Sept. for 1-2 years	Med, noise could be elevated but short-term and attenuated by sea conditions and ambient noise	Austin et al. 2009, USN 2007
Directional drilling, and laying cable under/on seabed		Vibration of immediate area being drilled	Low, vibration could be localized, assuming similar to directional drilling on land	Low, drilling will occur for 1-2 weeks in summer	Low, noise expected to be localized and short-term	CPUC 2009
Operation and Maintenance						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic infrequent during O&M	Low, noise would occur infrequently	USN 2007
Operation of turbines or other moving parts of devices		Adds to existing natural and man-made noise in project area	Unknown levels generated; site specific attenuation and ambient noise also unknown	High, noise would occur over life of the project	Unknown	Austin et al. 2009, Study warranted
Decommissioning						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, boat traffic will occur during May-Sept. for 1-2 years	Med, noise could be elevated but short-term and attenuated by sea conditions and ambient noise	Austin et al. 2009, USN 2007
Decommissioning of structures on water's surface or seabed	Noise and vibration	Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, deconstruction will occur during May-Sept. for 1-2 years	Med, noise could be elevated but short-term and attenuated by sea conditions and ambient noise	Austin et al. 2009, USN 2007

Potential effects on sediment and water chemistry due to Small Commercial Pelamis at Makapu'u site

Project activity	Project action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high, or unknown)	Source(s)
Construction						
Boat traffic	Oil/chemical release, assumed seepage from exhaust and general use, not a spill from collision or other release	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	High, traffic and boat frequency will be the highest during construction	Low, given low spatial and temporal extent	USN 2007
Construction of electrical collector system, moorings and foundations; device installation	Oil/chemical release		Low, seepage will have a small spatial and areal extent relative to the project	Low, construction will be 1 to 2 years over the 15 to 25 year project life	Low, given low spatial and temporal extent	USN 2007
Directional drilling, and laying cable under/on seabed (assume normal conditions, not a drilling mud "blow out" scenario)	Seabed disturbance	Ocean floor is primarily limestone; cables likely laid on exposed limestone and secured with rock bolts. Sediment could be introduced into water column.	Med, cable length approx 1 to 2 miles;	Low, little sediment introduced in water column and would mix or dilute quickly.	Low, due to surface cable and quick dilution of sediment in water column	MMS 2007
Operation and Maintenance						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	Low, O&M vessel traffic will be much less than during construction	Low, due to low seepage spatial extent, and low volume of vessel traffic during O&M	USN 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Concrete footings are sources of alkaline elements (sodium, potassium) that could leach into water column; however, footings in rocky seabed unknown and may not be concrete	Low, effect would be localized to vicinity of concrete footings; project area ~1.6 km by 0.5 km or 0.8 km^2 (0.3 mi^2)	High, any leaching would occur throughout life of project	Low, effects would be diluted and may not be measurable	Substructure [date unknown]
	Water circulation changes	Erosion in lee of footings possible but much slower in rocky seabed substrate	Low, effect would be localized to lee side of footings	Med, any erosion occurring would be throughout the life of the project	Low, effect is small and localized, although it would occur over life of project	USN 2007

Project activity	**Project action**	**Description of action's effect on site physical attribute**	**Spatial exposure of attribute (low, med, high)**	**Temporal exposure of attribute (low, med, high)**	**Overall risk to attribute (low, med, high, or unknown)**	**Source(s)**
Structures on water's surface	Structure	Biofouling organisms slough off on to the seabed surface; potential for hydraulic fluids release from devices, 12800 liters (3381 gal) per device	Low, effect localized to seabed directly under devices	Low, antifouling paint and maintenance likely to remove organisms before sloughing	Low, effect is localized to immediate vicinity of seabed under devices	MMS 2007
Decommissioning						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial/area extent relative to the project	High, traffic and boat frequency will be high during decommissioning	Low, given low spatial and temporal extent	USN 2007
Decommissioning of structures on water's surface or seabed	Oil/chemical release			Low, decommissioning will be 1 to 2 years over the 15 to 25 year project life	Low, given low spatial and temporal extent	USN 2007
	Seabed disturbance	Sediment could be introduced into water column when removing anchors or footings and/or surface cable	Med, cable length approx 1 to 2 miles; project area ~ 1.6 km by 0.5 km or 0.8 km^2 (0.3 mi^2)	Low, increased sediment in water column would mix or dilute quickly.	Low, due to quick dilution of sediment in water column	MMS 2007

Potential effects on Humpback Whales due to Small Commercial Pelamis at Makupu'u site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring when few if any humpbacks are in area.	Low, few in area, May-Sept during breeding, some calves in early May.	Low; few in area during construction; med due to humpback whale-boat collisions one of the highest rates among marine mammals	Laist et al. 2001, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med, increase of traffic from Honolulu, sound travels beyond project area	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; whales may flee approaching boat while still distant	Craig and Herman 1997, Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but volume of fluids released low	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; low volume of contaminants expected	Craig and Herman 1997
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med-High, sound travels far, animals will hear it outside of the project area	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; may interfere with male vocalization in spring (March-April)	Craig and Herman 1997, Richardson and Wursig 1997
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on fish attracted to light	Unknown	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; limited area of effect	Craig and Herman 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Med; increase in use of chemicals, but volume of fluids released low-med	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; low volume of contaminants expected	Craig and Herman 1997

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med-High, sound travels far, animals will hear it outside of the project area	Low, occurs when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during construction; may interfere with male vocalization in spring (March-April); short overall duration of activity	Craig and Herman 1997
Operation and Maintenance							
Boat traffic. (Assuming maintenance done throughout the year)	Direct impact	Collision injuries	Med, increase of traffic traveling along coast from Honolulu to project site	Med during Dec-May breeding season, over life of project	Med, during Dec-May breeding season	Med-high; boat traffic likely to occur in area frequented by humpbacks; boat collision/ strikes for species one of the highest among cetaceans	Laist et al. 2001, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, increase in traffic but the volume of fluids released low	Med during Dec-May breeding season, over life of project	Med, during Dec-May breeding season	Low; humpbacks abundant in winter; individuals show site fidelity; low volume of contaminants expected	Craig and Herman 1997
	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med, sound travels far, animals will hear it outside of the project area	Med during Dec-May breeding season, over life of project	Med, during Dec-May breeding season	Med-high; humpbacks abundant in winter; individuals show site fidelity; whales may flee approaching boat while still distant	Craig and Herman 1997, Richardson and Wursig 1997
Operation of turbines or other moving parts of devices	Moving device parts	Movement of device and mooring lines could injure animals	Low, area of the devices small and interaction with animals low	Med, movement continuous through life of project but whales there only Dec-May	Med during Dec-May breeding season when calves present.	Low; small area of impact; large whales unlikely to approach moving parts close enough to be at risk	Mazzuca et al. 1998
	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med, sound travels far, animals will hear it outside of the project area	Med during Dec-May breeding season, over life of project	Med during Dec-May breeding season	Unknown; noise in area frequented by humpbacks; may interfere with male vocalization; potential long term reduction in use of area	Craig and Herman 1997, Richardson and Wursig 1997

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Collision, entanglement with devices or derelict fishing gear	Med-High, project in coastal breeding area where whales concentrate.	Med during Dec-May breeding season, over life of project	Med-High, humpbacks very coastal during breeding season, esp. calves	Low for adults; high risk of entanglement for young of the year	Lien et al. 1992, Mazzuca et al. 1998, SIMON 2008
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect electricity/EMF generated over project duration	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Med-High, project in coastal breeding area where whales concentrate.	Med during Dec-May breeding season, over life of project	Med-High, humpbacks very coastal during breeding season, esp. calves	Low; low potential for collision with structure because on water's surface	Lien et al. 1992, Mazzuca et al. 1998, SIMON 2008
	Navigation lights	Visual disorientation could lead to collision	Low, device lights of low intensity, shielded, intended for navigation safety	Med during Dec-May breeding season, over life of project	Med, humpbacks very coastal during breeding season, esp. calves	Low; low intensity of lights; similar to existing navigation lights on boats and buoys encountered around Hawaiian islands	Baker and Herman 1981
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase of traffic along coast from Honolulu to project site	Low, occurring when few if any humpbacks are in area.	Low, few in area May-Sept during breeding, some calves in early May.	Low; few in area during deconstruction; humpback whale-boat collisions one of the highest among marine mammals	Laist et al. 2001, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med, sound travels far, animals will hear it outside of the project area	Low, occurring when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during deconstruction; whales may flee approaching boat while still distant	Craig and Herman 1997, Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in existing traffic but volume of fluids released low	Low, occurring when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during deconstruction; low volume of contaminants expected	Craig and Herman 1997

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance, masking of environmental cues, song and communication signals	Med-High, sound travels far, animals will hear it outside of the project area	Low, occurring when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during deconstruction; may interfere with male vocalization in spring (March-April); potential long term reduction in use of areas	Craig and Herman 1997, Richardson and Wursig 1997
	Oil/chemical release	Visual disorientation could lead to collision, enhance foraging on species attracted to light	Unknown	Low, occurring when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks in area.	Low; few in area during deconstruction; volume of contaminants expected to be low	Craig and Herman 1997
	Construction lights, vessel deck lights and spotlights.	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, significant increase in traffic but low volume of fluids released	Low, occurring when few if any humpbacks are in area.	Low, starts at end of breeding when few if any humpbacks	Low; few in area during deconstruction; limited area of effect	Craig and Herman 1997

Potential effects on False Killer whales due to Small Commercial Pelamis system at Makupu'u site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to the indicator (low, med, high or unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase of boat traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; species tends to use deeper water than project area; potential overlap as boats travel through near shore deep water along SE edge of Oahu	Low; limited potential for interaction; false-killer whale-boat collisions apparently rare	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance of area	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; false killer whales tend to utilize water deeper than project area; may be attracted to vessels in search of hooked fish	Low; not likely in project area for extended periods; may travel through area; likely in deep water offshore	HMRG [date unknown], Mobley Jr. et al. 2000
	Oil/chemical release	Bioaccumulation, direct ingestion of toxins, breathing exhaust fumes, Assuming no catastrophic	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; limited potential for direct exposure;	Low; limited direct exposure; false killer whales show some of highest levels of accumulated toxins among marine mammals	Stacey et al. 1994
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance of area	Low-med; false killer whales likely to be less sensitive to lower frequency noises (below 2kHz)	Low, occurring over 1 to 2 summers	Low; likely to be less sensitive to lower frequency noise; higher frequency sounds may cause avoidance of project area	Low; area sub-optimal habitat for species; likely audible to animals in deep water immediately offshore of project site	HMRG [date unknown], Mobley Jr. et al. 2000, Nitta and Henderson 1993, Van Waerebeek and Leaper 2008
	Oil/chemical release	Bioaccumulation, direct ingestion of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low-med; limited potential for direct exposure	Low; limited direct exposure; false killer whales show some of the highest levels of accumulated toxins among marine mammals	Stacey et al. 1994

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to the indicator (low, med, high or unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low; species presumably nocturnal foragers; provide benefit by concentrating prey	Low; species infrequently in project area; if lights attract prey could increase risk of interactions	Mobley Jr. et al. 2000, Stacey et al. 1994
Directional drilling, and laying cable under/on seabed	Noise and vibration from drilling and support vessels	Avoidance of nearshore area and support vessels	Low; false killer whales less sensitive to lower frequency noise	Low, occurring over 1 summer	Low; effect area relatively small and close to shore	Low; species rarely observed in nearshore waters around Hawaii	Mobley Jr. et al. 2000, Thomas et al. 1988
Operations and maintenance							
Boat traffic. (Assuming maintenance done throughout the year)	Direct impact	Collision injuries	Low-Med; increase in boat traffic traveling along coast from Honolulu to project site	med, occurring at low frequency over project duration	Low; species tend to use deeper waters than project area; potential overlap as vessels travel through nearshore deep water along SE edge of Oahu	Low; limited potential for interaction; false killer whale-boat collisions apparently rare	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008
	Oil/chemical release	Bioaccumulation, direct ingestion of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	High; occurring over project duration	Low; limited potential for direct exposure	Low; limited direct exposure; species has one of highest levels of accumulated toxins among marine mammals	Stacey et al. 1994
	Noise and vibration	Avoidance of area	Low-Med, increased boat traffic traveling along coast from Honolulu to project site	Low, occurring at low frequency over project duration	Low; species tends to use water deeper then project area; may be attracted to vessels	Low; species not likely in project area but may travel through; likely audible in deep water offshore of project site	HMRG [date unknown], Mobley Jr. et al. 2000
Operation of turbines or other moving parts of devices	Moving device parts	Movement of devices and mooring lines could injure animals	Low-Med; project location likely to be traveled through	High, the movement occurs over project duration	Low; false killer whales tend to use water deeper then project area	Low; moving parts readily avoided; expected infrequently in project area	Mobley Jr. et al. 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to the indicator (low, med, high or unknown)	Source(s)
	Noise and vibration	Avoidance of area	Noise likely to be low frequency and not likely to invoke behavioral response by false killer whales unless very close to equipment	High, noise level would be constant over project duration	Low; likely less sensitive to lower frequency noise (below 2kHz); higher frequency sounds may cause avoidance of project area	Low; area sub-optimal habitat for species; noise likely audible in deep water immediately offshore of project site	HMRG [date unknown], Mobley Jr. et al. 2000, Nitta and Henderson 1993, Thomas et al. 1988, Van Waerebeek and Leaper 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Biofouling inverts could create artificial reef and attract fish; entanglement with devices or derelict fishing gear	Low, structures likely to be avoided as false killer whales travel through project area	High, structure present over project duration	Low; structures should be readily avoided	Low; may be attracted to fish aggregations; risk of entanglement if derelict gear, cables, lines present	Mobley Jr. et al. 2000, Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if effect; electricity/ EMF generated over project duration	Unknown; false killer whales tend to utilize water deeper then cable area	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, structures likely to be avoided as false killer whales travel through project area	High, structure present over project duration	Low; structures should be readily avoided;	Low; may enhance foraging for large fish attracted to artificial reef; species expected to occur infrequently in project area	Mobley Jr. et al. 2000, Relini et al. 2000
	Navigation lights	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over project duration	Low; false killer whales presumably are nocturnal foragers but navigational lights low intensity	Low; unlikely lights will attract fish aggregations due to low intensity; species expected to be rare at project site	Stacey et al. 1994
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase of boat traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; species uses water deeper than project area; potential overlap as boats travel through near shore deep water SE of Oahu	Low; limited potential for interaction; false-killer whale-boat collisions apparently rare	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to the indicator (low, med, high or unknown)	Source(s)
	Oil/chemical release	Bioaccumulation (forage on large fish), direct ingestion of toxins, breathing exhaust fumes, Assuming no catastrophic	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; limited potential for direct exposure	Low; limited direct exposure; false killer whales show some of highest levels of accumulated toxins among marine mammals	Stacey et al. 1994
	Noise and vibration	Avoidance of area	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; false killer whales tend to utilize water deeper then project area; may be attracted to vessels in search of hooked fish	Low; area sub-optimal habitat for species; noise likely audible in deep water immediately offshore of project site	HMRG [date unknown], Mobley Jr. et al. 2000, Nitta and Henderson 1993, Van Waerebeek and Leaper 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance of area	Low-med; false killer whales likely to be less sensitive to lower frequency noises (below 2kHz)	Low, occurring over 1 to 2 summers	Low; likely to be less sensitive to lower frequency noise; higher frequency sounds may cause avoidance of project area	Low; area sub-optimal habitat for species; noise likely audible in deep water immediately offshore of project site	HMRG [date unknown], Mobley Jr. et al. 2000, Nitta and Henderson 1993, Thomas et al. 1988, Van Waerebeek and Leaper 2008
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low; species presumably nocturnal foragers; provide benefit by concentrating prey	Low; lights could attract prey and false killer whales; if lights attract prey could may increase risk of interactions	Mobley Jr. et al. 2000, Stacey et al. 1994
	Oil/chemical release	Bioaccumulation, direct ingestion of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low; limited direct exposure; med bioaccumulation effect	Low; limited direct exposure; false killer whales show some of the highest levels of accumulated toxins among marine mammals	Stacey et al. 1994

Potential effects on Bottlenose dolphins due to Small Commercial Pelamis system at Makupu'u site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure tp indicator(low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase of boat traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels are close to shore or as dolphins travel to and from deeper waters	Med-high; bottlenose dolphin-boat collision rate one of the highest among dolphin species; risk high if boat travel along coast from Honolulu to site	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance of area	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels close to shore or as dolphins travel to and from deeper waters; may not react to boats unless harassed.	Low; significant increase in boat traffic; increase risk if boats travel along shore from Honolulu to project site	Irvine et al. 1981, Mobley Jr. et al. 2000, Tyack et al. 1993, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, overall accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from deeper waters	Low; low contaminant volume expected; exposure along coast or traveling through project sites on way to offshore waters	Mobley Jr. et al. 2000
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masking environmental cues. Reduction of hearing sensitivity (TTS), resulting in potential increase in predation	Low-med; dolphins likely to be less sensitive to lower frequency noises unless they are within the immediate project area	Low, occurring over 1 to 2 summers	Low; likely to be less sensitive to lower frequency noise; higher frequency sounds may cause avoidance of project area	Low; activities far enough from shore to reduce noise impacts on species while nearshore; potential temporary impact to hearing if dolphins in area	Irvine et al. 1981, Tyack et al. 1993, Schlundt et al. 2000
	Oil/chemical release	Ingestion, overall accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from deeper waters	Low; exposure risk as dolphins travel through and around the project area; low level of contaminants expected	Mobley Jr. et al. 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure tp indicator(low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low, Bottlenose dolphins do forage at night but home range (~125 km^2) is much larger than project area	Low; area of effect low relative to range; may attract dolphins pursuing prey attracted to lights	Day and Defran 1995, Klatsky et al. 2007, Reynolds III et al. 2000
Directional drilling, and laying cable under/on seabed	Noise and vibration from drilling and support vessels	Avoidance of nearshore area and support vessels; and area around support vessels moving offshore	Low; bottlenose dolphins less sensitive to lower frequency noise	Low, occurring over 1 summer	Low; effect area small relative to large home range (~125 km^2)	Low; may displace dolphins form nearshore area; increased potential of propeller strike from boats in small area nearshore	Reynolds III et al. 2000, Tyack et al. 1993, Van Waerebeek and Leaper 2008
Operations and maintenance							
Boat traffic. (Assuming maintenance done throughout the year)	Direct impact	Collision injuries	Low-Med; increase in boat traffic traveling along coast from Honolulu to project site	med, occurring at low frequency over project duration	Low; effects amplified if vessels are close to shore or as dolphins travel to and from deeper waters	Low; moderate increase in boat traffic; bottlenose dolphin-boat collision rate one of highest among dolphin spp.; risk elevated if traffic along coast from Honolulu to project site	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes Assuming no catastrophic spills.	Low; increased boat traffic but the volume of fluids released low	Low, occurring at low frequency over project duration	Dolphins may pass through project area traveling to and from foraging areas increasing potential for exposure	Low; contaminant volume expected to be low; possible exposure along coast or while traveling to offshore waters	Mobley Jr. et al. 2000
	Noise and vibration	Avoidance of area	Low-Med, increased boat traffic traveling along coast from Honolulu to project site	Low, occurring at low frequency over project duration	Low; effects amplified if boats near shore or as dolphins travel to and from deeper waters; may not react to sound unless harassed	Low; moderate increase in boat traffic; potential impact greater if boats travel along shore from Honolulu to project site	Irvine et al. 1981, Mobley Jr. et al. 2000, Tyack et al. 1993

Project activity	Project action	Description of action's effect on indicator	Spatial exposure tp indicator(low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Movement of devices and mooring lines could injure animals	Low-Med; project location likely to be traveled through	High, the movement occurs over project duration	Low; area occupied by moving parts small relative to the animal's home range (~125 km^2)	Low; dolphins sensitive to surrounding envir., unlikely to approach close enough	Reynolds III et al. 2000
	Noise and vibration	Avoidance of area	Noise likely to be low frequency and not likely to invoke behavioral response by bottlenose dolphins unless very close to equipment	High, noise level would be constant over project duration	Low; frequency and sound pressure levels expected to be below hearing sensitivity of dolphins unless they are very close to equipment	Low; not expected to be audible to dolphins in nearshore waters; likely detectable to dolphins within area immediately around machinery	Tyack et al. 1993
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Biofouling invertebrates could create artificial reef and attract fish; entanglement with devices or derelict fishing gear	Low, structures likely to be avoided as dolphins travel to and from deeper waters	High, structure present over project duration	Low; structures should be readily avoided; may enhance foraging opportunities	Low; dolphins highly sensitive to surrounding environment; structure readily avoided	Mobley Jr. et al. 2000, Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect, electricity/ EMF generated over project duration	Unknown; large home range may reduce extent of effects is there are any	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, structures likely to be avoided as dolphins travel to and from deeper waters	High, structure present over project duration	Low; structures readily avoided	Low; structure readily avoided	Mobley Jr. et al. 2000, Relini et al. 2000
	Navigation lights	Visual disorientation could lead to collision, could enhance foraging on species attracted to light	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over project duration	Low, species forages at night but home range (~125 km^2) much larger than project area	Low; area of effect low relative to range; lights not unlike other common navigational light sources	Day and Defran 1995, Klatsky et al. 2007, Reynolds III et al. 2000
Decommissioning							

Project activity	Project action	Description of action's effect on indicator	Spatial exposure tp indicator(low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Direct impact	Collision injuries	High, significant increase of boat traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels are close to shore or as dolphins travel to and from deeper waters	Med-high; bottlenose dolphin boat collision rate one of highest among dolphin spp; risk high if travel along coast to project site	Mobley Jr. et al. 2000, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from deeper waters	Low; low contaminant volume expected; exposure along coast or traveling through project sites	Mobley Jr. et al. 2000
	Noise and vibration	Avoidance of area	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if boats near shore or as dolphins travel to and from deeper waters	Low; increase risk if boats travel along shore from Honolulu to project site; may not react to boats unless harassed.	Irvine et al. 1981, Mobley Jr et al. 2000, Tyack et al. 1993, Van Waerebeek and Leaper 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Avoidance, masking environmental cues. Reduction of hearing sensitivity (TTS), could increase predation	Low-med; dolphins likely to be less sensitive to lower frequency noises unless within project area	Low, occurring over 1 to 2 summers	Low; likely less sensitive to lower freq noise; higher freq sounds may cause avoidance of project area	Low; far enough from shore to reduce noise impacts; potential impact if dolphins remain in project area	Irvine et al. 1981, Schlundt et al. 2000, Tyack et al. 1993
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low, species forages at night but home range (~125 km^2) much larger than project area	Low; area of effect low relative to range; may attract dolphins pursuing prey attracted to lights	Day and Defran 1995, Klatsky et al. 2007, Reynolds III et al. 2000
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes; Assuming no catastrophic spills.	Med; significant increase in use of chemicals, but volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from deeper waters	Low; exposure risk as dolphins travel through project area; low level of contaminants expected	Mobley Jr. et al. 2000

Potential effects on Hawaiian spinner dolphin due to Small Commercial Pelamis at Makupu'u site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels close to shore or as dolphins travel to and from offshore foraging areas	Low; collisions between spinner dolphins and boats relatively infrequent	Camargo and Bellini 2007, Van Waerebeek and Leaper 2008
	Noise and vibration	Repeated disturbance may disrupt daytime resting period and cause avoidance of area.	Med, significant increase in boat traffic	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels close to shore or as dolphins travel between resting and foraging areas	Low; risk increased if boats travel close to nearshore resting areas	Danil et al. 2005
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from foraging areas	Low; volume of contaminants expected to be low; area of potential impact relatively small compared to range	Norris et al. 1994
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masks environmental cues. Reduction of hearing sensitivity (TTS), resulting in potential increase in predation	Low-med; dolphins likely to be less sensitive to low frequency unless they are within the immediate project area;	Low, occurring over 1 to 2 summers	Low; likely to be less sensitive to noise in low frequencies; higher frequency may cause avoidance of project area	Low; construction activities far enough from shore to reduce impacts on resting dolphins; transit through/past project area regular but brief	Norris et al. 1994
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Dolphins may pass through project area traveling to and from foraging areas increasing potential for exposure	Low; volume of contaminants expected to be low; area of potential impact relatively small compared to range	Norris et al. 1994

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Spinner dolphins are nocturnal foragers but typically forage further offshore than project location	Low; may disrupt dolphins traveling from nocturnal foraging areas to nearshore resting areas; not likely to impact foraging	Norris et al. 1994
Directional drilling, and laying cable under/on seabed	Noise and vibration from drilling and support vessels	Avoidance of nearshore area, disruption of resting (spinner dolphins highly sensitive to boats and people while resting)	High, dolphins will avoid areas they may regularly use for resting due to noise levels and presence of support vessels	Low, occurring over 1 summer	High; Spinner dolphins rest in shallow waters during the day; vessels likely significant disturbance to resting animals	Low; low if drilling at location not used by resting dolphins; high if occurs in area used by resting dolphins	Danil et al. 2005, Norris et al. 1994, Richardson and Wursig 1997
Operation and Maintenance							
Boat traffic. (Assuming maintenance done throughout the year)	Direct impact	Collision injuries	Low-med; moderate increase in boat traffic traveling along coast from Honolulu to project site	Med, occurring at low frequency over project duration	Low; effects amplified if boats close to shore or cross paths of dolphins traveling to and from offshore foraging areas	Low; collisions between spinner dolphins and boats relatively infrequent; level of traffic expected to be relatively low	Camargo and Bellini 2007, Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes, overall Assuming no catastrophic spills.	Low-Med, increased boat traffic but the volume of fluids released low	Low, occurring at low frequency over project duration	Dolphins may pass through project area traveling to and from foraging areas increasing potential for exposure	Low; volume of contaminants expected to be low; area of potential impact relatively small compared to range	Norris et al. 1994
	Noise and vibration	Repeated disturbance may disrupt daytime resting and cause avoidance of area.	Med, significant increase in boat traffic	Low, occurring over 1 to 2 summers	Low; effects amplified if boats close to shore or as dolphins travel between resting and offshore foraging	Low; risk increased if boats travel close to shore; may result in disruption of rest period	Danil et al. 2005
Operation of turbines or other moving parts of devices	Moving device parts	Movement of devices and mooring lines could injure animals	Low-Med; project location likely to be traveled through, but not used for foraging or resting	High, the movement occurs over project duration	Low; area occupied by moving parts small relative to the animal's home range;	Low; species sensitive to surrounding environment but not likely to approach close enough to be at risk	Norris et al. 1994

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Repeated disturbance may disrupt daytime resting period and cause avoidance of area.	Noise likely to be low frequency and not audible by spinner dolphins, beyond project area	High, noise level would be constant over project duration	Low; frequency and sound pressure levels expected to be below hearing sensitivity of dolphins unless very close to equipment	Low; generators sufficiently far from shore to reduce impacts of noise; transit through/past project area regular but brief	Norris et al. 1994
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Biofouling inverts could create artificial reef and attract fish; entanglement with devices or derelict fishing gear	Low, structures likely to be avoided as animals pass between during travel to and from foraging areas	High, structure present over project duration	Low; structures should be readily avoided while traveling to and from foraging areas	Low; may enhance foraging on prey species attracted to floating structures	Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect, electricity generated over project duration	Unknown; effects amplified if power cable brought onshore across resting area	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, structures readily avoided as animals pass between during travel to and from foraging areas	High, structure present over project duration	Low; structures readily avoided while traveling to and from foraging areas	Low; structures detected and avoided	Norris et al. 1994, Relini et al. 2000
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over project duration	Spinner dolphins are nocturnal foragers but typically forage further offshore than project location	Low; light intensity low and like other vessel/buoy navigation lights; not expected to impact foraging or travel	Norris et al. 1994
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low; effects amplified if vessels close to shore or as dolphins travel to and from offshore foraging areas	Low; collisions between spinner dolphins and boats relatively infrequent	Camargo and Bellini 2007, Van Waerebeek and Leaper 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes, Assuming no catastrophic spills.	Med, significant increase in boat traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low; possible contact as dolphins pass through project area traveling to and from foraging areas	Low; volume of contaminants expected to be low; area of potential impact relatively small compared to range	Norris et al. 1994
	Noise and vibration	Repeated disturbance may disrupt daytime resting and cause avoidance of area.	Med, significant increase in boat traffic	Low, occurring over 1 to 2 summers	Low; effects amplified if boats close to shore or as dolphins travel between resting and offshore foraging areas	Low; risk increased if boats travel close to nearshore resting areas	Danil et al. 2005
Decommissioning of structures on water's surface or seabed	Noise and vibration	Repeated disturbance may disrupt daytime resting period and cause avoidance of area.	Low-med; dolphins likely to be less sensitive to low frequency unless they are within immediate project area	Low, occurring over 1 to 2 summers	Low; likely to be less sensitive to noise in low frequencies; higher frequency sounds may disrupt resting period	Low; deconstruction far enough from shore to reduce noise impacts; transit through project area regular but brief	Norris et al. 1994
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Spinner dolphins are nocturnal foragers but typically forage further offshore than project location	Low; may disrupt dolphins traveling from nocturnal foraging areas offshore to nearshore resting areas; not likely to impact foraging	Norris et al. 1994
	Oil/chemical release	Ingestion, accumulation of toxins, breathing exhaust fumes; Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Dolphins may pass through project area traveling to and from foraging areas increasing potential for exposure	Low; volume of contaminants expected to be low; area of potential impact relatively small compared to range	Norris et al. 1994

Potential effects on Hawaiian monk seal due to Small Commercial Pelamis at Makupu'u site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low-high; likelihood of collision low as there are few seals in the area and collisions infrequent; high risk due to potential for loss of a single individual of a species at risk of extinction	Antonelis et al. 2006, Baker and Johanos 2004
	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduced hearing sensitivity could mask envir. cues	Med, significant increase in boat traffic, low frequency sound detectable for several km	Low, occurring over 1 to 2 summers	Potential for reducing from low occurrence frequency of monk seals to complete avoidance of area	Low; risk of avoidance of area during construction; numbers of seals observed in the region is low	Antonelis et al. 2006, Baker and Johanos 2004, Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assuming no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low; monk seals infrequent in project area; additional inputs may compound elevated contaminant levels in few monk seals present	Baker and Johanos 2004, Ylitalo et al. 2008
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduction of hearing sensitivity could mask envir. cues	High, seals will avoid project area depending on sound propagation; low freq. sound detectable for several km	Low, occurring over 1 to 2 summers	Med-high; potential for reducing monk seal use of water around Oahu	Unknown; potential for reducing occurrence of monk seals from low frequency to complete avoidance of area	Baker and Johanos 2004

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, overall accumulation of toxins. Assuming no catastrophic spills.	Med; significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low; monk seals infrequent in project area; additional inputs may compound elevated contaminant levels in few monk seals present	Baker and Johanos 2004, Ylitalo et al. 2008
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Unknown; monk seals forage at night; lights may hinder or result in avoidance; or could enhance foraging on prey attracted to lights	Baker and Johanos 2004, Goodman-Lowe 1998
Directional drilling, and laying cable under/on seabed	Noise and vibration from drilling and support vessels	Avoidance of area, masks environmental cues, affecting foraging, predation, and threat avoidance	High, seals will avoid the project area and beyond depending on propagation; sound detectable for several km.	Low, occurring over 1 summer	Potential for reducing from low occurrence frequency of monk seals to complete avoidance of area	Low; monk seals occur infrequently in area may haul out on beach where drilling is to occur; any disturbance constitutes "take" of this species	Antonelis et al. 2006
Operations and maintenance							
Boat traffic. (Assuming maintenance done throughout the year)	Direct impact	Collision injuries	High, significant increase existing traffic traveling along coast from Honolulu to project site	Med, occurring at low frequency over project duration	Low due to relative infrequent occurrence of monk seals near Oahu	Low-high; likelihood of collision low because few seals in area, low boat traffic expected and collisions infrequent; high risk due to potential for loss of a single individual	Antonelis et al. 2006, Baker and Johanos 2004
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Med, occurring at low frequency over project duration	Low due to relative infrequent occurrence of monk seals near Oahu	Low; monk seals infrequent in project area; additional inputs may compound elevated levels in few monk seals present	Baker and Johanos 2004, Ylitalo et al. 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduction of hearing sensitivity could mask environmental cues	Med, significant increase in boat traffic, sound detectable for several km.	Med, occurring at low frequency over project duration	Potential for reducing from low occurrence frequency of monk seals to complete avoidance of area.	Low; may cause avoidance of area; occurrence currently rare but present; level of boat traffic expected to be relatively low	Antonelis et al. 2006, Baker and Johanos 2004, Kastak et al. 2005, Tougaard et al. 2009
Operation of turbines or other moving parts of devices	Moving device parts	Movement of devices and mooring lines could injure animals	Med, areas of movement small compared to project area but monk seals show highest rates of entanglement among pinnipeds	High, the movement occurs over project duration	Low due to relative infrequent occurrence of monk seals near Oahu	Low; rare occurrence in the area; moving parts small relative to range and readily avoidable	Baker and Johanos 2004
	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduction of hearing sensitivity could mask environmental cues	Unknown noise levels, but attenuation dependent on sea state. sound detectable for several km.	High, noise level would be constant over project duration	Med-high; potential for reducing monk seal use of water around Oahu	Med-high; may cause permanent avoidance of area; may affect rate of reestablishment on Oahu; occurrence currently rare but they are present	Antonelis et al. 2006, Baker and Johanos 2004, Kastak et al. 2005, Tougaard et al. 2009
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Artificial reef and attract fish; entanglement with devices or derelict fishing gear	Med, the project area is small but monk seals show highest rates of entanglement among pinnipeds	High, structure present over project duration	Low; possibly beneficial effect by increasing forage on fishes, relative infrequent occurrence of monk seals near Oahu	High; monk seals show highest rates of entanglement among pinnipeds	Baker and Johanos 2004, Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect because electricity generated over project duration	Unknown; effects amplified if power cable brought onshore across a resting area	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Structures on water's surface	Structure	Collision	Low, monk seals prefer sandy beach haulouts, not likely to use buoys for resting	High, structure present over project duration	Low	Low; rare occurrence in the area; structures readily avoidable	Baker and Johanos 2004, Relini et al. 2000
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over project duration	Low due to relative infrequent occurrence of monk seals near Oahu	Low; low light intensity; similar to lights on existing buoys and boats	Baker and Johanos 2004
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High, significant increase of traffic traveling along coast from Honolulu to project site	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low-high; likelihood of collision low as there are few seals in area and collisions infrequent; high risk due to potential for loss of a single individual of species at risk of extinction	Antonelis et al. 2006, Baker and Johanos 2004
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assuming no catastrophic spills.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low; monk seals occur infrequently in project area; additional inputs may compound elevated levels in few monk seals present	Baker and Johanos 2004, Ylitalo et al. 2008
	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduction of hearing sensitivity could mask environmental cues	Med, significant increase in boat traffic, sound detectable for several km.	Low, occurring over 1 to 2 summers	Potential for reducing from low occurrence frequency of monk seals to complete avoidance of area	Low; risk of avoidance of area; numbers of seals in the region is low	Antonelis et al. 2006, Baker and Johanos 2004, Kastak et al. 2005, Tougaard et al. 2009

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high or unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Repeated disturbance will cause permanent avoidance of area. Reduction of hearing sensitivity could mask environmental cues	High, seals will avoid the project area and beyond depending on propagation; sound detectable for several km.	Low, occurring over 1 to 2 summers	Med-high; potential for reducing monk seal use of water around Oahu	Med-high; potential for reducing occurrence of monk seals from low frequency to complete avoidance of area	Antonelis et al. 2006, Bodson et al. 2007, Kastak et al. 2005, Kastelein et al. 2009, Tougaard et al. 2009
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Med to low extent beyond project site.	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Unknown; monk seals forage at night; lights may hinder or result in avoidance; lights may enhance foraging on prey attracted to lights	Baker and Johanos 2004, Goodman-Lowe 1998
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, overall accumulation of toxins. Assuming no catastrophic spills.	Med, significant increase in use of chemicals, solvents, fuels, grease but the volume of fluids released low-med	Low, occurring over 1 to 2 summers	Low due to relative infrequent occurrence of monk seals near Oahu	Low; monk seals occur infrequently in project area; additional inputs may compound elevated levels in few monk seals in the area	Baker and Johanos 2004, Ylitalo et al. 2008
	Decommissioning of cables and mooring	Entanglement in debris if not removed from project area	Med, depending on thoroughness of removal;	Low to Med; depending on extent of debris	Low to med due to relative infrequent occurrence of monk seals near Oahu	Low-high depending on extent of removal; monk seals show highest rates of entanglement among pinnipeds; any debris presents potentially significant risk	Antonelis et al. 2006, Baker and Johanos 2004, Henderson 2001

Potential effects on bottomfishes due to small commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	Low, May-Sept. for 1-2 years	Low, species occur on or near bottom	Low	Cada 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area, although noise travels far in water	Low, May-Sept. for 1-2 years	Med, species present in area during construction	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in these habitats during construction	Low	Nelson 2008
	Construction lights	Attraction to prey aggregation, beneficial effect	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, likely prey attracted to surface not bottom where species occur	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, occurs over a short time period	Med, species present in area when drilling and/or cable laying	Low	Nelson 2008
	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	Low, occurs over a short time period	Med, species present in area when drilling and/or cable laying	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	Low, wouldn't persist long-term	Low, species occur on or near bottom	Low	Cada 2008
Operation of turbines or other moving parts of devices	Moving device parts	None, moving parts on water's surface, fish on bottom	N/A	N/A	N/A	Low	
	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	High, would be continuous for life of project	Low, species occur on or near bottom	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Structure in water column acts similarly to FAD, no effect of seafloor structure	Low, would occur in very small area	High, would be continuous for life of project	Med, wave structures may attract species to project area	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in very small area	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects on species unknown, could include behavior, orientation changes	Low, would occur in very small area	High, would be continuous for life of project	Med, wave structures may attract species to project area	Unknown	Nelson 2008
Structures on water's surface	Structure	FAD, changes in predator/prey abundance, interactions	Med, would occur in very small area	High, would be continuous for life of project	Low, species in water column or bottom	Unknown	Nelson 2008
	Navigation lights	None, species don't occur at surface	N/A	N/A	N/A	Low	N/A
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	Low, May-Sept. for 1-2 years	Low, species occur on or near bottom	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior, may interact with some species communication	Low, would occur in very small area although noise travels far in water	Low, May-Sept. for 1-2 years	Med, species present in area during decommissioning	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during decommissioning	Low	Nelson 2008
	Deconstruction lights	Attraction to prey aggregation, beneficial effect	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, likely prey attracted to surface not bottom where species occur	Low	Nightingale et al. 2006

Potential effects on mahimahi and scombrids (tunas, wahoo) due to Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Cada 2008, Sara et al. 2007
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Cada 2008, Sara et al. 2007
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Construction lights	Attraction to prey aggregation, beneficial effect	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, occurs over a short time period	Low, species are highly mobile	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, occurs over a short time period	Med, species present in area during construction although highly mobile	Low	Cada 2008, Sara et al. 2007
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, wouldn't persist long-term	Med, species present in area although highly mobile	Low	Cada 2008, Sara et al. 2007
Operation of turbines or other	Moving device parts	None, species very mobile	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
moving parts of devices	Noise and vibration	Possible altered behavior	Low, would occur in very small area	High, would be continuous for life of project	Med, species present in area although highly mobile	Low	Cada 2008, Sara et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Structure in water column acts similarly to FAD, no effect of seafloor structure	Med, would occur in very small area	High, would be continuous for life of project	High, species exhibit attraction to FADs on Oahu	Unknown	Dagorn et al. 2007, Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in very small area	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface		Nelson and Woo 2008
Electricity conduction through cable	EMF	Changes in orientation, behavior	Low, would occur in very small area	High, would be continuous for life of project	Unknown, laboratory studies show tunas can detect magnetic fields	Unknown	Nelson 2008, Walker 1984
Structures on water's surface	Structure	FAD, changes in predator/prey abundance, interactions	Med, would occur in very small area	High, would be continuous for life of project	High, species exhibit attraction to FADs on Oahu	Unknown	Dagorn et al. 2007, Nelson 2008
	Navigation lights	Attraction to prey aggregation, beneficial effect	Low, would occur in very small area	High, would be continuous for life of project	Med, species present in area	Med	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area although highly mobile	Low	Cada 2008, Sara et al. 2007
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area although highly mobile	Low	Cada 2008, Sara et al. 2007
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species are highly mobile	Low	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Deconstruction lights	Attraction to prey aggregation beneficial effect	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area	Low	Nightingale et al. 2006

Potential effects on Swordfish and Billfishes due to Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, Medium for large, catastrophic spill because they are migratory/mobile	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Nelson 2008
	Construction lights	Attraction to prey aggregation	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, occurs over a short time period	Low, species distributed predominantly offshore of the project area	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, occurs over a short time period	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, wouldn't persist long-term	Low, species distributed predominantly offshore of the project area	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	None, species very mobile	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Disturbance	Low, would occur in very small area	High, would be continuous for life of project	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Structure in water column acts similarly to FAD, no effect of seafloor structure	Med, would occur in very small area	High, would be continuous for life of project	High, species known to be attracted to FADs	Unknown	Dempster and Taquet 2004
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in very small area	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Changes in orientation, behavior	Low, would occur in very small area	High, would be continuous for life of project	Low, species distributed predominantly offshore of the project area	Low	Nelson 2008
Structures on water's surface	Structure	FAD	Med, would occur in very small area	High, would be continuous for life of project	High, species known to be attracted to FADs	Med	Nelson 2008
	Navigation lights	Attraction to prey aggregation	Low, would occur in very small area	Low, occurs over a short time period	Low, species distributed predominantly offshore of the project area	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	
	Deconstruction lights	Attraction to prey aggregation	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Low, species distributed predominantly offshore of the project area	Low	Nightingale et al. 2006

Potential effects on sharks (e.g., Oceanic whitetip, Tiger, Shortfin mako, and Longfin mako) due to Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large spill	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Cada 2008, Parrish and Goto 1997
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Cada 2008, Parrish and Goto 1997
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Nelson 2008
	Construction lights	Attraction to prey aggregation	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area during construction although highly mobile	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, occurs over a short time period	Med, species present in area during construction although highly mobile	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, occurs over a short time period	Med, species present in area during construction although highly mobile	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, wouldn't persist long-term	Med, species present in area although highly mobile	Low	Cada 2008
Operation of turbines or other	Moving device parts	None, species very mobile	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
moving parts of devices	Noise and vibration	Possible altered behavior	Low, would occur in very small area	High, would be continuous for life of project	Med, species present in area although highly mobile	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Structure in water column acts similar to FAD, no effect of seafloor structure	Med, would occur in very small area	High, would be continuous for life of project	High, species known to be attracted to FADs	Unknown	Dempster and Taquet 2004
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in very small area	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Changes in orientation, behavior	Low, would occur in very small area	High, would be continuous for life of project	High, species known to be able to detect EMFs, although actual effect on behavior unknown	Unknown	Nelson 2008
Structures on water's surface	Structure	FAD	Med, would occur in very small area	High, would be continuous for life of project	High, species known to be attracted to FADs	Med	Nelson 2008
	Navigation lights	Attraction to prey aggregation	Low, would occur in very small area	High, would be continuous for life of project	Med, species present in area although highly mobile	Med	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large spill	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area although highly mobile	Low	Cada 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, species present in area although highly mobile	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Medium, species present in area although highly mobile	Low	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Deconstruction lights	Attraction to prey aggregation	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Medium, species present in area although highly mobile	Low	Nightingale et al. 2006

Effects on green sea turtles and hawksbill sea turtles from Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision and injury or mortality	Med, species nearshore where boats would pass	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Noise and vibration	Disturbance, avoidance of area	Med, species nearshore where boats would pass	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USN 2005
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Disturbance, avoidance of area	Med, species nearshore where construction would occur	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USN 2005
	Seabed disturbance	Temporary loss of foraging habitat	Med, species nearshore where construction would occur	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Construction lights	Attraction, disorientation of hatchlings	Med, see above	Low, May-Sept. for 1-2 years	High, hatching occurs in summer and fall	Med	Michel et al. 2007, USN 2005
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary loss of foraging habitat	Med, see above	Low, short-term disturbance	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Noise and vibration	Disturbance, avoidance of area	Med, see above	Low, short-term disturbance	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
Operation and Maintenance							
Boat traffic	Direct impact	Collision and injury or mortality	Low, would occur in small area	Low, only from periodic trips	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USN 2005
	Noise and vibration	Disturbance, avoidance of area	Low, would occur in small area	Low, only from periodic trips	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
Operation of turbines or other moving parts of devices	Moving device parts	Effects unlikely, moving parts on surface, turtles underwater	N/A	N/A	N/A	Low	Cada 2008, USN 2005
	Noise and vibration	Disturbance, avoidance of area	Low, would occur in small area	High, continuous for life of project	Med, these species nest on Oahu and forage nearshore	Unknown	Michel et al. 2007, USN 2005
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with devices or derelict fishing gear	Low, would occupy small area	High, continuous for life of project	Med, these species nest on Oahu and forage nearshore	High	Cada 2008, USN 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large release from device failure	Low, wouldn't persist long-term	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USFWS 2005
Electricity conduction through cable	EMF	Disorientation, alteration of behavior	Low, would occur in small area	High, continuous for life of project	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
Structures on water's surface	Navigation lights	Attraction, disorientation of hatchlings	Low, would occur in small area	High, continuous for life of project	High, hatching occurs in summer and fall	High	Michel et al. 2007, USN 2005
	Structure	Effects unlikely, turtles do not feed at surface	N/A	N/A	N/A	Low	Michel et al. 2007, USN 2005
Decommissioning							
Boat traffic	Direct impact	Collision and injury or mortality	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USN 2005
	Noise and vibration	Disturbance, avoidance of area	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
Decommissioning of structures on water's surface or seabed	Noise and vibration	Disturbance, avoidance of area	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	Low, species in water column, oil floats on surface	Low	Michel et al. 2007, USN 2005
	Seabed disturbance	Temporary loss of foraging habitat	Low, would occur in very small area	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu and forage nearshore	Med	Michel et al. 2007, USN 2005
	Deconstruction lights	Attraction, disorientation of hatchlings	Low, would occur in very small area	Low, May-Sept. for 1-2 years	High, hatching occurs in summer and fall	Med	Michel et al. 2007, USN 2005

Effects on albatrosses, shearwaters, and storm-petrels from Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	None, species do not forage nearshore where boats would pass	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	None for small release, Low for large release because these species forage far offshore and unlikely to contact oil	Low	USFWS 2005
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Seabed disturbance	None, species are surface-feeders and do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	Attraction/ disorientation	Med, species may congregate nearshore at night	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu Island and could be attracted to lights while attending nests	Med	Montevecchi 2006, USFWS 2005
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, species are surface-feeders and do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, from periodic trips only	None for small release, Low for large release because these species forage far offshore and unlikely to contact oil	Low	Michel et al. 2007, USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	None, species do not forage nearshore where boats would pass	N/A	N/A	N/A	Low	USFWS 2005
Operation of turbines or other moving parts of devices	Moving device parts	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Low, wouldn't persist long-term	None for small release, Low for large release because these species forage far offshore and unlikely to contact oil	Low	Michel et al. 2007, USFWS 2005
Structures on water's surface	Navigation lights	Attraction/ disorientation	Low, would occur in very small area	High, would be continuous for life of project	High, these species nest on Oahu Island and could be attracted to lights while attending nests	High	Montevecchi 2006, USFWS 2005
	Structure	Possible collision while flying	Low, would occur in very small area	High, would be continuous for life of project	Med, these species nest on Oahu Island and attraction to lights could increase collision risk	Unknown	LGL Limited et al. 2009, USFWS 2005
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, May-Sept. for 1-2 years	None for small release, Low for large release because these species forage far offshore and unlikely to contact oil	Low	USFWS 2005
	Noise and vibration	None, these species do not forage nearshore where boats would pass	N/A	N/A	N/A	Low	USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	None, species do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005
	Deconstruction and deck lights	Attraction/ disorientation	Med, species may congregate nearshore at night	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu Island and could be attracted to lights while attending nests	Med	Montevecchi 2006, USFWS 2005
	Seabed disturbance	None, species are surface-feeders and do not forage in project area	N/A	N/A	N/A	Low	USFWS 2005

Effects on noddies and terns from Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from area and disruption of foraging	Low, would only pass by foraging areas	Low, May-Sept. for 1-2 years	High, these species nest on Oahu Island and forage inshore	Med	LGL Limited et al. 2009, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	High, see above	Low	Michel et al. 2007, USFWS 2005
Construction of electrical collector system, moorings/foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Med, may occur in foraging areas	Low, May-Sept. for 1-2 years	High, see above	Med	Michel et al. 2007, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, May-Sept. for 1-2 years	High, see above	Low	Michel et al. 2007, USFWS 2005
	Seabed disturbance	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	None, species are not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Med, may occur in foraging areas	Low, short-term disturbance	High, these species nest on Oahu Island and forage inshore	Med	Michel et al. 2007, USFWS 2005
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	High, see above	Low	Michel et al. 2007, USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would only pass by foraging areas	Low, only from periodic trips in summer	High, see above	Low	LGL Limited et al. 2009, USFWS 2005
Operation of turbines or other moving parts of devices	Moving device parts	None, moving parts at the surface and visible to birds	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible movement away from area and disruption of foraging	Med, may occur in foraging areas	High, would be continuous for life of project	High, these species nest on Oahu Island and forage inshore	Med	Michel et al. 2007, USFWS 2005
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, these species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, these species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large release from device failure	Low, wouldn't persist long-term	High, these species nest on Oahu Island and forage inshore	Low	Michel et al. 2007, USFWS 2005
Structures on water's surface	Navigation lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Structure	Possible attractant to birds due to increased prey abundance, collision while flying	Med, may occur in foraging areas	High, would be continuous for life of project	High, these species nest on Oahu Island and forage inshore	Unknown	Boehlert et al. 2008, USFWS 2005, LGL Limited et al. 2009
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	High, see above	Low	Michel et al. 2007, USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would only pass by foraging areas	Low, May-Sept. for 1-2 years	High, see above	Med	LGL Limited et al. 2009, USFWS 2005
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Med, may occur in foraging areas	Low, May-Sept. for 1-2 years	High, see above	Med	Michel et al. 2007, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, wouldn't persist long-term	High, see above	Low	Michel et al. 2007, USFWS 2005
	Construction lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Seabed disturbance	None, these species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005

Effects on white-tailed tropicbird, brown booby, and great frigatebirds from Small Commercial Pelamis project at Makapu'u site

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from area and disruption of foraging	Low, would occur in small area relative to species' range	Low, May-Sept. for 1-2 years	Med, these species nest on Oahu Island and could forage in project area	Low	LGL Limited et al. 2009, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, see above	Low	Michel et al. 2007, USFWS 2005
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging	Low, would occur in small area relative to species' range	Low, May-Sept. for 1-2 years	Med, see above	Low	Michel et al. 2007, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, May-Sept. for 1-2 years	Med, see above	Low	Michel et al. 2007, USFWS 2005
	Seabed disturbance	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	None, species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over short time-period	Med, these species nest on Oahu Island and could forage in project area	Low	Michel et al. 2007, USFWS 2005
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, see above	Low	Michel et al. 2007, USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Med, see above	Low	LGL Limited et al. 2009, USFWS 2005
Operation of turbines or other moving parts of devices	Moving device parts	None, moving parts at the surface and visible to birds	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible movement away from area and disruption of foraging	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, these species could forage in project area	Low	Michel et al. 2007, USFWS 2005
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large release from device failure	Low, wouldn't persist long-term	Med, these species could forage in project area	Low	Michel et al. 2007, USFWS 2005
Structures on water's surface	Navigation lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Structure	Possible attractant to birds due to increased prey abundance, collision while flying	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, frigatebirds could attracted to and steal prey from other seabirds, other species could be attracted to FAD	Unknown	Boehlert et al. 2008, USFWS 2005, LGL Limited et al. 2009
Decommissioning							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, these species nest on Oahu Island and could forage in project area	Low	Michel et al. 2007, USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, May-Sept. for 1-2 years	Med, see above	Low	LGL Limited et al. 2009, USFWS 2005
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, May-Sept. for 1-2 years	Med, see above	Low	Michel et al. 2007, USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, wouldn't persist long-term	Med, see above	Low	Michel et al. 2007, USFWS 2005
	Construction lights	None, species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Seabed disturbance	None, species are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005

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Appendix F. Effects of Pilot Scale MCT SeaGen project at Tacoma Narrows

Included in Appendix F are 1) a project description of the pilot scale MCT SeaGen project at the Tacoma Narrows site; 2) an effects analysis of the project on site physical and biological indicators in tabular format; and 3) a list of references used to complete the effects analysis.

Project description for construction, operations and maintenance, and decommissioning phases for Pilot Scale MCT SeaGen project at the Tacoma Narrows site.

Project phase	Project activity or characteristic	Information specific to a pilot scale MCT Seagen at Tacoma Narrows
Construction	Location and deployment depths	Tacoma Narrows. Deployment depth approximately 34 m.
	Footprint	1 device, monopole footprint 7 m^2
	Loading ports and dock locations	Port of Tacoma
	Shipping routes for delivery and installation	from Port of Tacoma to project site
	Ship types and sizes	1 drill rig, 2 tug boats, 1 derrick barge, 1 supply boat
	Installation and assembly procedures	Cable directionally drilled from land to water, subsea cable installed to turbine site Tug brings barge, barge is moored into place, piling hole is drilled, the piling is installed and grouted. Turbine cross arm installed onto pile, top of device installed, turbine unit lowered into water
	Installation equipment	Barge with crane
	Temporary structures	Barge with crane
	Types, composition, locations, and numbers of anchoring and mooring systems	Barge is moored with 2 or more moors controlled by hydraulic winches. Monopile does not require mooring cables.
	Installation schedule and phasing	Directional drilling from sea to land power, subsea cable installation, pile fabrication and drilling, pile and device installation, installation of power equipment, connect subsea cable to turbine, commissioning, approximately 4 months
	Chemicals and fuels used	Hydraulic fluids, gearbox oil, bearing grease, boat fuel
	Sources and levels of noise	Pile driving, vessel traffic, directional drilling
	Sources, levels, and characteristics of light	Navigational lights on boats, construction lights on decks
	Number of vessel trips	Unknown
Operations and Maintenance	General description of technology	1 dual-rotor turbine supported by a mono-pile foundation
	O&M procedures and schedule	Annual inspections and maintenance, access via small craft (i.e., rigid inflatable boat). Includes replacement of gearbox oil, application of bearing grease, changing oil filters, inspection & repairs if needed of electrical equipment. For larger and infrequent, components hoisted out with crane or winch, placed on barge (brought by tug-boat) and repaired.

Project phase	Project activity or characteristic	Information specific to a pilot scale MCT Seagen at Tacoma Narrows
	Operating equipment other than tidal device(s)	None
	Listing of all moving parts	2 underwater turbine blades
	Listing of all structures on surface and below	Mono-pile foundation with dual rotors attached, minimum of 15 m below water's surface in 50 m water depth. The pile pierces the surface.
	Vessel routes and schedule for operation and maintenance	Routes unknown but assumed from Port of Tacoma to project site. See above for O&M schedule.
	Ship types and sizes	Rigid inflatable boat for annual inspections and maintenance. Tug and barge for large repairs (infrequent, as needed)
	Potential emergency conditions and procedures	Oil or hydraulic fluid releases from boats or devices
	Chemicals used by devices, e.g., hydraulic fluids, antifouling paints.	Hydraulic fluids, bearing grease, gearbox oil, anti-fouling paint, boat fuel
	Sources and levels of noise	Sources are the turbine blades, level of noise unknown
	Sources and levels of light	Navigational lights on boats and on device monopile that pierces surface
Decommissioning	Description of equipment or structures removed	Electrical and mechanical equipment, pile above seabed, subsea cable
	Description of equipment or structures to be left in place	Pile foundation (in seabed)
	Monitoring procedure and schedule for equipment left in place	None
	Shipping routes for equipment removed	Assumed from Port of Tacoma
	Ship types and size	Derrick barge, 2 tug boats, 1 supply boat. Sizes unknown
	Decommissioning and disassembly procedures	Electrical and mechanical equipment removed with barge and crane, pile above grade cut off and recovered, subsea cable removed, shore landing from directional drilling capped
	Decommissioning equipment	Derrick barge, crane
	Temporary structures	None
	Decommissioning schedule and phasing	Recover electrical and mechanical components, cut off pile and recover upper portion, remove subsea cable, cap shore landing of directional drilled hole. Approximately 1 to 2 months.
	Chemicals and fuels used	Hydraulic fluids, gearbox oil, bearing grease, boat fuel
	Sources and levels of noise	Removal of pile's upper portion, boat traffic, deconstruction noise while dismantling device from monopile
	Vessels required, number of trips	Derrick barge, 2 tug boats, 1 supply boat. Number of trips unknown
	Best management practices planned	Oil and fuel handling, vessel traffic laws,

Effects of Pilot Scale MCT SeaGen project at Tacoma Narrows on physical and biological indicators

Potential effects on visual environment due to Pilot Scale MCT SeaGen project at Tacoma Narrows site

Project activity	Action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high)	Source(s)
Construction						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Port of Tacoma to project site	Low, visibility varies with atmospheric conditions, will be seen from shore	Low, construction vessel traffic will occur over 1 to 2 years during summer	Low, boat lights visible in shipping lanes but existing traffic ameliorates effect	Snohomish PUD 2008, USN 2008
Construction of electrical collector system, moorings and foundations; device installation	Construction and deck lights	Construction lights much brighter than vessel lights, will be visible from shore	High, construction lights brighter than navigation lights and may be visible 2 to 5 nm.	Low, construction will occur over 1 to 2 years during summer	Med, lights may be visible from shore but location in industrial/ urban area ameliorates effect	IALA 2008, Snohomish PUD 2008
Operation and maintenance						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Port of Tacoma to project site	Med, visibility varies with atmospheric conditions, will be seen from shore	Med, traffic over life of project but at reduced frequency compared to construction	Low, boat lights visible in shipping lanes in Tacoma Narrows, but existing traffic ameliorates effect	Snohomish PUD 2008, USN 2008
Structures on water's surface	Structure	Single device 15 m above water's surface and < 1 km from shore	Low, device will be visible from shore but only one device	High, will be present through life of project	Low, only a single device located in an industrial/urban area	Snohomish PUD 2008
	Navigation lights	Device will have navigational lights visible from 2 to 5 nm.	Low, device lights from a single device, will be visible from shore	High, device lights will be required throughout the life of the project	Low, lights only from a single device, location in industrial/ urban area ameliorates effect	Snohomish PUD 2008
Decommissioning						
Boat traffic	Navigation lights	Vessel lights will be visible along shipping lanes from Port of Tacoma to project site	Med, lights will be seen from shore	Low, decommissioning vessel traffic will occur over 1 to 2 years during summer	Low, boat lights visiblein shipping lanes in Tacoma Narrows but existing traffic ameliorates effect	Snohomish PUD 2008, USN 2008
Decommissioning of structures on water's surface or seabed	Deconstruction and deck lights	Deconstruction lights much brighter than vessel lights, will be visible from shore.	High, deconstruction lights brighter than navigation lights and may be visible 2 to 5 nm.	Low, deconstruction will occur over 1 to 2 years during summer	Med, lights may be visible from shore but location in industrial/ urban area ameliorates effect	IALA 2008, Snohomish PUD 2008

Potential effects on acoustic environment due to Pilot Scale MCT SeaGen project at Tacoma Narrows site

Project activity	Project action	Description of action's effect on site physical attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high or unknown)	Source(s)
Construction						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic will occur over 1 to 2 years during the summer	Low, noise could be elevated but short-term, pre-existing boat traffic in Puget Sound ameliorates effect	Austin et al. 2009, Snohomish PUD 2008
Construction of electrical collector system, moorings and foundations; device installation	Noise and vibration	Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, construction noise will occur over 1 to 2 years during the summer	Med, noise could be elevated but short-term, pre-existing noise in Puget Sound ameliorates effect	Austin et al. 2009
Directional drilling, and laying cable under/on seabed	Noise and vibration	Vibration of immediate area being drilled	Low, vibration could be localized, assuming similar to directional drilling on land	Low, drilling will occur for 1-2 weeks	Low, effect expected to be localized and short-term	CPUC 2009
Operation and Maintenance						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic infrequent during O&M	Low, elevated noise would occur infrequently, pre-existing boat traffic in Puget Sound ameliorates effect	Austin et al. 2009
Operation of turbines or other moving parts of devices	Noise and vibration	Adds to existing natural and man-made noise in project area	Unknown levels generated; site specific attenuation and ambient noise also unknown	High, noise would occur over life of the project	Unknown	Study warranted
Decommissioning						
Boat traffic	Noise and vibration	Propellers cavitate, causing pressure differences	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, vessel traffic will occur over 1 to 2 years during the summer	Low, noise could be elevated but short-term, pre-existing boat traffic in Puget Sound ameliorates effect	Austin et al. 2009
Decommissioning of structures on water's surface or seabed	Noise and vibration	Adds to existing natural and man-made noise in project area	High, modeled noise of 120 dB extended approx 20 km in ocean wind turbine project	Low, noise will occur over 1 to 2 years during the summer	Med, noise could be elevated but short-term, pre-existing noise in Puget Sound ameliorates effect	Austin et al. 2009

Potential effects on sediment and water chemistry due to Pilot Scale MCT SeaGen project at Tacoma Narrows site

Project activity	Project action	Description of action's effect on attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high)	Source(s)
Construction						
Boat traffic	Oil/chemical release, assumed seepage from exhaust and general use, not a spill from collision or other release	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	High, traffic and boat frequency will be the highest during construction	Low, given low spatial exposure and high pre-existing contaminants and boat traffic in Puget Sound	EVS 2003
Construction of electrical collector system, moorings and foundations; device installation	Oil/chemical release		Low, seepage will have a small spatial and areal extent relative to the project	Low, construction will occur over 2 months	Low, given low spatial and temporal extent and high pre-existing contaminants in Puget Sound	EVS 2003
Directional drilling, and laying cable under/on seabed (assume normal conditions, not a drilling mud "blow out" scenario)	Seabed disturbance	Sediment would be introduced into water column; deeper sediments with different chemistry brought to seabed surface	Low, cable length <1 nm	Low, increased sediment in water column would mix or dilute quickly.	Low, due to quick dilution of sediment in water column	Previsic 2009
Operation and maintenance						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to project	Low, O&M vessel traffic will be much less than during construction	Low, due to low spatial extent, low volume of vessel traffic during O&M, and high pre-existing contaminants in Puget Sound	EVS 2003
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Concrete footings are sources of alkaline elements (sodium, potassium) that could leach into water column	Low, effect would be localized to vicinity of concrete footings	High, any leaching would occur throughout life of project	Low, effects would be diluted and may not be measurable	Substructure [date unknown]
	Water circulation changes	Concrete footing could cause seabed erosion in lee of the footings	Low, effect would be localized to lee side of footings	High, any erosion occurring would be throughout the life of the project	Low, effect is localized although occurring over life of project	Largier et al. 2008
Structures on water's surface	Structure	Biofouling organisms slough off on to the seabed surface	Low, effect localized to seabed directly under devices	Low, antifouling paint and maintenance likely to remove organisms before sloughing	Low, effect is localized to immediate vicinity of seabed under devices	MMS 2007

Project activity	Project action	Description of action's effect on attribute	Spatial exposure of attribute (low, med, high)	Temporal exposure of attribute (low, med, high)	Overall risk to attribute (low, med, high)	Source(s)
Decommissioning						
Boat traffic	Oil/chemical release, assumed seepage from general use, not a spill from collision	Could add compounds that change the physical and chemical characteristics of sediment and water	Low, seepage will have a small spatial and areal extent relative to the project	High, traffic and boat frequency will be the high during decommissioning	Low, given low spatial extent and high pre-existing boat traffic and contaminants in Puget Sound	EVS 2003
Decommissioning of structures on water's surface or seabed	Oil/chemical release			Low, decommissioning will occur over 2 months	Low, given low spatial and temporal extent and high pre-existing contaminants in Puget Sound	EVS 2003
	Seabed disturbance	Sediment would be introduced into water column when removing footings and/or subsea cable	Low, cable length <1 nm	Low, increased sediment in water column would mix or dilute quickly.	Low, due to quick dilution of sediment in water column	Previsic 2009

Potential effects on Gray Whales due to Pilot Scale MCT SeaGen project at Tacoma Narrows site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic including subsea cable laying vessel	Direct impact	Collision injuries	High, boat traffic crosses migration path along the coast	Low, occurring during summer for 1 to 2 years	Low, effects' spatial extent small compared to animal's range	Low; acclimation likely due to high boat traffic; gray whale-boat collisions not uncommon	Calambokidis et al. 2002, Sullivan et al. 1983, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of envir. cues, communication signals	Med to high, sound travels far, animals will hear outside project area	Low, occurring during summer for 1 to 2 years	Low, effect influences small part of large range	Low; likely tolerate vessel noise due to high levels in Puget Sounds	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Low, low volume of fluids released; medium for PCFA whales due to potentially increased contamination levels	Low, occurring during 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Low, significant increase in existing traffic but volume of fluids released low.	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
	Construction lights	Avoidance	Low, not likely to be attracted to lighted areas	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; high levels of shoreline development, boat traffic, industry in Puget Sound	Todd et al. 2009
	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Low to med, sound travels far and animals will hear it outside project area, but affected area small part of range	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; spp. likely displaced if noise high; displacement area small portion of range and short duration	Richardson and Wursig 1997

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Low to med, sound travels far and animals will hear it outside project area, affected area small part of range	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; see above	Richardson and Wursig 1997
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Low, boat traffic crosses migration path along the coast but frequency is low	Med, occurs in summer during northward migration	Low, effects' spatial extent small compared to animal's range	Low; insignificant increase in traffic over existing (235,000 vessels /yr) in Puget sound; gray whale-boat collisions not uncommon	USCG [date unknown], Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, breathing exhaust fumes, overall accumulation of toxins.	Low, low volume of fluids released; could increase contaminant levels for PCFA whales	Med, throughout project duration but not likely to be year round action	Low, effects' spatial extent small compared to animal's range	Low; exposure are small relative to range; inputs compound elevated background levels	Ebbert et al. 2000
	Noise and vibration	Avoidance, masking of environmental cues, communication signals	Low, sound travels far, animals will hear outside project area, but affects small part of large range	Low, maintenance via boats occurring infrequently but during summer	Low, effects' spatial extent small compared to animal's range	Low; insignificant increase in boat traffic over existing (235,000 vessels/yr in Puget sound)	Morton and Symonds 2002
Operation of turbines, rotation of rotors, or other moving parts of devices	Direct impact	Direct injury or mortality; secondary mortality due to infection, loss of mobility, secondary complications, predation	Low, areas of movement small (~1%) compared to channel area (approximated channel width x average depth)	High, the movement occurs over the life of the project	High while foraging, traveling	High; significant risk of rotor strike – may be less detectable than ship rotor due to slower speed; strike at 12 m/s will cause serious trauma	Dadswell and Rulifson 1994, Todd et al. 2009, Wilson et al. 2007
	Noise and vibration	Avoidance, masks environmental cues, communication signals	Unknown, sound travels far and animals will hear outside project area, affects small part of large range	Med, occurring throughout the duration of the project	Low; effect not expected to extend beyond immediate area around turbine	Unknown; could mask environmental cues near turbine (<70m); acclimation likely due to ambient industrial noise	Richardson and Wursig 1997

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with derelict gear caught on devices; artificial reef effects could attract fish, increase forage, and attract species	Low, home range is large compared to project area;	High, occurring throughout project duration.	Low, effects' spatial extent small compared to animal's range	Unknown; risk of entanglement in derelict gear unknown	
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding provides some attenuation	High if there is an effect, would continue over life of project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, area is small compared to home range	High, occurring throughout project duration	Low; no effect expected	Low; no risk expected	
	Navigation lights	Low intensity; likelihood of impacts low to none	Low, associated with nav lights on devices	High, occurring throughout project duration	Low, light intensity low	Low; high levels of shoreline development, boat traffic, industry in Puget Sound	Todd et al. 2009
Decommissioning							
Boat traffic	Direct impact	Collision injuries	High; boat traffic crosses migration path along the coast	Low – Med depending on timing of construction *	Low, effects' spatial extent small compared to animal's range	Low; exposure area small relative to range; acclimation likely due to high boat traffic; gray whale-boat collisions not uncommon	Calambokidis et al. 2002, Sullivan et al. 1983, Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masks environmental cues, communication signals	Low, sound travels far, animals will hear it outside project area, but affects small part of range	Low, occurring only during early months of 1 to 2 summers,	Low, effect influences small part of large range	Low; likely to tolerate vessel noise due to high levels of background noise in Puget Sound	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Low, low volume of fluids; could increase contaminant levels for PCFA whales	Low, occurring only during 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning and removal of electrical collector system, subsea cable, mooring cables, foundations or anchors, and devices	Noise and vibration	Avoidance, masks environmental cues, communication signals	Low-med, sound travels far, animals will hear it outside of project area, but affects small part of range	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; likely displaced from by high sound levels; displacement area small portion of range	Richardson and Wursig 1997
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Med, sig. potential increase for exposure from leakage of chemicals	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
	Construction lights	Avoidance	Low – not likely to be attracted to lighted areas	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; high levels of shoreline development, boat traffic, industry in Puget Sound	Todd et al. 2009

Potential effects on Northern sea lion due to Pilot Scale MCT Seagen project at Tacoma Narrows site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	Low-med; increase in boat traffic between project site and dock	Low, occurring over ~ 2 months	Med; males of the species only normally present during non-summer months	Med; increase in boat traffic compared to existing (~235,000 vessels/yr)	Calambokidis and Baird 1994; Stroud and Roffe 1979, USCG [date unknown]
	Noise and vibration	Reduction of hearing sensitivity (Temporary Threshold Shift), could increase predation	Low-med, increase in boat traffic between project site and dock; sound potentially detectable (~3km)	Low, occurring over ~ 2 months	Low-med; related to foraging, travel and predation	Low; noise not sig. more than background; not likely a threat unless animals approach vessels	Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med, significant increase in existing traffic but volume of fluids released low	Low, occurring over ~ 2 months	Low; inputs insignificant relative to background levels in Puget Sound	Low; low volume of contaminants expected	Ebbert et al. 2000, Hall 2003 & refs therein
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance of area, affects foraging and travel, haul out; TTS could increase predation	Med; increase in industrial activity, pre-existing noise levels expected to be high	Low, occurring over ~ 2 months	Low due to foraging and traveling near construction site	Low; could impact hearing if sea lions near; high ambient noise levels	Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med; significant increase in use of chemicals, volume of fluids released	Low, occurring over ~ 2 months	Low; inputs insignificant relative to background levels in Puget Sound	Low; low volume of contaminants expected	Ebbert et al. 2000, Hall 2003 & refs therein
	Construction lights (bright deck lights and spotlights)	May be attracted increasing other impacts, could enhance foraging on prey attracted to light	Med to high	Low, occurring over ~2 months	Low; possibly affecting travel and foraging at night	Low; exposure low relative to range; short duration of construction	Yurk and Trites 2000
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, affects foraging and travel, resting onshore in Bay	Low, activities focused nearshore; localized around support vessels when offshore	Low, occurring over ~2 months	Low, activities focused nearshore	Low; increase in noise but high ambient noise levels	Kastak et al. 2005, Tougaard et al. 2009
Operation and Maintenance							

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic.	Direct impact	Collision injuries	Medium, increase in existing traffic (especially in bay and jetties)	Medium, occurring during summer for life of the project	Low; low if during summer when animals are rare; med if during non-summer	Low; boat traffic not significantly more than existing (~235,000 vessels/yr)	Calambokidis and Baird 1994, Stroud and Roffe 1979, USCG [date unknown]
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Low, slight increase in existing traffic but volume of fluids released low	Med, maintenance occurs over life of project during summer	Low; inputs insignificant relative to background levels	Low; low volume of contaminants expected	Ebbert et al. 2000, Hall 2003 & refs therein
	Noise and vibration	TTS, resulting in potential increased in predation	Med, noise will be heard past project area (~3km) but increase in traffic slight.	High, occurs during summer months over project duration	Low for adults/ subadults effects on foraging and travel; med for juv., may increase predation	Low; not likely a threat unless animals approach vessels	Kastak et al. 2005, Tougaard et al. 2009, USCG [date unknown]
Operation of turbines or other moving parts of devices	Direct impact	Direct injury or mortality; secondary mortality due to infection, loss of mobility, predation	Low, the areas of movement are small (~1%) compared to channel area (approximated channel width x average depth)	High, the movement occurs over the life of the project	High for any animals foraging or traveling in Tacoma narrows	High; sig. risk of rotor strike– may be less detectable than ship rotor due to slower speed; strike at 12 m/s will cause serious trauma	Dadswell and Rulifson 1994, Wilson et al. 2007
	Noise and vibration	Reduction of hearing sensitivity could increase predation, avoidance, mask of envir. cues	Likely to extend beyond project area; other pinnipeds show auditory response at ~3km.	High, if effect occurs, movement occurs over the life of the project	Low; foraging and traveling in project area; sounds not expected to result in sig. increase	Unknown; not likely a threat unless animals close to structures	Kastak et al. 2005, Koschinski et al. 2003, Tougaard et al. 2009
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with derelict gear caught on devices; artificial reef effects could attract fish and species	Low, currently not much structure nearby but home ranges are large.	High, structure present over life of project	Med, possibly beneficial effect by increasing forage	Unknown; structure easily avoided but could lure sea lions into rotor path in pursuit of prey	Schusterman and Balliet 1970, Todd et al. 2009
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding provides some attenuation	High if an effect, it would occur over life of the project	Unknown; any effects would likely impact all age classes	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures on water's surface	Structure	Could provide haul out structure; attract sea lions and increase potential impacts	Limited to above surface structures	High, structure present over life of project	Low; structure not suitable for haul out	Low; risk if animals attracted to structure in search of haul out	Jeffries et al. 2000
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, lights associated with devices and buoys are low intensity, affecting a small area	High, lights would be on over the life of the project	Low; not expected to effect nocturnal foraging due to high pre-existing light levels	Low; ambient light levels high; nav lights dim and similar to those on other structures and vessels	USCG [date unknown]
Decommissioning							
Boat traffic	Direct impact	Collision injuries	Low-med; moderate relative increase in boat traffic between project site and dock	Low, occurring over ~ 2 months	Low-med; males only normally present during non-summer	Low; increase in boat traffic than existing (~235,000 vessels/yr)	Calambokidis and Baird 1994, Stroud and Roffe 1979, USCG [date unknown]
	Noise and vibration	Reduction of hearing sensitivity (TTS); may increase predation	Low-med, moderate increase in boat traffic; sound may be detectable (~3km)	Low, occurring over ~ 2 months	Low; related to foraging, travel and predation	Low; noise not more than background	Kastak et al. 2005, Tougaard et al. 2009, USCG [date unknown]
	Oil/chemical release, assumes no catastrophic spills.	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med, significant increase existing traffic but the volume of fluids released low	Low, occurring over ~ 2 months	Low; inputs insignificant relative to background levels	Low; low volume of contaminants expected	Ebbert et al. 2000, Hall 2003 & refs therein
Decommissioning and removal of electrical collector system, subsea cable, mooring cables, foundations or anchors, and devices	Noise and vibration	Avoidance of area, affects foraging, travel, resting onshore; could increase predation	Med; increase in industrial activity, pre-existing noise levels expected to be high	Low, occurring over ~ 2 months	Low due to foraging and traveling near construction site	Low; could impact hearing; high ambient noise levels	Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release, assumes no catastrophic spills.	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Med; significant increase in use of chemicals, volume of fluids released low	Low, occurring over ~ 2 months	Low; inputs insignificant relative to background levels	Low; low volume of contaminants expected	Ebbert et al. 2000, Hall 2003 & refs therein
	Deconstruction lights	If attracted could increase impacts, enhance foraging on prey attracted to light	Med to high	Low, occurring over ~2 months	Low; possibly affecting travel and foraging at night	Low; exposure low relative to range; short duration	Yurk and Trites 2000

Potential effects on harbor seal due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high unknown)	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	Med; low to moderate increase in high levels of pre-existing boat traffic	Low, occurring over 1 to 2 summers	Low for adults med for pups due to foraging and travel in construction zones; acclimation likely due to high boat traffic in Puget Sound	Low; increase in boat traffic; vessels similar to existing and do not represent new types of impacts	Stroud and Roffe 1979
	Noise and vibration	Avoidance, masks environmental cues. Reduction of hearing sensitivity (TTS) could increase predation	Med; moderate increase in boat traffic, pre-existing ambient noise levels expected to be high	Low, occurring over 1 to 2 summers	Low-med for adults med for pups; see above	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low; increase in existing traffic but the volume of fluids released low and pre-existing ambient levels high	Low, occurring over 1 to 2 summers	Low-med all age classes; inputs insignificant relative to background levels in Puget Sound	Low; volume of contaminants expected to be low and not significantly greater than background levels	Ebbert et al. 2000
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance of area, masking of environmental cues, TTS possible which could increase predation.	Med; moderate overall increase in industrial activity, pre-existing ambient noise levels expected to be high	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in construction zone; acclimation likely due to high industrial noise in Puget Sound	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase in use of chemicals; low volume of fluids released	Low, occurring over 1 to 2 summers	Low	Low; volume of contaminants expected to be low and not significantly greater then existing background levels	Ebbert et al. 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Low; increase in high levels of boat traffic, deck lights illuminate only a small area	Low, occurring over 1 to 2 summers	Low all age classes due to shoreline development, boat traffic, and industrial activity in Puget Sound	Low; vessels and construction activities similar to existing and do not represent new types of impact	Yurk and Trites 2000
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, masks environmental cues, TTS possible which could increase predation	Med, seals likely to avoid areas occupied by cable and support vessels	Low, occurring over 1 summer	Low all age classes; avoidance of construction area occupied by cable ship and support vessels	Low; activities highly localized and short term; seals likely to acclimate and tolerate noise	Kastak et al. 2005, Tougaard et al. 2009
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Med; low to moderate increase in already high levels of pre-existing boat traffic	Med, routine maintenance occurs over life of the project	Low; boat traffic infrequent relative to pre-existing traffic in Puget Sound	Low; vessels similar to existing fleet(s) and do not represent new types of impacts	Stroud and Roffe 1979
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low; increase in existing traffic but the volume of fluids released low and pre-existing ambient levels high	Med, routine maintenance occurs over life of the project	Low all age classes; inputs insignificant relative to background levels in Puget Sound	Low; low volume of contaminants expected and not significantly greater than background	Ebbert et al. 2000
	Noise and vibration	Avoidance of area, masks environmental cues, TTS possible which could increase predation	Med; moderate increase in boat traffic, pre-existing ambient noise levels high	Med, routine maintenance occurs over life of the project	Low for adults; med for pups due to foraging and travel in turbine and transport zones; acclimation likely due to high levels of boat traffic in Puget Sound	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high unknown)	Source(s)
Operation of turbines, rotation of rotors, or other moving parts of devices	Direct impact	Direct injury or mortality; secondary mortality due to infection, loss of mobility, secondary complications, predation	Low, the areas of movement are small (~1%) compared to channel area (approximated channel width x average depth)	High, the movement occurs over the life of the project	High for all age classes	High; significant risk of rotor strike due to rotational speed – may be less detectable then ship rotor due to slower speed; strike at 12 m/s (~27 mph) will cause serious trauma	Dadswell and Rulifson 1994, Wilson et al. 2007
	Noise (cavitation off rotor) and vibration	Avoidance of area, masks environmental cues, TTS possible which could increase predation	Turbine sound propagated over sig. distance (~3 km); behavioral reaction likely at close range (<15M)	High, any effect would be constant over project	Low for all age classes; harbor seals can detect low-freq. sounds at great distances; acclimation likely due to noise in Puget Sound	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with derelict gear caught on devices; artificial reef effects could attract fish, increase forage, and attract species	Low, abundant man-made structures nearby; home ranges large - harbor seal pup home range 10.4 km^2 and adults travel range is 30-45 km.	High, structure present over life of project duration	Med, effect overlaps with all age classes foraging and traveling in Puget Sound	Unknown; structure readily avoided unless turbidity high enough to decrease visual acuity; high if structures lure seals into path of rotors in pursuit of prey	Dadswell and Rulifson 1994, Herder 1986, Wilson et al. 2007
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect, it would occur over life of the project	Unknown; any effects would likely impact all age classes	Unknown	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, no haulout potential	High, structure present over life of project	Low for all age classes; harbor seals do no haul out on such structures	Low, structure easily avoided; similar to existing navigation buoys; not suitable for hauling out	Schusterman and Balliet 1970
	Navigation lights	Visual disorientation; could lure seals into path of rotors if prey species attracted to lights	Low, device lights of low intensity, shielded	High, lights shining over life of the project	Low for all age classes due to high levels of pre-existing light levels in Puget Sound.	Low; lights similar to existing navigation buoy lights; significant ambient light	Yurk and Trites 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high unknown)	Source(s)
Decommissioning							
Boat traffic	Direct impact	Collision injuries	Med; low to moderate increase in already high levels of existing boat traffic	Low, occurring over 1 to 2 summers	Low for adults; med for pups due to foraging and travel in construction zones; acclimation likely due to high boat traffic in Puget Sound	Low; vessels similar to existing fleet(s) and do not represent new types of impacts	Stroud and Roffe 1979
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins.	Low; increase in existing traffic but low volume of fluids released and pre-existing levels high	Low, occurring over 1 to 2 summers	Low all age classes; additional inputs insignificant relative to background levels in Puget Sound	Low; low volume of contaminants expected and not significantly greater than background	Ebbert et al. 2000
	Noise and vibration	Avoidance of area, masks environmental cues, TTS possible which could increase predation	Med; moderate increase in boat traffic, pre-existing ambient noise levels expected to be high	Low, occurring over 1 to 2 summers	Low for adults med for pups due to foraging and travel in and near construction zones; acclimation & likely due to boat traffic in Puget Sound	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
Decommissioning and removal of electrical collector system, subsea cable, mooring cables, foundations or anchors, and devices	Noise and vibration	Avoidance of area, masks environmental cues, TTS could increase predation	Med; moderate overall increase in industrial activity, pre-existing ambient noise levels expected to be high	Low, occurring over 1 to 2 summers	Low-med for adults med for pups; see above	Low; similar species (*Phoca hispida*) show considerable tolerance to similar types of noise	Blackwell et al. 2004, Kastak et al. 2005, Tougaard et al. 2009
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, but could also enhance foraging on species attracted to light	Low; moderate increase in already high levels of boat traffic vessel, deck lights illuminate only a small area	Low, occurring over 1 to 2 summers	Low all age classes due to high shoreline development, boat traffic, and industrial activity in Puget Sound	Low; vessels and construction similar to existing activities and do not represent new types of impact	Yurk and Trites 2000
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, significant increase in use of chemicals released low, high pre-existing levels	Low, occurring over 1 to 2 summers	Low all age classes; inputs insignificant relative to pre-existing levels in Puget Sound	Low; volume of contaminants expected to be low and not sig. greater than background	Ebbert et al. 2000

Potential effects on Killer Whales due to Pilot Scale MCT SeaGen project at Tacoma Narrows site

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Direct impact	Collision injuries	Low, significant increase in existing traffic but in a small area of their large range.	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; small area of exposure relative to home range; acclimation and avoidance likely due to high boat traffic in Puget Sound; killer whale-boat collisions not uncommon	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low, sound travels far, animals will hear noises outside of project area, but affects a small part of large range	Low, occurring over 1 to 2 summers	Low, small part of large range.	Low; may be displaced by high amplitude sound; background noise levels high; short duration	Morton and Symonds 2002
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low, significant increase in existing traffic but volume of fluids released low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; additional inputs insignificant relative to background levels	Ebbert et al. 2000
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear outside project area, but affects a small part of large range	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; may be displaced by high amplitude noise; displacement area small portion of range	Morton and Symonds 2002
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, t increase in use of chemicals, fuels, solvents, grease; ambient levels elevated	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; additional inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; high levels of shoreline development, boat traffic, industrial activity in Sound	USCG [date unknown]
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; likely displaced from area if noise levels high; displacement area small portion of range and short duration	Morton and Symonds 2002
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Low, slight increase in existing traffic in small area of their large range.	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; insignificant increase in boat traffic (235,000 vessels/yr); killer whale-boat collisions not uncommon	USCG [date unknown], Van Waerebeek and Leaper 2008
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low, increase in existing traffic but the volume of fluids released low	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; area of exposure small relative to range; inputs compound elevated levels in Puget Sound	Ebbert et al. 2000
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside of project area, but affects a small part of large range	High, traffic will occur over life of the project in summer	Low, effects' spatial extent small compared to animal's range	Low; insignificant increase in boat traffic over existing levels (235,000 vessels/yr in Puget sound)	Morton and Symonds 2002

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines, rotation of rotors, or other moving parts of devices	Direct impact	Direct injury or mortality; secondary mortality due to infection, loss of mobility, secondary complications, predation	Low, the areas of movement are small (~1%) compared to channel area (approximated channel width x average depth)	High, the movement occurs over the life of the project	High for all age classes while foraging, traveling; increasingly significant impact if killer whales attracted to prey species attracted to structure	High; significant risk of rotor strike – may be less detectable then a ship rotor due to slower rotational speed; direct strike at 12 m/s (~27 mph) will cause serious trauma	Dadswell and Rulifson 1994, Wilson et al. 2007
	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Turbine sound will likely produce behavioral reaction at close range (< 15m; detectable at 70m)	High, any effect would be constant over life of project	Low for all age classes; effect not expected to extend beyond immediate area around turbine	Unknown; could mask cues near turbine (<70m); acclimation likely due to ambient noise in Puget Sound	Morton and Symonds 2002
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with derelict gear caught on devices; artificial reef effects could attract fish and species	Low, home range large compared to project area; may create new habitat relative to habitat already there	High, any positive or negative effects would occur over the life of the project.	Low-med, structure readily avoided; loose or unattached cables	Unknown; may attract killer whales if structures concentrate pinnipeds pursuing fish prey	Relini et al. 2000
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if an effect because electricity generated over life of the project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision, artificial reef effects could attract fish, sea lions, small odontocetes	Low, reef effect area is small compared to home range	High, any effects would occur over the life of the project.	Low, may incrementally increase forage as marine reserve	Low; structure readily avoided	
	Navigation lights	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Low, device lights are low intensity and shielded	High, lights shining over life of the project	Low, light intensity low	Low due to high shoreline development, boat traffic and industry in Puget Sound	USCG [date unknown]

Project activity	Project action	Description of action's effect on indicator	Spatial exposure on indicator (low, med, high)	Temporal exposure on indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning							
Boat traffic	Direct impact	Collision injuries	Low, significant increase existing traffic in small area of their large range.	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; acclimation and avoidance likely due to existing traffic; killer whale-boat collisions not uncommon	Van Waerebeek and Leaper 2008
	Noise and vibration	Avoidance, masks environmental cues, communication signals, echolocation	Low-Med, sound travels far, animals will hear it outside project area, but affects small part of large range	Low, occurring over 1 summer	Low, small part of large range.	Low; may be displaced by high amplitude sound; background noise levels high; short overall duration	Morton and Symonds 2002
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low, significant increase existing traffic but the volume of fluids released low	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; additional inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
Decommissioning and removal of electrical collector system, subsea cable, mooring cables, foundations or anchors, and devices	Noise and vibration	Avoidance, masking of environmental cues, communication signals, echolocation	Low-Med, sound travels far, will hear it even if they never approach, but small part of large range	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; may be displaced by high amplitude noise; displacement area represents small portion of range	Morton and Symonds 2002
	Oil/chemical release	Ingestion, breathing exhaust fumes, accumulation of toxins.	Med, increase in use of chemicals, solvents, fuels, grease; ambient levels elevated	Low, occurring over 1 to 2 summers	Low, effects' spatial extent small compared to animal's range	Low; additional inputs insignificant relative to background	Ebbert et al. 2000
	Deconstruction lights (deck work lights and spotlights, vessel navigation lights)	Visual disorientation could lead to collision, could also enhance foraging on species attracted to light	Unknown	Low, occurring over 1 summer	Low, effects' spatial extent small compared to animal's range	Low; high levels of shoreline development, boat traffic and industry in Puget Sound	USCG [date unknown]

Potential effects on harbor porpoise and Dall's porpoise due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high unknown	Source(s)
Construction							
Boat traffic, assumed to occur day and night	Direct impact	Collision injuries	Med; low to moderate increase in already high levels of pre-existing boat traffic.	Low, occurring over 1 to 2 summers	Low for adults; med for calves due to foraging and travel in construction and transport zones	Low; area of exposure small relative to home range; acclimation and avoidance likely due to high boat traffic; boat collisions with harbor porpoise infrequent	Stroud and Roffe 1979
	Noise and vibration	Avoidance, masks environmental cues. Reduction of hearing sensitivity (TTS), could increase predation	Med; moderate increase in boat traffic, pre-existing ambient noise levels expected to be high	Low, occurring over 1 to 2 summers	Low for adults; med for calves due to foraging and travel in construction and transport zones	Low; acclimation and tolerance likely due to pre-existing boat traffic noise in Puget Sound; short duration	Tougaard et al. 2009
	Oil/chemical release	Ingestion, fur fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low; increase in traffic but the volume of fluids released low and ambient levels high	Low, occurring over 1 to 2 summers	Low; area of potential exposure small relative to home range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
Construction and installation of electrical collector system, mooring cables, anchors or foundations, and devices	Noise and vibration	Avoidance of area, masking of environmental cues, TTS could increase predation.	Med; moderate increase in industrial activity, high pre-existing noise levels	Low, occurring over 1 to 2 summers	Low-med for adults med for calves due to foraging and travel in construction zone	Low; acclimation likely due to high levels of boat traffic in Puget Sound;	Blackwell et al. 2004, Kastak et al. 2005, Todd et al. 2009, Tougaard et al. 2009
	Oil/chemical release	Ingestion, skin fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, increase in use of chemicals; volume of fluids released low, pre-existing levels high	Low, occurring over 1 to 2 summers	Low to med; area of potential exposure is small relative to home range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
	Construction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, enhance foraging on species attracted to light	Low; area affected by lights small relative to home range	Low, occurring over 1 to 2 summers	Area affected by lights small relative to home range	Low due to high levels of shoreline development, boat traffic and industrial activity in Sound	Todd et al. 2009

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high unknown	Source(s)
Directional drilling, and laying cable under/on seabed	Noise and vibration	Avoidance of area, masking of envir. cues, TTS could increase predation	Med, porpoises likely to avoid areas occupied by cable and support vessels	Low, occurring over 1 summer	Low; avoidance of construction area occupied by cable ship and support vessels	Low; could concentrate impacts nearshore; disruption of movement along shore	Kastak et al. 2005, Koschinski et al. 2003, Tougaard et al. 2009
Operation and Maintenance							
Boat traffic	Direct impact	Collision injuries	Med; low to moderate increase in already high levels of pre-existing boat traffic	Med, routine maintenance occurs over life of the project	Low; O&M boat traffic infrequent relative to pre-existing traffic in Puget Sound	Low; area of exposure small relative to home range; acclimation likely due to high levels of existing boat traffic; boat collisions with porpoise infrequent	Stroud and Roffe 1979
	Noise and vibration	Avoidance of area, masking of environmental cues, TTS possible which could increase predation	Med; moderate increase in boat traffic, pre-existing ambient noise levels high	Med, routine maintenance occurs over life of the project	Low adults, med for calves due to foraging and travel in and near turbine and transport zones	Low; acclimation likely due to high levels of pre-existing boat traffic noise in Puget Sound; short overall duration	Tougaard et al. 2009
	Oil/chemical release	Ingestion, skin fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Low; increase in traffic but volume of fluids released low and pre-existing levels high	Med, routine maintenance occurs over life of the project	Low	Low; additional inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
Operation of turbines, rotation of rotors, or other moving parts of devices	Noise and vibration	Avoidance of area, masking of environmental cues, TTS possible which could increase predation	Turbine sound could produce behavioral reaction at close range (< 15m; detectable at 70m); high pre-existing noise levels expected	High, any effect would be constant over life of project	Low-med for all age classes; effect not expected to extend beyond immediate area around turbine	Unknown; porpoises less sensitive to low-freq. sounds and generated noise likely inaudible at >100m; acclimation likely due to noise in Sound	Blackwell et al. 2004, Kastak et al. 2005, Koschinski et al. 2003, Tougaard et al. 2009

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high unknown	Source(s)
	Direct impact	Injury or mortality; secondary mortality due to infection, loss of mobility, predation	Low, areas of movement small (~1%) compared to channel area (approximated channel width x average depth)	High, the movement occurs over the life of the project	High for all age classes while foraging, traveling; greater impact if porpoises attracted to prey species attracted to structure	High; significant risk of rotor strike – may be less detectable then a ship rotor due to slower rotational speed; direct strike at 12 m/s will likely cause serious trauma	Dadswell and Rulifson 1994, Todd et al. 2009, Wilson et al. 2007
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Entanglement with derelict gear caught on devices; artificial reef could attract fish and attract species	Low, abundant man-made structures nearby; home range large (> 200 km^2)	High, structure present over life of project	Med; potential impacts while foraging, if attracted to prey concentrated around structure	Unknown; structure is readily avoided with echolocation; but could lure porpoises in pursuit of prey	Todd et al. 2009
Electricity conduction through cable	EMF	Unknown	Unknown, cable shielding and burial provides some attenuation	High if there is an effect, it would occur over life of the project	Unknown	Unknown; High uncertainty about effects on marine mammals	Boehlert et al. 2008
Structures on water's surface	Structure	Collision	Low, no haulout potential	High, structure present over life of project	Low, structure easily avoided with echolocation; similar to existing navigation buoys	Low; structure similar to other structures in Puget Sound; above water structure immobile	Hatakeyama and Soeda 1990
	Navigation lights	Visual disorientation; could lure porpoises into path of rotors if prey attracted to lights	Low, device lights of low intensity, shielded, intended for navigation safety	High, lights shining over life of the project	Low; area affected small relative to home range; may enhance foraging on prey attracted to lights	Low due to high levels of shoreline development, boat traffic and industrial activity in Sound	Todd et al. 2009
Decommissioning							
	Direct impact	Collision injuries	Med; low to moderate increase in already high levels of existing boat traffic	Low, occurring over 1 to 2 summers	Low for adults; med for calves due to foraging and travel in and near construction and transport zones	Low; exposure area small relative to home range; avoidance likely due to existing boat traffic; boat collisions with harbor porpoise infrequent	Stroud and Roffe 1979

Project activity	Project action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat, or resource (low, med, high)	Overall risk to indicator (low, med, high unknown	Source(s)
Boat traffic	Oil/chemical release	Ingestion, skin fouling, breathing exhaust fumes, accumulation of toxins.	Low; increase in traffic but low volume of fluids released and pre-existing levels high	Low, occurring over 1 to 2 summers	Low; area of potential exposure small relative to home range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000
	Noise and vibration	Avoidance, masks environmental cues. TTS could increase predation	Med; moderate increase in boat traffic, pre-existing noise levels expected to be high	Low, occurring over 1 to 2 summers	Low for adults; med for calves due to foraging and travel in construction and transport zones	Low; acclimation and likely due to high levels of boat traffic noise in Puget Sound; short overall duration	Tougaard et al. 2009
Decommissioning and removal of electrical collector system, subsea cable, mooring cables, foundations or anchors, and devices	Noise and vibration	Avoidance, masks environmental cues. TTS, resulting in potential increase in predation	Med; moderate overall increase in industrial activity, pre-existing noise levels expected to be high	Low, occurring over 1 to 2 summers	Low for adults; med for calves due to foraging and travel in and near construction zone;	Low; acclimation and tolerance likely due to high levels of pre-existing boat traffic in Puget Sound	Blackwell et al. 2004, Kastak et al. 2005, Todd et al. 2009, Tougaard et al. 2009
	Deconstruction lights, vessel deck lights and spotlights.	Visual disorientation could lead to collision, could enhance foraging on species attracted to light	Low; moderate increase in existing boat traffic, deck lights illuminate only a small area	Low, occurring over 1 to 2 summers	Low; Area affected by lights small relative to home range	Low; high levels of shoreline development, boat traffic, and industry in Puget Sound	Todd et al. 2009
	Oil/chemical release	Ingestion, skin fouling, breathing exhaust fumes, accumulation of toxins. Assumes no catastrophic spills.	Med, increase in use of chemicals; volume of fluids released low, pre-existing levels high	Low, occurring over 1 to 2 summers	Low to med; area of potential exposure is small relative to home range	Low; inputs insignificant relative to background levels in Puget Sound	Ebbert et al. 2000

Potential effects on sharks, skates, and rays due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Nelson 2008
	Construction lights	Sharks may be attracted due to prey aggregation	Low, see above	Low, occurs over 2 months	Med, if sharks attracted to project area	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, see above	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Nelson 2008
	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species present but able to avoid disturbance area	Low	Cada 2008
Operation of turbines or other moving parts of	Moving device parts	Possible collision with turbines	Low, see above	High, would be continuous for life of project	Med, species present in project area	Unknown	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
devices	Noise and vibration	Possible altered behavior	Low, see above	High, would be continuous for life of project	Low, species present but able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, prey of these species not attracted to subsurface structures	N/A	N/A	N/A	Low	
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible changes in orientation, behavior	Low, see above	High, would be continuous for life of project	Med, species present in project area	Unknown	Nelson 2008
Structures on water's surface	Structure	Could attract prey (FAD effect) and/or pinniped haul-out and attract sharks	Low, see above	High, would be continuous for life of project	Med, sharks present in project area	Unknown	Nelson 2008
	Navigation lights	Sharks may be attracted due to prey aggregation	Low, see above	High, would be continuous for life of project	Med, sharks present in project area	Unknown	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, see above	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column while oil floats on surface	Low	Nelson and Woo 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	
	Deconstruction lights	Sharks may be attracted due to prey aggregation	Low, see above	Low, occurs over 2 months	Med, sharks present in project area	Low	Nightingale et al. 2006

Potential effects on flatfishes due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, flatfishes able to avoid disturbance area	Low	Nelson 2008
	Construction lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, flatfishes able to avoid disturbance area	Low	Nelson 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Operation of turbines or other moving parts of devices	Moving device parts	None, flatfishes occur on bottom, would not collide with turbines	N/A	N/A	N/A	Low	N/A
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible reef effect, changes in predator/ prey interactions	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, flatfishes in sand/gravel habitat where project located	Unknown	Boehlert et al. 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects to flatfishes unlikely, not known to have sensitive electroreceptive sense organs	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, flatfishes in sand/gravel bottom habitat where project located	Low	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, changes in predator/prey interactions	Low, see above	High, would be continuous for life of project	Low, flatfishes on bottom while effects on surface	Low	Boehlert et al. 2008
	Navigation lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
Decommissioning of structures on water's surface or seabed	Noise and vibration	None, flatfishes not very sensitive to sound	N/A	N/A	N/A	Low	Nedwell et al. 2004
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, flatfishes on bottom while oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, flatfishes able to avoid disturbance area	Low	Nelson 2008
	Deconstruction lights	None, flatfishes not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006

Potential effects on rockfishes, lingcod, and cabezon due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	None, species not present in sand/gravel bottom habitat where project located	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	None (see above)	N/A	N/A	N/A	Low	N/A
	Seabed disturbance	None (see above)	N/A	N/A	N/A	Low	N/A
	Construction lights	None (see above)	N/A	N/A	N/A	Low	N/A
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None (see above)	N/A	N/A	N/A	Low	N/A
	Noise and vibration	None (see above)	N/A	N/A	N/A	Low	N/A
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Operation of turbines or other moving parts of devices	Moving device parts	Collision with turbines unlikely, rockfishes occur on bottom	N/A	N/A	N/A	Low	
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, structures may attract species to project area	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Attraction to artificial reef, changes in fish community	Low, see above	High, would be continuous for life of project	Med, structures may attract species to project area	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Effects unlikely, species not known to have sensitive electroreceptive sense organs	Low, see above	High, would be continuous for life of project	Med, species may be present due to attraction to structure	Low	Nelson 2008
Structures on water's surface	Structure	Possible FAD effect, changes in predator/prey interactions	Low, see above	High, would be continuous for life of project	Low, species in water column or bottom	Unknown	N/A
	Navigation lights	None, species don't occur at surface	N/A	N/A	N/A	Low	N/A
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	None, species not likely to be affected	N/A	N/A	N/A	Low	N/A
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species may be present due to attraction to structure	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column or bottom but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	Habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species may be present due to attraction to structure	Low	Nelson 2008
	Deconstruction lights	None, species don't occur at surface	N/A	N/A	N/A	Low	N/A

Potential effects on forage fishes (herring, surf smelt, sand lance, and northern anchovy) due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to eggs at spawning grounds	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	High, spawning occurs at nearby beaches, intertidal, and subtidal zones	Low	Nelson and Woo 2008, Penttila 2007
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, fish have patchy distribution and able to avoid disturbance area	Low	Cada 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	High, spawning occurs at nearby beaches, intertidal, and subtidal zones	Low	Nelson and Woo 2008, Penttila 2007
	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, fish have patchy distribution and able to avoid disturbance area	Low	
	Construction lights	Aggregation, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species distribution patchy	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Temporary habitat loss, changes in prey resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, fish have patchy distribution and able to avoid disturbance area	Low	
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, fish have patchy distribution and able to avoid disturbance area	Low	Cada 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	High, spawning occurs at nearby beaches, intertidal, and subtidal zones	Low	Nelson and Woo 2008 Penttila 2007
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Collision with turbines	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species distribution patchy but does occur at 15 m depth of turbines	Low	Cardinale et al. 2003, Emmett et al. 2004
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, fish have patchy distribution and able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Reef effect, changes in predator/prey interactions	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species distribution patchy	Low	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	High, spawning occurs at nearby beaches, intertidal, and subtidal zones	Low	Nelson and Woo 2008, Penttila 2007
Electricity conduction through cable	EMF	Effects unlikely, species not known to have sensitive electroreceptive sense organs	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species distribution patchy	Low	Nelson 2008
Structures on water's surface	Structure	FAD effect, changes in predator/prey interactions	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species distribution patchy	Low	Nelson 2008
	Navigation lights	Aggregation, more vulnerable to predation	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species distribution patchy	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	High, spawning occurs at nearby beaches, intertidal, and subtidal zones	Low	Nelson and Woo 2008, Penttila 2007
	Noise and vibration	None, species too motile to be affected	N/A	N/A	N/A	Low	N/A
Decommissioning of structures on water's surface or	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, fish have patchy distribution and able to avoid disturbance area	Low	Cada 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
seabed	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	High, spawning occurs at nearby beaches intertidal, and subtidal zones	Low	Nelson and Woo 2008, Penttila 2007
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction lights	Aggregation, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species distribution patchy	Low	Nightingale et al. 2006

Potential effects on juvenile salmonids due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Construction and deck lights	Behavioral changes, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, species present in area and could be attracted to lights	Med	Nelson 2008, Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, these species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species present but able to avoid disturbance area	Low	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Collision with turbines	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, most juvenile salmon found from surface to 12 m depth, turbines are at 15 m depth	Unknown	Emmett et al. 2004
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species present but able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Reef effect, attraction of predators	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Possible behavior, orientation changes	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
Structures on water's surface	Structure	FAD effect, attraction of predators	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Navigation lights	Behavioral changes, more vulnerable to predation	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Med	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Decommissioning of structures on water's surface or	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
seabed	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction and deck lights	Behavioral changes, more vulnerable to predation	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, species present in area and could be attracted to lights	Med	Nightingale et al. 2006

Potential effects on adult salmonids due to Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Construction of electrical collector system, moorings and foundations, and device installation	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Construction lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Operation and Maintenance							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species present but able to avoid disturbance area	Low	Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Collision with turbines	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, most adult salmon in upper 10 m of water column, turbines at 15 m	Low	Olson and Quinn 1993, Ruggerone et al. 1990
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, species present but able to avoid disturbance area	Low	Cada 2008
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Attraction of predators (reef effect), more vulnerable to predation	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Toxicity to individuals and prey	Low, would occur in small area relative to species' range	Low, wouldn't persist long-term	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
Electricity conduction through cable	EMF	Behavior, orientation changes	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
Structures on water's surface	Structure	Attraction of predators (FAD effect), more vulnerable to predation	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species present in area in spring, summer and fall	Unknown	Nelson 2008
	Navigation lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006
Decommissioning							
Boat traffic	Oil/chemical release	Toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008
Decommissioning of structures on water's surface or	Noise and vibration	Possible altered behavior	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, species present but able to avoid disturbance area	Low	Cada 2008, Nelson 2008

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
seabed	Oil/chemical release	Toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, species in water column but oil floats on surface	Low	Nelson and Woo 2008
	Seabed disturbance	None, species too motile and near surface to be affected	N/A	N/A	N/A	Low	N/A
	Deconstruction lights	None, not known to be affected by lights	N/A	N/A	N/A	Low	Nightingale et al. 2006

Potential effects on diving ducks, loons, and grebes from Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, if done in winter when birds most abundant; low if in summer	Low	LGL Limited et al. 2009, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	Boehlert et al. 2008, SAS [date unknown]
	Construction lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over 2 months	Med, if done in winter when birds most abundant; low if in summer	Low	Boehlert et al. 2008, SAS [date unknown]
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, only from periodic trips	Med, boats could pass through foraging areas if done in winter	Low	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, only from periodic trips	Med, see above	Low	LGL Limited et al. 2009, SAS [date unknown]
Operation of turbines or other moving parts of devices	Moving device parts	Possible collision while diving	Low, see above	High, continuous for life of project	Med, will be present in winter when birds most abundant	Unknown	Boehlert et al. 2008, SAS [date unknown]
	Noise and vibration	Possible avoidance of project area	Low, see above	High, continuous for life of project	Med, see above	Low	Michel et al. 2007, SAS [date unknown]
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear	Low, see above	High, continuous for life of project	Med, birds could be attracted to structure	Unknown	Michel et al. 2007, SAS [date unknown]
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for catastrophic release from device failure	Med, continuous and intermittent for life of project	Low, could occur in winter when birds most abundant	Low	Michel et al. 2007, SAS [date unknown]
Structures on water's surface	Navigation lights	None, species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Structure	Possible attraction to increased prey (FAD effect), collision while flying	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, birds could be attracted to structure	Unknown	Boehlert et al. 2008, SAS [date unknown]
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, if done in winter when birds most abundant; low if in summer	Low	LGL Limited et al. 2009, SAS [date unknown]
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	LGL Limited et al. 2009, SAS [date unknown]
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Construction lights	None, these species not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med or low, see above	Low	Boehlert et al. 2008, SAS [date unknown]

Potential effects on cormorants from Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, boats could pass through foraging areas	Low	LGL Limited et al. 2009, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, see above	Low	Michel et al. 2007, SAS [date unknown]
Construction of electrical collector system, moorings/ foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Boehlert et al. 2008, SAS [date unknown]
	Construction lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Boehlert et al. 2008, SAS [date unknown]
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
Operation and Maintenance							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, see above	Low, only from periodic trips in summer	Med, boats could pass through foraging areas	Low	LGL Limited et al. 2009, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, see above	Low	Michel et al. 2007, SAS [date unknown]
Operation of turbines or other moving parts of devices	Moving device parts	Possible collision while diving	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, cormorants could be attracted to structures	Unknown	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible avoidance of project area	Low, see above	High, continuous for life of project	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear	Low, see above	High, continuous for life of project	Med, cormorants could be attracted to structures	Unknown	Michel et al. 2007, SAS [date unknown]
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for catastrophic release from device failure	Med, could be continuous and intermittent for life of project	Med, cormorants could be attracted to structures	Low	Michel et al. 2007, SAS [date unknown]
Structures on water's surface	Navigation lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Structure	Possible roosting habitat, attraction to increased prey (FAD effect), collision while flying	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, cormorants present in area year-round	Unknown	Michel et al. 2007, SAS [date unknown]
Decommissioning							

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, and boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, see above	Low	LGL Limited et al. 2009, SAS [date unknown]
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Boehlert et al. 2008, SAS [date unknown]
	Construction lights	None, cormorants not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006

Potential effects on gulls from Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	None, gulls follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	USFWS 2005
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]
Construction of electrical collector system, moorings/foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Construction lights	None, gulls not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
Directional drilling, and laying cable under/on seabed	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
Operation and Maintenance							
Boat traffic	Noise and vibration	None, gulls follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	USFWS 2005

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]
Operation of turbines or other moving parts of devices	Moving device parts	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005
	Noise and vibration	Possible avoidance of project area	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
Structures in water column and on seabed, such as devices and moorings and footings	Structure	None, gulls do not dive deep enough	N/A	N/A	N/A	Low	USFWS 2005
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic release from device failure	Med, could be continuous and intermittent for life of project	Med, species could be attracted to structures	Low	Michel et al. 2007, SAS [date unknown]
Structures on water's surface	Navigation lights	None, gulls not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Structure	Possible roosting on structures, collision while flying, attraction to increased prey (FAD effect)	Low, would occur in small area relative to species' range	High, would be continuous for life of project	Med, species could be attracted to structures	Unknown	Boehlert et al. 2008, SAS [date unknown]
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
	Noise and vibration	None, gulls follow boats and do not appear to be disturbed by boat noise	N/A	N/A	N/A	Low	USFWS 2005
Decommissioning of structures on water's surface or seabed	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	USFWS 2005
	Construction lights	None, gulls not known to be attracted to lights	N/A	N/A	N/A	Low	Montevecchi 2006
	Seabed disturbance	None, these are surface-feeders	N/A	N/A	N/A	Low	USFWS 2005

Potential effects on alcids and marbled murrelets from Pilot Scale MCT SeaGen project at Tacoma Narrows

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Construction							
Boat traffic	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, boats could pass through foraging areas	Low	LGL Limited et al. 2009, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large spill	Low, occurs over 2 months	Med, see above	Low	Michel et al. 2007, SAS [date unknown]
Construction of electrical collector system, moorings/foundation; installation of devices	Noise and vibration	Possible movement away from area and disruption of foraging or nesting	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Boehlert et al. 2008, SAS [date unknown]
	Construction lights	Attraction/ disorientation	Low, see above	Low, occurs over 2 months	Low, see above	Low	Montevecchi 2006, SAS [date unknown]
Directional drilling, and laying cable under/on seabed	Seabed disturbance	Possible short-term changes in food resources	Low, see above	Low, occurs over 2 months	Low, see above	Low	Boehlert et al. 2008, SAS [date unknown]
	Noise and vibration	Possible movement from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
Operation and Maintenance							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, wouldn't persist long-term	Med, boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, only from periodic trips in summer	Med, see above	Low	LGL Limited et al. 2009, SAS [date unknown]

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Operation of turbines or other moving parts of devices	Moving device parts	Possible collision while diving	Low, see above	High, continuous for life of project	Med, alcids present year-round and could be attracted to structure	Unknown	Boehlert et al. 2008, SAS [date unknown]
	Noise and vibration	Possible avoidance of project area	Low, see above	High, continuous for life of project	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
Structures in water column and on seabed, such as devices and moorings and footings	Structure	Possible attraction to increased prey (reef effect), entanglement with derelict fishing gear	Low, see above	High, continuous for life of project	Med, alcids present year-round and could be attracted to structure	Unknown	Michel et al. 2007, SAS [date unknown]
	Water circulation changes	None, project not large enough to affect prey	N/A	N/A	N/A	Low	N/A
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, release from device failure	Med, continuous and intermittent for life of project	Low, project not in known foraging area	Low	Michel et al. 2007, SAS [date unknown]
Structures on water's surface	Navigation lights	Attraction/ disorientation	Low, would occur in small area relative to species' range	High, continuous for life of project	Med, alcids present year-round and could be attracted to lights	Med	Montevecchi 2006, SAS [date unknown]
	Structure	Possible collision while flying, attraction to increased prey (FAD effect)	Low, see above	High, continuous for life of project	Med, alcids present year-round and could be attracted to structure	Unknown	Boehlert et al. 2008, SAS [date unknown]
Decommissioning							
Boat traffic	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low for typical small volume releases, High for large, catastrophic spill	Low, occurs over 2 months	Med, boats could pass through foraging areas	Low	Michel et al. 2007, SAS [date unknown]
	Noise and vibration	Possible movement away from boat and disruption of foraging	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Med, see above	Low	LGL Limited et al. 2009, SAS [date unknown]

Project activity	Action	Description of action's effect on indicator	Spatial exposure to indicator (low, med, high)	Temporal exposure to indicator (low, med, high)	Effect's overlap with critical life stage, behavior, habitat or resource (low, med, high)	Overall risk to indicator (low, med, high, unknown)	Source(s)
Decommissioning of structures on water's surface or seabed	Noise and vibration	Possible movement from area and disruption of foraging or nesting	Low, see above	Low, occurs over 2 months	Low, project not near nesting colony or known foraging area	Low	Michel et al. 2007, SAS [date unknown]
	Oil/chemical release	Hypothermia, toxicity to individuals and prey	Low, volume released would occupy small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Michel et al. 2007, SAS [date unknown]
	Construction lights	Attraction/ disorientation	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Montevecchi 2006, SAS [date unknown]
	Seabed disturbance	Possible short-term changes in food resources	Low, would occur in small area relative to species' range	Low, occurs over 2 months	Low, see above	Low	Boehlert et al. 2008, SAS [date unknown]

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