A User's Guide to the Structure of Longline Hook Data in GFBio, the Pacific Region's Groundfish Biological Database

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Cooke, K. and Olsen, N. 2019. A User's guide to the structure of longline hook data in GFBio, the Pacific region's groundfish biological database. Can. Manuscr. Rep. Fish. Aquat. Sci. 3174: viii + 52 p.

GFBio is a relational database system designed to archive groundfish biological data. It is organized hierarchically, modelling the at-sea data collection process. It houses data that are collected from many different gear types for which fishing methods, data collection, storage and extraction can differ significantly. Streams of longline hook data are received annually and are uploaded into GFBio. They are rich in information, consisting of data collected for each longline set or 'string', skates, and hooks, and populate a large number of fields, particularly in the Fishing Event and Catch tables. This document provides a guide to the storage of longline-specific data in GFBio.

RÉSUMÉ

Cooke, K. and Olsen, N. 2019. A User's guide to the structure of longline hook data in GFBio, the Pacific region's groundfish biological database. Can. Manuscr. Rep. Fish. Aquat. Sci. 3174: viii + 52 p.

GFBio est un système de base de données relationnel pour archiver les données biologiques sur le poisson de fond. Il est organisé de manière hiérarchique, selon le processus de collecte de données en mer. Il renferme des données recueillies de différents types d'engins; les méthodes de pêche ainsi que la collecte, le stockage et l'extraction des données peuvent varier considérablement. Des lots de données sur la palangre sont reçus chaque année et téléchargés dans GFBio. Ils contiennent beaucoup de renseignements, notamment les données recueillies pour chaque ensemble de palangres (cordage, lignes de fond et hameçons). Ils remplissent aussi un grand nombre de champs, particulièrement dans les tableaux sur l'événement de pêche et les prises. Le présent document fournit un guide sur la façon dont les données propres à la palangre sont stockées dans GFBio.

INTRODUCTION

GFBio is a relational database system developed by Fisheries and Oceans Canada (DFO) at the Pacific Biological Station in Nanaimo, British Columbia (BC), Canada. The database is used for storing, maintaining, and gaining access to groundfish biological data pertaining to research surveys and commercial fisheries in British Columbia, Canada. It was designed to archive the data collected from, and pertaining to, individual fish samples, in a standardized form. These data have been collected from groundfish species caught off the British Columbia coast since the 1940s from fish sampling activities at the dockside and on research and commercial trips. It includes data collected from various gear types such as bottom and midwater trawls, traps, gillnets, handlines and longlines. It typically includes information on individual specimens such as length, sex and age, together with the supporting sampling background data such as species, location and collection methodology. While the focus of the system is on individual fish data, the supporting relational table structure of auxiliary information provides the archiving and, therefore, analytical capability to query information that can be used to address scientific issues such as catch rate or geospatial analyses.

The data archived in GFBio model hierarchical events. For data collected using longline gear, one record can represent a **trip** in which a vessel leaves port to conduct longline fishing activities; many **fishing events** (or 'sets' or 'strings'), the individual events of putting the longline gear into the water along with the gear's associated skate events and hook events; the **catch** for the fishing events and each hook event; biological **samples** of selected fish species taken from the catch; or, **specimen** and attribute measurements recorded from individual fish. Figure 1 illustrates the relationship among the five primary tables in GFBio - TRIP, FISHING_EVENT, CATCH, SAMPLE, and SPECIMEN and the supporting secondary tables.

Longline fishing gear (Figure 2) and associated operations differ significantly from net-based gear types, particularly in the details of the gear's deployment and retrieval, and the use of multiple fishing devices (hooks) in a single fishing event. Longline hook survey data is therefore archived differently in GFBio, as compared to net-based survey data.

This report discusses the data structure in GFBio for the Inside Hard Bottom Longline Survey (HBLL IN) (Lochead et al. 2006*, Lochead et al. 2007*), the Outside Hard Bottom Longline Survey (HBLL OUT (Doherty et al. 2019), and the International Pacific Halibut Commission (IPHC) Fishery Independent Setline Survey (Flemming et al. 2012). Data from these surveys are loaded into GFBio annually.

The Hard Bottom Longline Hook (HBLL) survey program is designed to provide hook by hook species composition and catch rates for all species available to longline hook gear with a focus on inshore rockfish species habitat. The goal is to provide relative abundance indices for commonly caught species, distributional and occurrence data for all other species, and detailed biological data for inshore rockfish population

studies. These data are incorporated into stock assessments, status reports, and research publications.

The HBLL program employs a random depth-stratified survey design that includes a survey of outside waters conducted in collaboration with the Pacific Halibut Management Association (PHMA) and a survey of inside waters conducted by DFO. Each survey area is divided into northern and southern regions, and annual surveys alternate between the regions, such that the whole coast is surveyed over a two year period.

The HBLL OUT ("outside") area covers the entire BC coast excluding inlets and the protected waters east of Vancouver Island. The northern region of the outside survey area includes the mainland coast north of Milbanke Sound, Dixon Entrance, and both coasts of Haida Gwaii while the southern region includes the mainland coast south of Milbanke Sound, Queen Charlotte Sound, and the north and west coasts of Vancouver Island (Figure 3). The northern region of the outside area was surveyed during even numbered years from 2006 to 2012 and the southern region was surveyed in odd years from 2007 to 2011. The survey had a one year hiatus in 2013 but resumed in 2014 in the southern region. The current schedule is to survey the northern region in odd numbered years and the southern region in even numbered years.

The HBLL IN ("inside") area includes waters east of Vancouver Island. The northern region of the inside area includes Johnstone Strait and the Broughton Archipelago while the southern region includes Desolation Sound, the Strait of Georgia and the southern Gulf Islands (Figure 3). The northern region of the inside area was surveyed in years 2003, 2004, 2007, and in even numbered years to 2016. The southern region was surveyed in 2005, 2009, and continued in odd numbered years to 2015. The survey has been conducted annually since 2003 excluding 2006 and 2017 but resumed in 2018 in the southern region. The current schedule is to survey the northern region in odd numbered years and the southern region in even numbered years.

The IPHC Fishery Independent Setline Survey (FISS) is a fixed-station (non-random) depth-stratified longline hook survey that extends from southern Oregon to the Bering Sea. The survey serves to index Pacific Halibut (*Hippoglossus stenolepis*) abundance and provide accompanying biological data to assess the Pacific Halibut stock. The British Columbia portion of the survey has been conducted annually in various configurations from 1963 to the present (www.iphc.washington.edu). The survey is conducted by the IPHC from chartered commercial hook and line vessels, and typically two to three vessels complete the survey stations in British Columbia (Figure 4). Since 2003, DFO has collaborated with the PHMA and IPHC to fund an additional technician for the British Columbia portion of the survey to fully enumerate the non-halibut catch in the survey and to collect biological samples from rockfish species. This information has been collected every year except for a one-year hiatus in 2013. A one-time setline survey expansion of 135 stations was implemented in 2018. The expansion included large regions of previously un-surveyed habitat in waters within and near the

Strait of Georgia, and in the shallow waters in Hecate Strait, east of Haida Gwaii, as well as various channels and inlets (https://www.iphc.int/search-results?q=expansion).

This report is intended as a guide to help users become familiar with how data from the three longline hook surveys described above are stored in GFBio's primary tables, (TRIP, FISHING_EVENT and CATCH), many of its secondary and linking tables, and their associated code tables (Figures 1, 5 and 6).

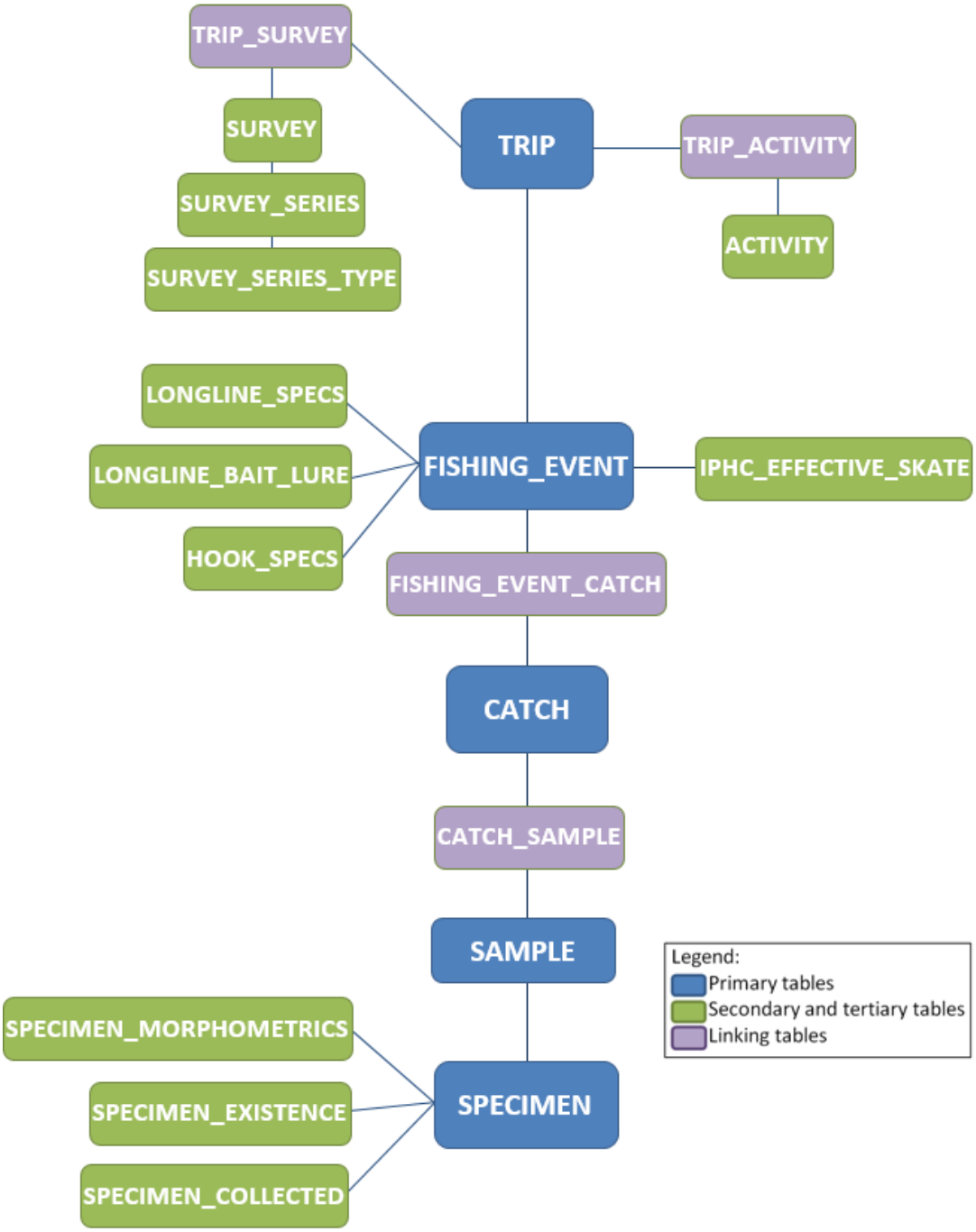


Figure 1. GFBio's relationship diagram of longline-specific tables.

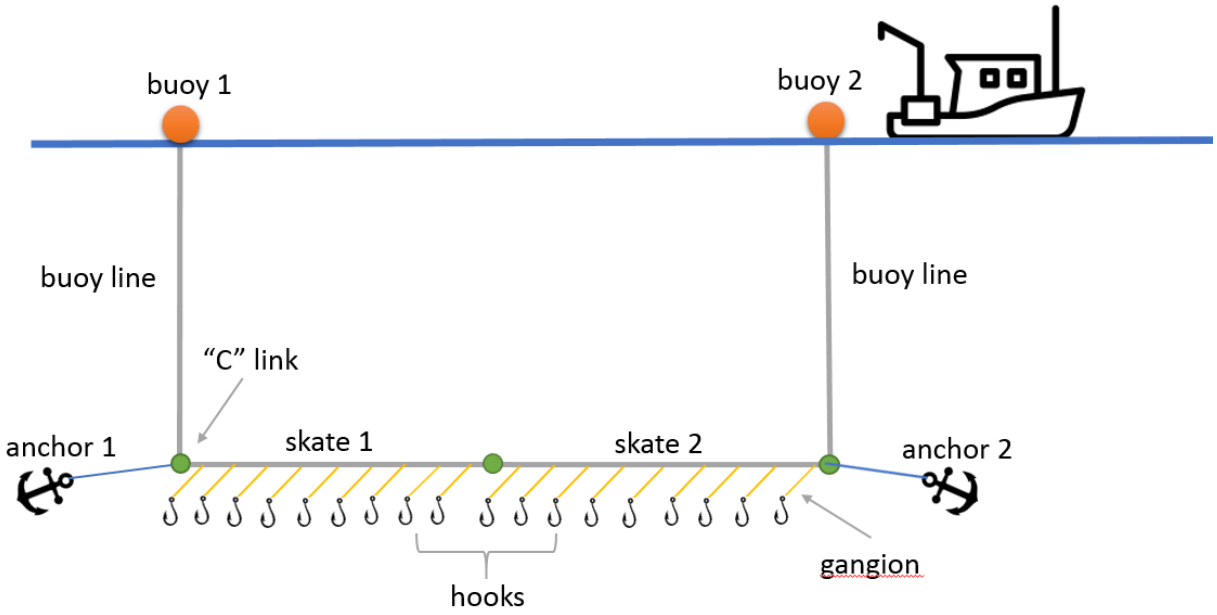


Figure 2. Longline fishing gear deployed at sea including the entire length of the 'string', made up of one or more skates and its many hooks.

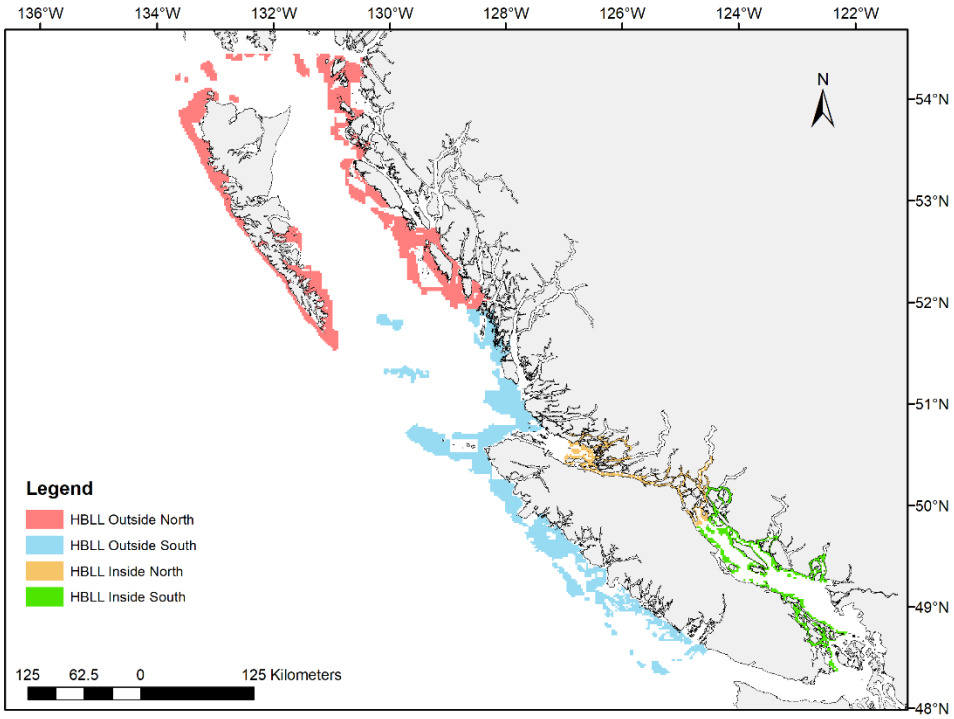


Figure 3. The random depth-stratified survey coverage of the HBLL survey program.

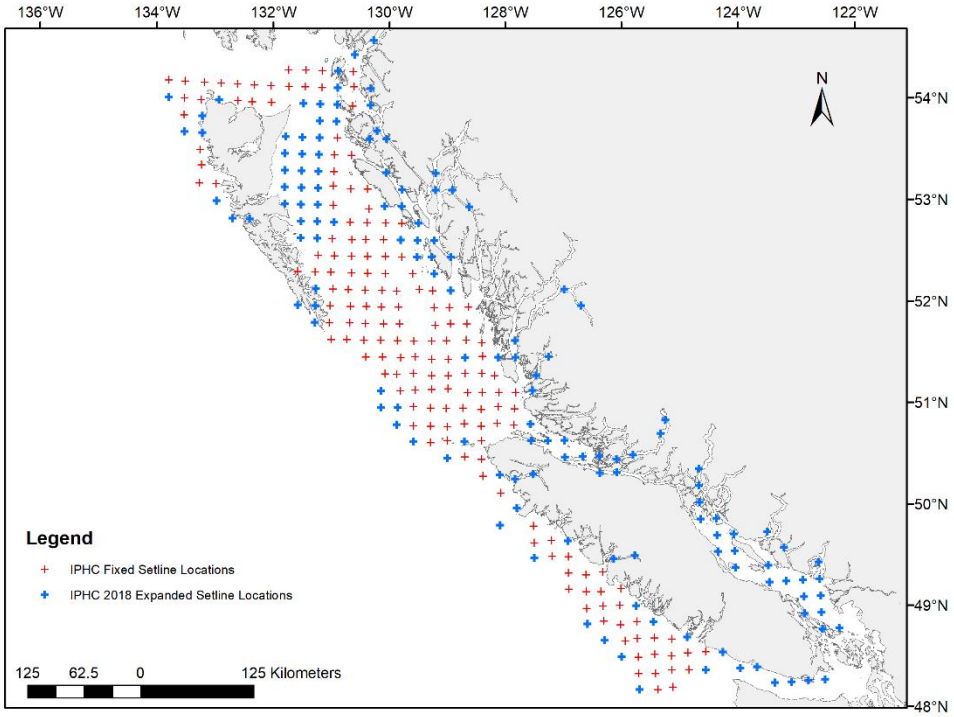


Figure 4. The non-random (fixed station) depth-stratified survey coverage of the IPHC survey program, including the 2018 setline expansion.

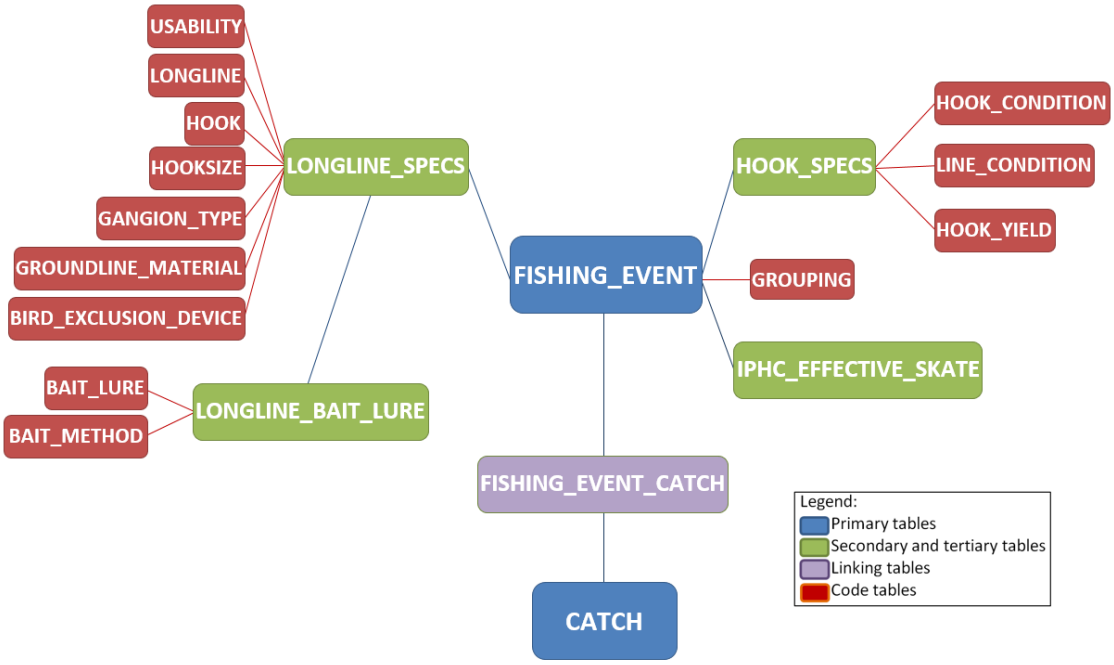


Figure 5. Primary tables FISHING_EVENT and CATCH with associated secondary tables and code tables.

IDENTIFYING LONGLINE HOOK SURVEY DATA IN GFBIO

Identifying longline hook survey data in GFBio can be achieved in one of two ways: the trip's ACTIVITY_CODE in the ACTIVITY table or its SURVEY _ID in the SURVEY table (Figure 6).

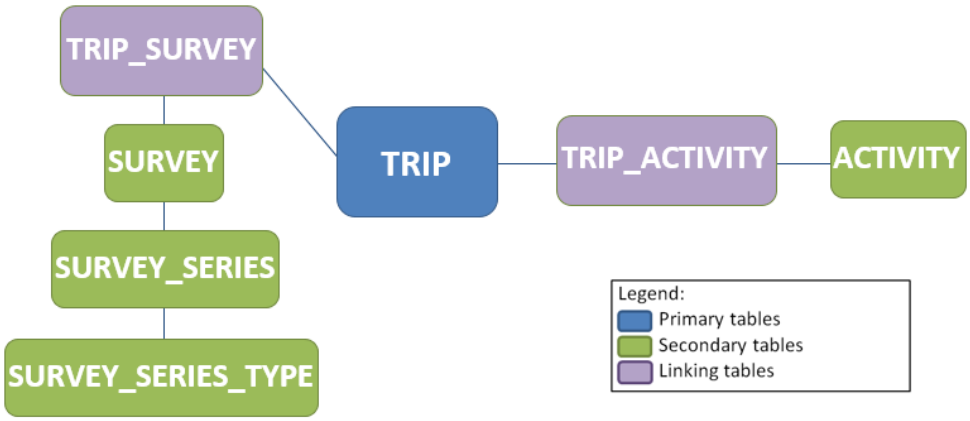


Figure 6. Linkages between TRIP and its tables used in identifying longline hook survey data in GFBio.

The simplest method to identify longline data in GFBio is by the trip's ACTIVITY CODE. The TRIP_ID data field, in the TRIP table or the FISHING_EVENT table, can be linked to the ACTIVITY table via the linking table, TRIP_ACTIVITY. The ACTIVITY table stores the descriptors for each of the five longline survey series groupings: IPHC, HBLL-IN N (inside north), HBLL-IN S (inside south), HBLL OUT N (outside north) and HBLL OUT S (outside south) (Table 1).

Table 1. Selected longline activity codes and descriptors.

ACTIVITY_CODE	ACTIVITY_DESC
24	INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY
48	HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH
49	HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH
50	HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH
51	HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH

A "survey" module (a group of tables) exists within GFBio whereby longline trip data can also be identified by type (SURVEY_SERIES_TYPE), series (SURVEY_SERIES) and survey (SURVEY). This module allows a single trip to be associated with any number of surveys or survey series, and allows a single survey to be composed of multiple trips. The chartered IPHC and PHMA surveys which occur on several different vessels each year are two examples of multiple trips making up a single survey. Results from a query linking tables SURVEY_SERIES_TYPE, SURVEY_SERIES, SURVEY and TRIP_SURVEY to TRIP are shown in Table 2. In this example, results are filtered to show a summary of records from 2015.

Table 2. Selected records of surveys and associated SURVEY_SERIES codes and descriptors.

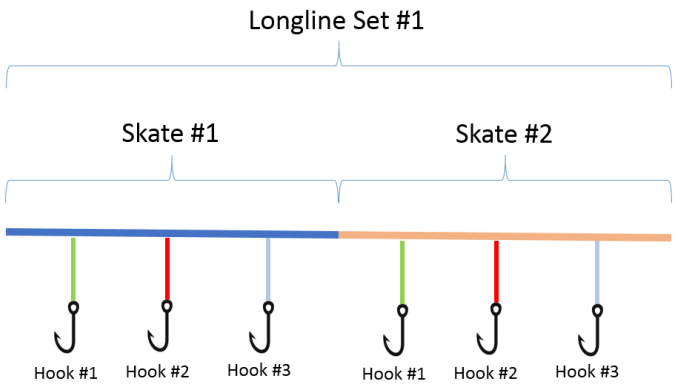
SURVEY_SERIES_ID	SURVEY_SERIES_TYPE_CODE	SURVEY_SERIES_TYPE_DESC	SURVEY_SERIES_TYPE_ALT_DESC	SURVEY_SERIES_DESC	SURVEY_SERIES_ALT_DESC	SURVEY_SERIES_HISTORIC_DESC	SURVEY_ID	SURVEY_DESC	TRIP_ID
14	6	International Pacific Halibut Commission	IPHC	International Pacific Halibut Commission Fishery-Independent Setline Survey	FISS	IPHC Longline Survey	458	2015 IPHC Longline Survey	77870
14	6	International Pacific Halibut Commission	IPHC	International Pacific Halibut Commission Fishery-Independent Setline Survey	FISS	IPHC Longline Survey	458	2015 IPHC Longline Survey	77871
22	3	Hard Bottom Longline Hook	HBLL	Hard Bottom Longline Outside North	OUT N	PHMA Rockfish Longline Survey - Outside North	459	2015 PHMA Rockfish Longline Survey - Outside North	77910
22	3	Hard Bottom Longline Hook	HBLL	Hard Bottom Longline Outside North	OUT N	PHMA Rockfish Longline Survey - Outside North	459	2015 PHMA Rockfish Longline Survey - Outside North	77911
40	3	Hard Bottom Longline Hook	HBLL	Hard Bottom Longline Inside South	INS S	IRF Longline Survey (South)	451	2015 Inshore Rockfish Longline Survey (South)	78090

FISHING_EVENT

For all gear types, the FISHING_EVENT table contains information about the individual events of deploying (or setting) fishing or other gear into the water, and retrieving (or hauling) the gear after some elapsed time. For net-based fishing gear, a fishing event consists of a single unit of fishing gear, the net, being deployed and retrieved on each set. For longline hook gear, a fishing event consists of sections of groundline (skates) containing many hooks, which are all deployed and retrieved together on each set. Therefore, longline hook fishing creates a three-level hierarchy of fishing events for each set, known as the major level or set (FE_MAJOR_LEVEL_ID), the sub level or skate (FE_SUB_LEVEL_ID), and the minor level or hook (FE_MINOR_LEVEL_ID). Each level has its own FISHING_EVENT_ID, and the sub level (skate) and minor level (hook) FISHING_EVENT_IDs also have a FE_PARENT_EVENT_ID that links everything back to the set. Skates link to sets, and hooks link to skates.

- The major-level is the set- or string-level event, and contains information about the deployment and retrieval of the entire set. This is also the “parent” record for the skate-level events.
- The sub-level is the skate level, and contains information about the individual sections of groundline that make up the string for that set. Surveys may use a single skate, or many skates joined together. The PARENT_EVENT for a skate, is the set.
- The minor-level is the hook level, and contains information about the individual hooks on each skate. The PARENT_EVENT for a hook is the skate, which in turn relates back to the set.

As an example, consider a longline deployment consisting of two skates with three hooks on each skate. A schematic of the gear follows, along with its representation in the FISHING_EVENT table (Figure 7).



FISHING_EVENT_ID	FE_PARENT_EVENT_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	
12345		1			<- set
12346	12345	1	1		<- skate
12347	12346	1	1	1	<- hook
12348	12346	1	1	2	<- hook
12349	12346	1	1	3	<- hook
12350	12345	1	2		<- skate
12351	12350	1	2	1	<- hook
12352	12350	1	2	2	<- hook
12353	12350	1	2	3	<- hook

Figure 7. A schematic of longline hook gear with its representation in the FISHING_EVENT table.

Set level records contain all the available information about the set: the gear used, dates and times, detailed location information, environmental data, etc. Skate and hook level records usually contain at least one deployment or retrieval time, and an area code which is a required field.

SET NUMBERING

The sequential numbering of sets in the FISHING_EVENT table is housed in the FE_MAJOR_LEVEL_ID data field (**set-level**) and starts at set number ‘1’ for each trip. However, in some instances trips may be part of a series and the numbering of the sets continues from one trip to the next. This is the case for some of the IPHC trips where fishing vessels had already fished in Alaska before beginning the BC survey. For these scenarios, set number ‘1’ had already been fished. To keep vessel and set number as unique values for each year, the BC surveys begin with the next available set number (Table 3).

From 2016 to present, the HBLL INSIDE survey collects data opportunistically from a conductivity, temperature and depth recorder (CTD) in as many of the selected survey blocks as possible. Date/time, position, and depth data from the CTD casts are captured in the FISHING_EVENT table using sequential set numbers starting at 1001. They can be identified by GEAR CODE ‘20’ - ‘PROFILING CTD’ and REASON_CODE ‘33’ - ‘CTD VERTICAL CAST’ (Table 3).

Table 3. Selected records showing minimum and maximum set numbers per trip for each of the survey series.

ACTIVITY_DESC	TRIP_ID	MinOfFE_ MAJOR_LEVEL_ID (set-level)	MaxOfFE_ MAJOR_LEVEL_ID (set-level)	GEAR_DESC	REASON_DESC
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1001	1071	PROFILING CTD	CTD VERTICAL CAST
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	71	LONGLINE	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	61	LONGLINE	
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	65	LONGLINE	
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	66	LONGLINE	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	125	LONGLINE	

SKATE NUMBERING

Skate numbering is housed in the FISHING_EVENT table in the FE_SUB_LEVEL_ID data field (**skate-level**). The HBLL INSIDE surveys deploy one skate per set, hence FE_SUB_LEVEL_ID equals ‘1’ for all records. The HBLL OUTSIDE surveys deploy two skates per set; however, there are no skate numbers assigned to the hooks during data collection. In this case, because the break between skate one and skate two is unknown, the FE_SUB_LEVEL_ID is assigned as‘1’ for all records. The IPHC surveys deploy between five and eight skates per set, and these are numbered accordingly. Table 4 shows selected trip records to exemplify skate numbering for the first 3 sets of each of the survey series.

Table 4. Selected trip records listing skate numbering for the first three sets of each of the survey series.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	2	1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	3	1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	2	1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	3	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	2	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	3	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	2	1
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	3	1
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	1
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	2
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	3
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	4
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	5
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	1
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	2
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	3
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	4
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	5
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	85	1
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	85	2
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	85	3
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	85	4
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	85	5

HOOK NUMBERING

Hook numbers are stored in the **hook-level** event, FE_MINOR_LEVEL_ID, in the FISHING_EVENT table.

When hook by hook data are collected in the field, varying circumstances dictate how the hook data is recorded. Numbering can vary between survey series, survey year, whether the gear was picked up from the first or last anchor deployed, or if the groundline separates into two pieces. Appendix A lists detailed descriptions of historic hook numbering under varying circumstances for each of the survey series. It includes screen shots of field data sheets and how these data are then uploaded into to GFBio. Historic and present-day scenarios are described below with emphasis on what this means if the associated data are to be used in geospatial analysis.

HAUL_POSITION_CODE

When fishing, the groundline is ‘set’ over the stern of the vessel and is generally hauled back in the direction it was set, where the first anchor deployed is the first anchor retrieved (the beginning position). It may also be hauled in the opposite

direction, where the last anchor deployed is the first anchor retrieved (the end position). If the groundline parts while hauling (i.e. breaks or separates into two pieces), the vessel travels to the other end of the string, where it continues to retrieve the gear.

Implemented in 2018 for **hook-level** events, the HAUL_POSITION_CODE in the FISHING_EVENT table simply describes which end of the string the hook was retrieved from and thus can only be one of 'BEGINNING' or 'END' (codes '1' or '2', respectively, Table 5). Having collected that information for all hooks retrieved, we can then record a more informative HAUL_POSITION_CODE at the **set-level** that describes how the hooks were retrieved: from the 'BEGINNING' or 'END' without the gear parting, or starting from the beginning with a part (PARTED FROM BEGINNING) or, starting from the end with a part (PARTED FROM END) (codes '1', '2', '4', or '5', respectively, Table 5). At the **skate-level**, HAUL_POSITION_CODE is null. The HAUL_POSITION_CODE data field, for all surveys and all years prior to 2018, has been updated to include a HAUL_POSITION_CODE at the **set-level** only ('BEGINNING' or 'END'). An update at the **hook-level** is being considered for the future.

Table 5. Haul position codes and their meanings.

HAUL_POSITION_CODE	HAUL_POSITION_DESC	SCENARIO
0	UNKNOWN	Haul position is unknown.
1	BEGINNING	Hooks retrieved beginning at the start of the string.
2	END	Hooks retrieved beginning at the end of the string.
3	PARTED	Parted but scenario is unknown.
4	PARTED FROM BEGINNING	Hook retrieval began with the start of the string and continued from the end of the string after the string parted.
5	PARTED FROM END	Hook retrieval began with the end of the string and continued from the start of the string after the string parted.

HBLL Surveys

Beginning in 2018, and for the HBLL surveys only, hooks are numbered sequentially starting from '1' to the number of hooks retrieved, regardless of which end of the string the haul began at or whether or not the gear parted; hooks are simply numbered in the order that they are brought aboard.

Hook numbering when gear is picked up at the 'BEGINNING' or 'END' haul position

1. ***Scenarios for all years:***

Hook numbering runs sequentially from '1' to the number of the last hook retrieved whether the gear was picked up at the beginning or end position (Table 6).

If the haul starts at the 'BEGINNING', then *hook number '1' is the first hook deployed and the first hook retrieved.*

If the haul starts at the 'END', then *hook number'1' is the last hook deployed and the first hook retrieved*. If using these data for geospatial analysis, the geospatial

polylines will need their start and end latitude and longitude values reversed to reflect correct positioning and specimen capture along the line.

Table 6. Selected HBLL trip records listing hook numbers and HAUL_POSITION_CODE at the set- and hook-levels. Haul position is null at the skate-level.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	FE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION_DESC
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	4			1	BEGINNING
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	4	1			
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	4	1	1	1	BEGINNING
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	4	1	2	1	BEGINNING
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	4	1	3	1	BEGINNING
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	84472	1			2	END
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	84472	1	1			
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	84472	1	1	1	2	END
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	84472	1	1	2	2	END
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	84472	1	1	3	2	END

Gear PARTED from either the 'BEGINNING' or the 'END' haul position

1. From 2018 and onwards:

Hook numbering runs sequentially from '1' to the number of the last hook retrieved. The HAUL_POSITION_CODE at the **hook-level**, 'BEGINNING' or 'END', tells the analyst the true order of the hooks on the line. The sequence of hook numbers after the position where the line parts therefore, does not match the sequence of hooks on the line. However, the true sequence of hooks can be determined by sorting the hook records in either ascending or descending order based on the haul position value. Using these data for geospatial analysis, the user must be aware of the set's 'PARTED FROM BEGINNING' or 'PARTED FROM END' position and where the part occurred i.e. between which two hooks. In the example given in Table 7 and at the **set-level**, hook retrieval began with the start of the string and continued at the end of the string after the string parted (HAUL_POSITION_CODE '4'). At the **hook-level**, the gear parted between hooks 157 and 158 (where HAUL_POSITION_CODE changes from '1' to '2'). Here, hook number 158 to the last hook number retrieved must be reversed to reflect the actual geospatial position of the hook along the groundline. This process would be reversed if the haul was retrieved from the 'END' position and gear parted.

Table 7. Selected HBLL trip records listing hook numbers and HAUL_POSITION_CODE at the set- and hook-levels. Hook numbers are reversed for correct geospatial positioning if gear parts.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	FE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION_DESC		
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15			4	PARTED FROM BEGINNING		
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1					
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	154	1	BEGINNING	154	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	155	1	BEGINNING	155	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	156	1	BEGINNING	156	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	157	1	BEGINNING	157	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	158	2	END	166	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	159	2	END	165	new hook numbers for true geospatial position
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	160	2	END	164	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	161	2	END	163	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	162	2	END	162	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	163	2	END	161	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	164	2	END	160	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	165	2	END	159	
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	84371	15	1	166 (max hook num)	2	END	158	

2. Prior to 2018:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order starting with the hook number associated with the last hook deployed. This collection method results in the total sequence of hooks on the 'page' matching the sequence of hooks for the full extent of the longline. If using these data geospatially, no change in numbering needs to occur. The HAUL_POSITION_CODE ('BEGINNING' or 'END') at the **set-level** simply indicates whether hook #1 is the first hook deployed or the last hook deployed.

An update at the **hook-level**, for data collected prior to 2018, is being considered for the future. The HAUL_POSITION_CODE would be populated the same ('BEGINNING' or 'END') as that recorded at the **set-level**. The position at which the gear parted (e.g. between hooks 157 and 158) would then be recorded in the data field FE_MISC_COMMENT in FISHING_EVENT.

IPHC Surveys

Hook numbering when gear is picked up at the 'BEGINNING' haul position

1. From 2007 and onwards:

In these years, hook numbering runs sequentially from '1' to the number of the last hook retrieved, **per skate**. Table 8 lists TRIP_ID 83039 and set number '84', skates 1 through 5, and hook numbering starting at '1' for each skate. *Hook number '1' on skate number '1' is the first hook deployed and the first hook retrieved; the last hook deployed and the last retrieved is on skate number '5' and hook number '102'.* For this example and at the set- and hook-levels, HAUL_POSITION_CODE is '1', 'BEGINNING'.

Table 8, Selected grouped records listing the minimum and maximum hook number values for each skate on one set of an IPHC survey, post 2006.

ACTIVITY_DESC	TRIP_ ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	MinOfFE_MINOR_LEVEL_ID (hook-level)	MaxOfFE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION _DESC
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	1	1	101	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	2	1	99	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	3	1	101	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	4	1	100	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	84	5	1	102	1	BEGINNING

2. Between years 2003 and 2006:

Hook numbering between years 2003 and 2006 run sequentially and continuously, no matter the number of skates, from '1' to the number of the last hook retrieved. Table 9 lists TRIP_ID 52040 and set number 7, skates 1 through 8, and hook numbering from 1 to 802. For this example and at the set- and hook-levels, HAUL_POSITION_CODE is '1', 'BEGINNING'. *Hook number '1' is the first hook deployed and the first hook retrieved.*

Table 9. Selected grouped records listing the minimum and maximum hook number values for each skate on one set of an IPHC survey, pre 2007.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	MinOfFE_MINOR_LEVEL_ID (hook-level)	MaxOfFE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION_CODE	HAUL_POSITION_DESC
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	1	1	103	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	2	104	202	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	3	203	303	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	4	304	402	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	5	403	503	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	6	504	603	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	7	604	703	1	BEGINNING
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	52040	7	8	704	802	1	BEGINNING

Hook numbering when gear is picked up at the 'END' haul position

1. Scenarios for all years:

When hauling from the 'END' position, the skate number of the last skate set is recorded first, followed by hook number 1 to the end of the last hook retrieved for the skate. **The IPHC records skates in reverse order and hooks are numbered sequentially from '1' for each skate**.

In Table 10, set number 83 is hauled from the 'END' position. *Hook number '1' on skate number '5' is the last hook deployed and the first retrieved; the first hook deployed and the last hook retrieved is hook number '100' on skate number '1'.* For this example and at the set- and hook-levels, HAUL_POSITION_CODE is '2',' END'. If using the associated data in geospatial analysis, each skate's hook numbering must be reversed. An example of the steps taken in SQL SERVER to re-number hook numbers can be found in Appendix B.

Table 10. Selected grouped records listing the minimum and maximum hook number values for each skate on one set of an IPHC survey where longline gear was picked up at the 'END' position.

ACTIVITY_DESC	TRIP_ ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	MinOfFE_MINOR_LEVEL_ID (hook-level)	MaxOfFE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION _DESC
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	5	1	102	2	END
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	4	1	101	2	END
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	3	1	100	2	END
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	2	1	98	2	END
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	83039	83	1	1	100	2	END

Gear PARTED from the 'BEGINNING' haul position

1. From 2018 and onwards:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order starting with the number of the last hook deployed on the last skate deployed. This collection method results in hook numbering that runs sequentially from '1' to the number of the last hook retrieved, **per skate**. In the example given in Table 11 and at the **set-level**, hook retrieval began with the start of the string and continued at the end of the string after the string parted (LINE_CONDITION_CODE '4'). At the **hook-level**, the gear parted on skate 7 between hooks 79 and 80 (where LINE_CONDITION_CODE changes from '1' to '4'). The part is noted at the set-level in the field FE_MISC_COMMENT ("Line parted between hooks 79 and 80 on skate 7.").

Table 11. Selected IPHC trip records listing hook numbers, HAUL_POSITION_CODE, and LINE_CONDITION_CODE at the set- , skate-, and hook-levels, for a set hauled from the BEGINNING position, on a skate where the gear parted during haul-back. Because the IPHC records the remaining hooks after the part in reverse order (i.e. starting from the end positon), hooks retain their sequential numbering from '1' to the number of the last hook retrieved, per skate (i.e. no need to renumber for geospatial analysis).

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	FE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION _DESC	LINE_CONDITION _CODE	LINE_CONDITION _DESC
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8			1	BEGINNING		
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7		1	BEGINNING		
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	**1 (first hook deployed; first hook retrieved)**	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	2	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	3	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	: :	: :	: :	: :	: :
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	76	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	77	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	78	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	**79 (last hook retrieved before part)**	1	BEGINNING	4	**GEAR PARTED**
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	**80 (last hook retrieved)**	1	BEGINNING	4	**GEAR PARTED**
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	81	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	82	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	83	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	: :	: :	: :	: :	: :
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	100	1	BEGINNING	1	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84530	8	7	**101 (last hook deployed; first hook retrieved after part)**	1	BEGINNING	1	NORMAL

2. 2017:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order starting with the number of the last hook deployed on the last skate deployed. This collection method results in hook numbering that runs sequentially from '1' to the number of the last hook retrieved, **per skate**. The HAUL_POSITION_CODE 'BEGINNING' at the **set-level** simply indicates that hook #1 *is the first hook deployed and the first hook retrieved on skate #1*.

An update at the **hook-level**, for data collected prior to 2018, is being considered for the future. The HAUL_POSITION_CODE would be populated the same ('BEGINNING' or 'END') as that recorded at the **set-level**. The position at which the

gear parted (e.g. between hooks 15 and 16 on skate 2) would then be recorded at the set-level in the field FE_MISC_COMMENT in FISHING_EVENT.

3. Between years 2007 and 2016:

Sets in which the gear has parted during retrieval cannot be used for geospatial analysis because hook numbers recorded at sea cannot be confirmed to be correct. These sets are identified by USABILITY_CODE 53, 'USABLE BUT OMIT FROM ANY GEOSPATIAL ANALYSIS', in the table LONGLINE_SPECS. (See the section on GFBIO'S LONGLINE-SPECIFIC SECONDARY TABLES.)

4. Between years 2003 and 2006:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order starting with the hook number associated with the last hook deployed. This collection method results in the total sequence of hooks on the 'page' matching the sequence of hooks for the full extent of the longline. If using these data geospatially, then no change in numbering needs to occur.

An update at the **hook-level**, for data collected prior to 2018, is being considered for the future. The HAUL_POSITION_CODE would be populated the same ('BEGINNING' or 'END') as that recorded at the **set-level**. The position at which the gear parted (e.g. between hooks 117 and 118 on skate 2) would then be recorded in the data field FE_MISC_COMMENT in FISHING_EVENT.

Gear PARTED from the 'END' haul position

1. From 2018 and onwards:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order. This collection method results in hook numbering that runs sequentially from '1' to the number of the last hook retrieved, **per skate**. As stated previously and when hauled from the 'END' position, **the IPHC records skates in reverse order and hooks are numbered sequentially from '1' for each skate.** In the example given in Table 12 and at the **set-level**, hook retrieval began at the end of the string and continued at the start of the string after the string parted (HAUL_POSTION_CODE '5'). At the **hook-level**, the gear parted on skate 6 between hooks 12 and 13 (where LINE_CONDITION_CODE changes from '1' to '4'). The part is noted at the set-level in the field FE_MISC_COMMENT ("Line parted between hooks 12 and 13 on skate 6."). If using the associated data are used in geospatial analysis, then each skate's hook numbering must be reversed.

2. 2017:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order. As stated previously and when hauled from the 'END' position, **the IPHC**

records skates in reverse order and hooks are numbered sequentially from '1' for each skate. This collection method results in hook numbering that runs sequentially from '1' to the number of the last hook retrieved, **per skate**. The HAUL_POSITION_CODE 'END' at the **set-level** simply indicates that hook #1 *is the first hook deployed and the first hook retrieved on the skate number that was deployed last.* If using the associated data in geospatial analysis, then each skate's hook numbering must be reversed.

Table 12. Selected IPHC trip records listing hook numbers, HAUL_POSITION_CODE, and LINE_CONDITION_CODE at the set- , skate-, and hook-levels, for a set hauled from the END position, on a skate where the gear parted during haul-back. When gear is hauled from the END position, the IPHC numbers the skates in the order deployed (reverse of the order retrieved), but numbers the hooks in the order retrieved (reverse of the order deployed). When the gear parts, hooks are recorded in reverse order (i.e. starting from the beginning position), so that hooks retain their sequential numbering from '1' to the number of the last hook retrieved, per skate. Hook numbers should be reversed within the skate for correct geospatial positioning if gear parts.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	FE_MINOR_LEVEL_ID (hook-level)	HAUL_POSITION _CODE	HAUL_POSITION _DESC	LINE_CONDITION _CODE	LINE_CONDITION _DESC		
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71			2	END				
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6		2	END				
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	**1 (last hook deployed; first hook retrieved)**	2	END	1	NORMAL	100	new hook numbers for true geospatial position
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	2	2	END	1	NORMAL	99	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	3	2	END	1	NORMAL	98	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	: :	: :	: :	: :	: :	: :	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	9	2	END	1	NORMAL	92	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	10	2	END	1	NORMAL	91	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	11	2	END	1	NORMAL	90	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	**12 (last hook retrieved before part)**	2	END	4	**GEAR PARTED**	89	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	**13 (last hook retrieved)**	2	END	4	**GEAR PARTED**	88	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	14	2	END	1	NORMAL	87	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	15	2	END	1	NORMAL	86	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	16	2	END	1	NORMAL	85	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	: :	: :	: :	: :	: :	: :	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	99	2	END	1	NORMAL	2	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	84531	71	6	**100 (first hook deployed; first hook retrieved after part)**	2	END	1	NORMAL	1	

An update at the **hook-level**, for data collected prior to 2018, is being considered for the future. The HAUL_POSITION_CODE would be populated the same

('BEGINNING' or 'END') as that recorded at the **set-level**. The position at which the gear parted (e.g. between hooks 15 and 16 on skate 2) would then be recorded in the data field FE_MISC_COMMENT in FISHING_EVENT.

3. Between years 2007 and 2016:

Sets in which the gear has parted during retrieval cannot be used for geospatial analysis because the hook numbers recorded at sea cannot be confirmed to be correct. These sets are identified by USABILITY_CODE 53, 'USABLE BUT OMIT FROM ANY GEOSPATIAL ANALYSIS', in the table LONGLINE_SPECS. (See the section on GFBIO'S LONGLINE-SPECIFIC SECONDARY TABLES.)

4. Between years 2003 and 2006:

When the longline gear's groundline parts during retrieval, the vessel travels to the other end of the string to retrieve the gear. The remaining hooks are recorded in reverse order starting with the hook number associated with the last hook deployed. This collection method results in the total sequence of hooks on the 'page' matching the sequence of hooks for the full extent of the longline. If using these data geospatially, then no change in numbering needs to occur.

An update at the **hook-level**, for data collected prior to 2018, is being considered for the future. The HAUL_POSITION_CODE would be populated the same ('BEGINNING' or 'END') as that recorded at the **set-level**. The position at which the gear parted (e.g. between hooks 117 and 118 on skate 2) would then be recorded in the data field FE_MISC_COMMENT in FISHING_EVENT.

SOAK TIME

The amount of time the gear is in the water is referred to as 'soak time'. Soak time represents the time the gear was actually fishing (i.e., available to catch fish). It is defined as follows:

- HBLL INSIDE: Elapsed time between the last anchor entering the water at the end of setting and the first anchor leaving the water at the start of hauling (Yamanaka et al., 2003)
- HBLL OUTSIDE: Elapsed time between the last anchor entering the water at the end of setting and the first anchor leaving the water at the start of hauling (Doherty et al., 2019)
- IPHC: Elapsed time between release of the first flag/buoy at the start of setting and retrieval of the first flag/buoy at the start of hauling (E. Soderlund, IPHC, Seattle, Washington, personal communication, 2019).

The FISHING_EVENT table stores times and dates of gear deployment and retrieval. The fields that capture these data are FE_BEGIN_DEPLOYMENT_TIME (time/date at beginning of gear deployment), FE_END_DEPLOYMENT_TIME (time/date at end of gear deployment), FE_BEGIN_RETRIEVAL_TIME (time/date at beginning of gear retrieval, and FE_END_RETRIEVAL_TIME (time/date at end of gear retrieval). The

HBLL INSIDE surveys collects data for each of the four data fields; the HBLL OUTSIDE survey collects data for end deployment time and begin retrieval time only; the IPHC survey collects data for all fields except begin deployment time (Table 13).

Across all surveys, the start of the soak time is stored in the FE_END_DEPLOYMENT field and the end of the soak time in FE_BEGIN_RETRIEVAL field. Hence, the difference in time between FE_BEGIN_RETRIEVAL_TIME and FE_END_DEPLOYMENT_TIME equals the soak time for the set. Soak time is two hours for the HBLL surveys and a minimum of five hours for the IPHC surveys.

Table 13. Selected records representing which deployment and retrieval times and dates are collected on each survey.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_BEGIN_DEPLOYMENT_TIME	FE_END_DEPLOYMENT_TIME	FE_BEGIN_RETRIEVAL_TIME	FE_END_RETRIEVAL_TIME
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	08/02/2016 7:58	08/02/2016 8:10	08/02/2016 10:07	08/02/2016 10:33
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	08/01/2015 13:49	08/01/2015 13:58	08/01/2015 15:57	08/01/2015 16:19
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1		08/13/2017 7:39	08/13/2017 9:23	
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1		08/01/2016 6:45	08/01/2016 8:53	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83		07/05/2017 5:05	07/05/2017 10:06	07/05/2017 11:47

BLOCK_DESIGNATION AND GROUPING_CODE

Survey areas are divided into numbered blocks (HBLL) or have stations at pre-determined locations (IPHC). For the HBLL surveys, the coast is divided into 2 km by 2 km blocks, and each year, a random number of blocks are chosen to be surveyed. For the IPHC survey, there are 170 fixed survey stations in British Columbia, and each year, all are surveyed. The HBLL block numbers and the IPHC Station numbers are stored in the FISHING_EVENT table in the BLOCK_DESIGNATION field at the **set-level** (Table 14).

Each survey series has its own set of GROUPING_CODEs. Code descriptions include the survey name, area and depth range fished. HBLL survey blocks are assigned a depth stratum (range) based on the average bottom depth within the block. The three depth strata for the outside area are 20 to 70 meters, 71 to 150 meters, and 151 to 260 meters. Suitable hard bottom regions in the Strait of Georgia and Johnstone Strait are more limited, so the depth strata for the inside area are 20 to 70 meters and 71 to 100 meters. Area descriptors can include ‘north’ or ‘south’ or Groundfish Management Areas (i.e. 5A, 3C, etc.). The IPHC is divided into four regions: Charlotte Station, Goose Island Station, James Station and Vancouver Station. GROUPING_CODE is housed in FISHING_EVENT at the **set-level**.

Table 14. Selected records representing data stored in the FISHING_EVENT table, showing BLOCK_DESIGNATION and GROUPING_CODE.

ACTIVITY_DESC	TRIP_ID	BLOCK_DESIGNATION	GROUPING_CODE	GROUPING_DESC
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1024	318	IRF North, 71 - 100 m
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	2498	319	IRF South, 40 - 70 m
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	889	322	PHMA North, 71 - 150 m
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	3320	326	PHMA South, 151 - 260 m
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	2166	134	IPHC - Charlotte Station

CATCH

The CATCH table is linked to the FISHING_EVENT table through an associative (linking) table, FISHING_EVENT_CATCH. The CATCH table contains information on individual catch from a fishing event. In longline surveys, the species caught is recorded on a hook by hook basis as the gear is hauled onboard and is then sorted into baskets. The collection of data up to and including 2018 has varied between the HBLL INSIDE, the IPHC and the HBLL OUTSIDE surveys. The HBLL INSIDE survey collects weights and counts at the **set-level** as well as counts at the **hook-level**. These counts are independent estimates. The IPHC and HBLL OUTSIDE surveys do not collect any weights, and **set-level** catch is generated from the collection of **hook-level** catch. Starting in 2019, the HBLL INSIDE survey will follow the same methodology as the HBLL OUTSIDE and IPHC surveys, collecting only counts at the hook-level, and generating set-level catch from the hook-level catch.

Keeping in mind the previous discussion of fishing events, the CATCH table also holds catch information for different levels of the fishing event hierarchy, but in this case only for the **set-level** and **hook-level** records, not the skate-level records. The **set-level** catch record stores the total catch for a given species for the set, while each **hook-level** catch record stores the catch for a particular hook (Table 15).

Table 15. Selected records for TRIP_IDs 79290 (HBLL IN) and 82912 (HBLL OUT) for set #1 of catch recorded at both the FE_MAJOR_LEVEL_ID (set-level) and FE_MINOR_LEVEL_ID (hook-level).

TRIP_ ID	FE_PARENT _EVENT_ID	FE_MAJOR_ EVENT_ID (set-level)	FE_SUB_L EVEL_ID (skate-level)	FE_MINOR _LEVEL_ID (hook-level)	SPECIES_ CODE	SPECIES_DESC	CATCH_ WEIGHT	CATCH_ COUNT	
79290		1			442	YELLOWEYE ROCKFISH	2.65	3	
79290	4120825	1	1	141	442	YELLOWEYE ROCKFISH		1	=3
79290	4120825	1	1	148	442	YELLOWEYE ROCKFISH		1	
79290	4120825	1	1	220	442	YELLOWEYE ROCKFISH		1	
82912		1			424	QUILLBACK ROCKFISH		8	
82912	4423415	1	1	26	424	QUILLBACK ROCKFISH		1	=8
82912	4423415	1	1	27	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	28	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	63	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	128	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	131	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	156	424	QUILLBACK ROCKFISH		1	
82912	4423415	1	1	174	424	QUILLBACK ROCKFISH		1	

When summing catch it is extremely important to separate the set- and hook-levels to avoid double-counting. When summing **set-level** catch, ensure that FE_PARENT_EVENT_ID value is null (i.e., include only set-level events). When summing **hook-level** catch, ensure that FE_PARENT_EVENT_ID is not null (i.e., exclude the set-level events).

Catch at the set-level may not always sum to the same value as catch at the hook-level for a variety of reasons. Specimens could be missed by the hook-by-hook recorder, but seen later during sampling. Two specimens could be caught on one hook, with a small individual inside the mouth of a larger individual that is not visible to the hook-by-hook recorder but is later counted when sorted at the set-level (for the OUTSIDE and INSIDE HBLL Surveys).

GFBIO'S LONGLINE-SPECIFIC SECONDARY TABLES

LONGLINE_SPECS

The LONGLINE_SPECS table is linked to the FISHING_EVENT table by the FISHING_EVENT_ID, at the **set-level**. It houses information on the set's usability, specifications on the gear used, skate and hook numbers deployed and retrieved, and for some surveys, the type of bird exclusion device used. Table 16 lists its data fields and comments describing each field.

Table 16. Data fields housed in the LONGLINE_SPECS table.

LONGLINE_SPECS	COMMENTS
LONGLINE_CODE	Unique identifier for type of longline used
LGLSP_HOOK_COUNT	Number of hooks actually fished on the longline during an event
LGLSP_HOOK_SPACING	Spacing in meters between hooks on the longline
HOOK_CODE	Unique identifier for type of hook used for longline gear
HOOKSIZE_CODE	Unique identifier for size of hook used for longline gear
LGLSP_GROUNDLINE_WEIGHT	Weight in kilograms of groundline used for longline gear
GANGION_TYPE_CODE	Unique identifier for type of gangion used for longline gear
LGLSP_GANGION_LENGTH	Length in meters of the gangion used for longline gear
LGLSP_HOOKS_SET_COUNT	Number of hooks deployed on the longline during an event
LGLSP_HOOKS_LOST_COUNT	Number of hooks lost during the fishing event
GROUNDLINE_MATERIAL_CODE	Unique code for the groundline material used
SKATE_COUNT	Number of skates used during a fishing event
USABILITY_CODE	The usability of the longline fishing event
GROUNDLINE_DIAMETER	Diameter in millimeters of the groundline
BIRD_EXCLUSION_DEVICE_CODE	Unique code for the type of bird exclusion device used
LGLSP_COMMENT	Miscellaneous comment regarding the longline specifications

The USABILITY_CODE and associated code table (USABILITY) describes whether a set was successfully fished and if it can be used in various analyses at a later date. Table 17 lists the usability codes that are presently used in longline hook data. USABILITY_CODE ‘5’ (FAIL-NO USABLE DATA) indicates a set that failed to fish correctly or at all, and is therefore unusable for any analysis. Situations which result in USABILITY_CODE ‘5’ may include sets where retrieval of the gear occurred much later than the required soak time due to buoys sinking and disappearing out of view, or a very rocky bottom where sections of the gear may be suspended above the ocean floor.

Table 17. USABILITY_CODEs and USABILITY_DESCs used to describe the success, or lack of success of longline fishing events.

ACTIVITY_CODE	USABILITY_CODE	USABILITY_DESC
24	1	FULLY USABLE
48	5	FAIL, NO USABLE DATA
48	10	GEAR LOST OR DESTROYED
48	17	OUT OF DEPTH RANGE BUT ALL OTHER DATA USABLE
50	19	SOME/ALL SKATES LOST - DATA UNUSABLE FOR CPUE EST
48	20	TOO MANY SNARLS IN LONGLINE - DATA UNUSABLE FOR CPUE EST
51	22	USABLE BUT REMOVED DUE TO RE-DEFINITION OF SURVEY AREA
48	23	TEST TOW - NO USABLE DATA
51	28	UNUSABLE - GEAR DEPLOYED IN AN AREA CLOSED TO FISHING
24	51	UNUSABLE HOOK AND LINE - FISHING GEAR SET ACROSS LONGLINE SURVEY SET
24	52	USABLE BUT OMIT FROM ANY GEOSPATIAL ANALYSIS
24	53	DATA LOST - DATA UNUSABLE FOR CPUE EST

Table 18 summarizes the gear specifications for all survey series. It links the LONGLINE_SPECS table to its many gear code tables: HOOK, HOOK_SIZE, LONGLINE, GANGION_TYPE, and GROUNDLINE_MATERIAL. As their names suggest, the gear code tables include information about the type of longline gear used, hook size, hook and gangion types, and groundline material.

Groundline and gangion information have not been collected for the HBLL OUTSIDE and IPHC surveys. Their details are either unknown or vary from year to year and from vessel to vessel. However, throughout the survey years, gangion lengths have been allowed to range from 0.30 m (12 inches) to 0.46 m (18 inches) in length for the HBLL OUTSIDE survey (Doherty et al, 2019) and have been allowed to range from 0.61 m (24 inches) to 1.22 m (48 inches) in length for the IPHC surveys (E. Soderlund, IPHC, Seattle, Washington, personal communication, 2019).

Table 18. Summary of gear specifications for all survey series.

ACTIVITY_DESC	LONGLINE _CODE	LONGLINE_DESC	LGLSP_ HOOK_ SPACING (meters)	HOOK_ CODE	HOOK_ DESC	HOOKSIZE _CODE	HOOKSIZE _DESC	GROUNDLINE_ MATERIAL_ CODE	GROUNDLINE_ MATERIAL_ DESC	GROUNDLINE _DIAMETER (millimeters)	LGLSP_ GROUNDLINE _WEIGHT (kilograms)	GANGION _TYPE_ CODE	GANGION _TYPE _DESC	LGLSP_ GANGION_ LENGTH (meters)
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	2	SUNKEN - SNAP	2.44	1	CIRCLE HOOK	13	13/0	5	LEADED POLYPROPYLENE	9	30	13	250 PERLON	0.38
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	2	SUNKEN - SNAP	2.44	1	CIRCLE HOOK	13	13/0	5	LEADED POLYPROPYLENE	9	30	13	250 PERLON	0.38
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	2	SUNKEN - SNAP	2.44	1	CIRCLE HOOK	14	14/0							
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	2	SUNKEN - SNAP	2.44	1	CIRCLE HOOK	14	14/0							
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	1	SUNKEN - FIXED/CONVENTIONAL	5.49	1	CIRCLE HOOK	16	16/0							

For each set fished, the LONGLINE_SPECS table also holds the number of skates deployed (SKATE_COUNT), the target number of hooks deployed (LGLSP_HOOKS_SET_COUNT), and the actual number of hooks retrieved (LGLSP_HOOK_COUNT). Note that the actual number of hooks deployed is not recorded because this value is rarely known – hooks are counted carefully only upon retrieval.

The SKATE_COUNT remains constant for each of the HBLL surveys: one skate is deployed per set for the HBLL INSIDE survey and two skates are deployed for the HBLL OUTSIDE survey. Note that for the HBLL OUTSIDE survey, a count of ‘1’ skate is recorded in the FISHING_EVENT table and FE_SUB_LEVEL_ID field. The reason for this is explained in another section of this report (FISHING_EVENT, sub-section SKATE NUMBERING). The IPHC deploys between five and eight skates per set, and this is recorded accordingly, in the SKATE NUMBERING field.

The target number of hooks/set for all surveys is stored in the LGLSP_HOOKS_SET_COUNT data field. Target numbers are 225 hooks per skate for the HBLL INSIDE survey, a total of 450 for the HBLL OUTSIDE, and 100 hooks per skate for the IPHC. The actual number of hooks deployed on a set can vary slightly for various reasons: hooks dropped while setting, a miscount of hooks in bundles, or a miscount of bundles during setup. Note that 500 hooks were deployed on the first year

of the HBLL OUTSIDE survey (2006). In subsequent years, 450 hooks have been deployed, as this better accommodates the length of the groundline (L. Yamanaka, DFO, Nanaimo, B.C., personal communication, 2019).

Since the start of the HBLL OUTSIDE surveys (2006), and since 2003 for the IPHC surveys, vessels have used bird exclusion devices, which are intended to reduce the bycatch of seabirds. Table 19 summarizes the types of devices used, to present.

Table 19. Summary of bird exclusion devices used on HBLL OUT N, HBLL OUT S and IPHC surveys.

ACTIVITY_DESC	BIRD_EXCLUSION_DEVICE_CODE	BIRD_EXCLUSION_DEVICE_DESC
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	11	SINGLE STREAMER
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	12	PAIRED STREAMERS
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	30	PAIRED STREAMER AND TOWED BUOY
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	31	SINGLE STREAMER AND TOWED BUOY
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	99	ABSENT
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	11	SINGLE STREAMER
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	12	PAIRED STREAMERS
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	21	TOWED BUOY
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	30	PAIRED STREAMER AND TOWED BUOY
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	31	SINGLE STREAMER AND TOWED BUOY
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	11	SINGLE STREAMER
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	12	PAIRED STREAMERS
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE SURVEY	99	ABSENT

HOOK_SPECS

Table 20 shows examples of line condition, hook condition, and hook yield for each survey series.

Table 20. Selected records of the first set, skate, and five hooks retrieved of each of the survey series.

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate_level)	FE_MINOR_LEVEL_ID (hook-level)	LINE_CONDITION_DESC	HOOK_YIELD_DESC	HOOK_CONDITION_DESC
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1	1	NORMAL	NON-FISHING DEVICE (SEE HOOK CONDITIOI	ANCHOR
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1	2	NORMAL	NON-FISHING DEVICE (SEE HOOK CONDITIOI	TDR1
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1	3	NORMAL	ANIMAL - FISH OR INVERTEBRATE	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1	4	NORMAL	ANIMAL - FISH OR INVERTEBRATE	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	79290	1	1	5	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1	1	NORMAL	ANIMAL - FISH OR INVERTEBRATE	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1	2	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1	3	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1	4	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	78090	1	1	5	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1	1	NORMAL	ANIMAL - FISH OR INVERTEBRATE	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1	2	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1	3	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1	4	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	82912	1	1	5	NORMAL	BAIT ONLY (NO CATCH)	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1	1	NORMAL	ANIMAL - FISH OR INVERTEBRATE	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1	2	NORMAL	BAIT ONLY (NO CATCH)	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1	3	NORMAL	BAIT ONLY (NO CATCH)	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1	4	NORMAL	EMPTY	NORMAL
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	80332	1	1	5	NORMAL	EMPTY	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	1	1	NORMAL	EMPTY	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	1	2	NORMAL	EMPTY	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	1	3	NORMAL	EMPTY	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	1	4	NORMAL	EMPTY	NORMAL
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	1	5	NORMAL	EMPTY	NORMAL

As the gear is hauled onboard at the end of a fishing event, the condition of the groundline and of each attached hook is observed by the hook-by-hook recorder. These hook-specific attributes are housed in the HOOK_SPECS table which is linked to the FISHING_EVENT table by the FISHING_EVENT_ID at the **hook-level**. The state of the

groundline (normal or snarled) at a hook is recorded using the LINE_CONDITION code (Table 21), while the condition of the hook (broken, missing, replaced by a non-fishing device, etc.) is recorded using HOOK_CONDITION code (Table 22). The hook yield is recorded using HOOK_YIELD code (Table 23) and represents what was actually retrieved (if anything) at an individual hook position, for example, an animal (catch), left-over bait, an empty hook, a non-fishing device, etc.

Note that the HOOK_CONDITION_CODE ‘7’ (MISSING, BENT, BROKEN) in the HOOK_CONDITION table (Table 22), was used in the IPHC surveys from 2003 to 2009. In 2010 a change was made to adopt the hook descriptors used for the HBLL surveys (i.e. MISSING HOOK BUT SNAP PRESENT; BENT; etc).

Since 2016, the HBLL INSIDE surveys also record non-fishing devices that are attached along the longline in place of hooks. These include temperature-depth recorders (TDRs), anchors and sash weights. They are identified by HOOK_CONDITION_CODEs 10 through 23 (Table 22).

Table 21. LINE_CONDITION codes and descriptors.

LINE_CONDITION_CODE	LINE_CONDITION_DESC
0	UNKNOWN
1	NORMAL
2	SNARL
3	NOT OBSERVED

Table 22. HOOK_CONDITION codes and descriptors.

HOOK_CONDITION_CODE	HOOK_CONDITION_DESC
0	UNKNOWN
1	MISSING HOOK BUT SNAP PRESENT
2	BENT
3	BROKEN
4	BROKEN AT RAIL
5	NOT OBSERVED
6	NORMAL
7	MISSING, BENT, BROKEN
8	SNAP NOT ATTACHED TO GROUNDLINE
9	HOOK SNAGGED ON ADJACENT HOOK
10	TDR1
11	TDR2
12	TDR3
13	SASH WEIGHT
14	ANCHOR
15	TDR1 (Red)
16	TDR2 (Red)
17	TDR3 (Red)
18	TDR1 (Green)
19	TDR2 (Green)
20	TDR3 (Green)
21	TDR1 (Black)
22	TDR2 (Black)
23	TDR3 (Black)

Table 23. HOOK_YIELD codes and descriptors.

HOOK_YIELD_CODE	HOOK_YIELD_DESC
0	UNKNOWN
1	EMPTY
2	BAIT ONLY (NO CATCH)
3	ANIMAL - FISH OR INVERTEBRATE
4	FISH HEAD ONLY (BODY REMOVED BY PREDATOR)
5	ANIMAL DROPPED OFF DURING GEAR RETRIEVAL
6	BAIT SKIN
7	NOT OBSERVED
8	EATEN OR BITTEN BY DOGFISH, SHARK, WHALE, ETC. IGNORE HEALED BITE WOUNDS
9	NON-FISHING DEVICE (SEE HOOK CONDITION)

LONGLINE_BAIT_LURE

The LONGLINE_BAIT_LURE table describes the type and amount of bait used and how the hooks were baited. It is linked to the FISHING_EVENT table by the FISHING_EVENT_ID, at the **set-level**. Table 24 summarizes the longline bait specifications for all survey series. For the IPHC survey, the bait amount is not recorded; however, since 2003 the amount has consistently ranged between 0.11kg

(0.25 lb) and 0.15 kg (0.33 lb) per hook (E. Soderlund, IPHC, Seattle, Washington, personal communication, 2019).

Table 24. Longline bait summary for all survey series.

ACTIVITY_DESC	BAIT_LURE_CODE	BAIT_LURE_DESC	BAIT_METHOD_CODE	BAIT_METHOD_DESC	LGLBL_BAIT_AMOUNT (KG)
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE NORTH	15	SQUID	1	BY HAND	0.03
HARD BOTTOM LONGLINE HOOK SURVEY - INSIDE SOUTH	15	SQUID	1	BY HAND	0.03
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE NORTH	15	SQUID	1	BY HAND	0.03
HARD BOTTOM LONGLINE HOOK SURVEY - OUTSIDE SOUTH	15	SQUID	1	BY HAND	0.03
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	19	POLLOCK	1	BY HAND	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	109	PINK SALMON	1	BY HAND	
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	110	CHUM SALMON	1	BY HAND	

In 2012 (TRIP_IDs 73290 and 73291), the IPHC incorporated a bait comparison study into their survey. They baited 4 consecutive skates with the standard bait (Chum Salmon),and baited a skate each with Pollock and Pink Salmon. Adjacent bait types were separated from each other by an 1800’ length of groundline. They tracked which skates had each bait type and were able to distinguish which rockfish were captured on experimental skates and which were captured on standard survey skates. Table 25 summarizes the baiting methods used in the study. It is linked to the FISHING_EVENT table by the FISHING_EVENT_ID, at the **skate-level**.

As previously noted, the LONGLINE_SPECS table is linked to FISHING_EVENT by the FISHING_EVENT_ID, at the **set-level.** However, it is also linked to FISHING_EVENT_ID at the **skate-level** for the bait comparison study data, because different baits were utilized on different skates. At the **skate-level**, the USABILITY and LONGLINE codes are populated.

The structure of the LONGLINE_BAIT_LURE table will be reassessed in the future. Updates are being considered to move all data from the **skate-level** to the **hook-level**, as it is the hooks that hold the bait.

Table 25. Selected records for each of two trips in which the IPHC conducted a bait comparison study - TRIP_IDs 73290 and 73291, Set # 1 for each trip, their skate numbers, and bait used.

TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	BAIT_LURE_ CODE	BAIT_LURE_DESC	BAIT_METHOD _CODE	BAIT_METHOD_ DESC
73290	1	1	19	POLLOCK	1	BY HAND
73290	1	3	109	PINK SALMON	1	BY HAND
73290	1	5	110	CHUM SALMON	1	BY HAND
73290	1	6	110	CHUM SALMON	1	BY HAND
73290	1	7	110	CHUM SALMON	1	BY HAND
73290	1	8	110	CHUM SALMON	1	BY HAND
73291	1	1	19	POLLOCK	1	BY HAND
73291	1	3	109	PINK SALMON	1	BY HAND
73291	1	5	110	CHUM SALMON	1	BY HAND
73291	1	6	110	CHUM SALMON	1	BY HAND
73291	1	7	110	CHUM SALMON	1	BY HAND
73291	1	8	110	CHUM SALMON	1	BY HAND

IPHC_EFFECTIVE_SKATE

The IPHC data include a calculated ‘effective skate’ number for each set which is used by the IPHC in their calculation of fishing effort (Appendix C; Yamanaka et al. 2008). The effective skate number “standardizes survey data in years when the number of hooks, hook spacing, or hook type varied” (Yamanaka et al. 2008). An effective skate of one represents a skate of 100 circle hooks with 18-foot spacing (Yamanaka et al. 2008). It is housed in the IPHC_EFFECTIVE_SKATE table and is linked to the FISHING_EVENT table by the FISHING_EVENT_ID, at the **set-level (**Table 26).

Table 26. Selected records of IPHC ‘effective skate’ values in the IPHC_EFFECTIVE_SKATE table .

ACTIVITY_DESC	TRIP_ID	FE_MAJOR_LEVEL_ID (set-level)	EFFECTIVE_SKATE
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	83	5.019
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83039	84	5.019
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83040	1	4.968
INTERNATIONAL PACIFIC HALIBUT COMMISSION LONGLINE	83040	2	4.968

QUERYING HIERARCHICAL EVENTS

FISHING_EVENT

In summary, the FISHING_EVENT table models three hierarchical levels. They are:

1. FE_MAJOR_LEVEL_ID) - the **set-level**, representing the deployment of a single line of longline gear

2. FE_SUB_LEVEL_ID - the **skate-level**, representing individual skates that make up the longline
3. FE_MINOR_LEVEL_ID - the **hook-level**, representing individual hooks attached to the skates

Each of these records has a unique FISHING_EVENT_ID, which is the primary key for the table. The hierarchical relationships are established by the FE_PARENT_EVENT_ID. Thus, hook-level records store the FISHING_EVENT_ID value of the skate-level record they are attached to in their FE_PARENT_EVENT_ID field, and skate-level records store the FISHING_EVENT_ID value of the set-level record to which they are attached. Additionally, the columns FE_MAJOR_LEVEL_ID, FE_SUB_LEVEL_ID, and FE_MINOR_LEVEL_ID store the numerical deployment sequence of the three levels (e.g. set #1, skate #2, hook #1, etc.).

Take note of null data fields in Table 27. When querying FISHING_EVENT for:

- set information - include the criteria where FE_PARENT_EVENT_ID is null
- skate information - include the criteria where FE_SUB_LEVEL_ID is not null and FE_MINOR_LEVEL_ID is null
- hook information - include the criteria where FE_MINOR_LEVEL_IDs are not null

Table 27. Hierarchical events in the FISHING_EVENT table including 3 sets with one skate and five hooks each.

TRIP_ID	FISHING_EVENT_ID	FE_PARENT_EVENT_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate-level)	FE_MINOR_LEVEL_ID (hook-level)
79290	4124521		1		
79290	4120825	4124521	1	1	
79290	4120826	4120825	1	1	1
79290	4120827	4120825	1	1	2
79290	4120828	4120825	1	1	3
79290	4120829	4120825	1	1	4
79290	4120830	4120825	1	1	5
79290	4124532		2		
79290	4122686	4124532	2	1	
79290	4122687	4122686	2	1	1
79290	4122688	4122686	2	1	2
79290	4122689	4122686	2	1	3
79290	4122690	4122686	2	1	4
79290	4122691	4122686	2	1	5
79290	4124520		3		
79290	4123820	4124520	3	1	
79290	4123821	4123820	3	1	1
79290	4123822	4123820	3	1	2
79290	4123823	4123820	3	1	3
79290	4123824	4123820	3	1	4
79290	4123825	4123820	3	1	5

CATCH

In summary, total catch is stored at the **set-level** while individual hook catch is stored at the **hook-level** in the CATCH table. With catch stored at two levels, it is easy to double it. To avoid this scenario:

- include the criteria where FE_PARENT_EVENT_ID is null when summing set-level catch
- include the criteria where FE_PARENT_EVENT_ID is not null when summing hook-level catch

Referring to Table 28, taking note of the null data fields, and following the criteria above, a total of 8 counts of SPECIES_CODE 424 (Quillback Rockfish) are summed at the set-level which equals the count of 8 Quillback Rockfish at the hook-level.

Table 28. Selected records at the set- and hook-levels displaying the hierarchical events in CATCH.

TRIP_ID	FISHING_EVENT_ID	FE_PARENT_EVENT_ID	FE_MAJOR_LEVEL_ID (set-level)	FE_SUB_LEVEL_ID (skate_level)	FE_MINOR_LEVEL_ID (hook-level)	SPECIES_CODE	CATCH_COUNT
79290	4124521		1			424	1
79290	4121047	4120825	1	1	222	424	1
79290	4124532		2			424	3
79290	4122723	4122686	2	1	37	424	1
79290	4122828	4122686	2	1	142	424	1
79290	4122839	4122686	2	1	153	424	1
79290	4124520		3			424	4
79290	4123856	4123820	3	1	36	424	1
79290	4123858	4123820	3	1	38	424	1
79290	4123899	4123820	3	1	79	424	1
79290	4123952	4123820	3	1	132	424	1

AN EXAMPLE OF GEOSPATIAL ANALYSIS

Many pieces of information, housed in multiple tables within GFBIO, are used to translate hook by hook data to a geospatial format. For example, from the FISHING_EVENT table, the data fields which store detailed location information and HAUL_POSTION_CODE are used. From the LONGLINE_SPECS table, LGLSP_HOOK_COUNT and USABILITY are used, and, species at the **hook-level** are used from the CATCH table. Survey set lines are created and are then translated to a geography spatial data type, spatial data points (hooks) are generated, line lengths are calculated, and hook species presence and absence observations are assigned to the spatial data points. This is described in more detail in Appendix B.

Figure 8 illustrates the output of a Geospatial analysis, showing the presence and absence of Pacific Halibut, Quillback and Yelloweye Rockfish by longline hook at IPHC Station 2129, from 2003 to 2011. The multibeam bathymetry (collected by the Canadian Hydrographic Service) reveals the underlying habitat features where these fish are typically found.

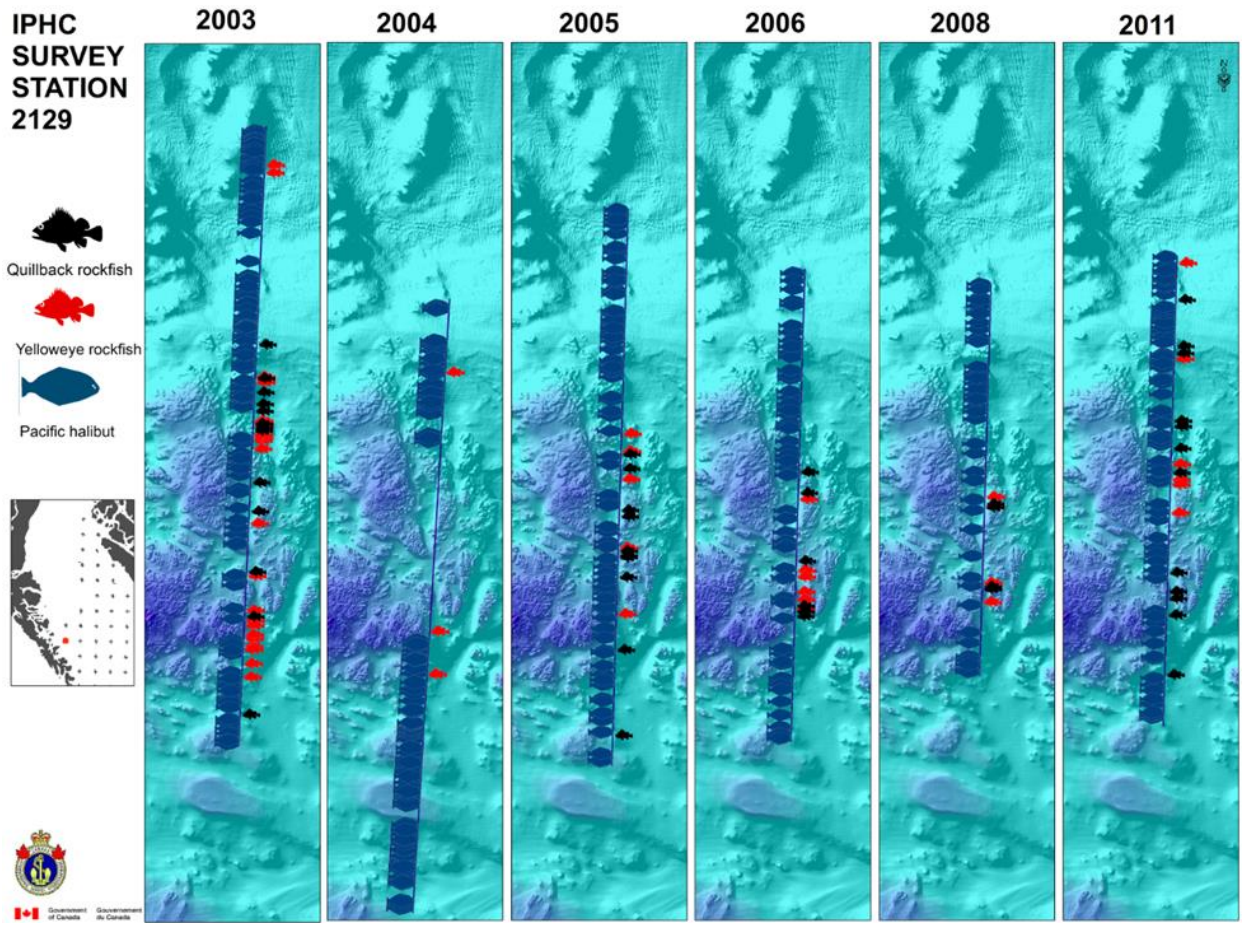


Figure 8. Image of IPHC Station 2129 from 2003 to 2011. Pacific Halibut, Quillback and Yelloweye Rockfish catch positions by longline hook are shown draped over multibeam bathymetry.

ADDITIONAL LONGLINE HOOK DATA IN GFBIO

In past years, a series of six North Pacific Spiny Dogfish longline hook trips were conducted to initially develop survey methodology and then to provide baseline biological and catch effort data for fishing sites in the Strait of Georgia (McFarlane et al. 2005). These data can be identified in GFBIO by filtering on TRIP_ACTIVITY code ‘39’ (Table 29).

Table 29. Strait of Georgia North Pacific Spiny Dogfish longline surveys, showing Trip_IDs, corresponding activity codes, and years conducted.

TRIP_ID	ACTIVITY_CODE	ACTIVITY_DESC	YEAR
75250	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	1986
75251	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	1989
82552	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	2005
82551	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	2008
82550	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	2011
76370	39	STRAIT OF GEORGIA DOGFISH LONGLINE SURVEY	2014

All associated data for these trips are linked at the **set-level**, only. Individual skate and hook data were not collected although gear specifications and number of hooks deployed are summarized in the LONGLINE_SPECS table.

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We sincerely thank Maria Cornthwaite for her comprehensive review and supportive suggestions and Lisa Lacko, for her review with respect to geospatial analysis and its application to longline hook data. We thank Malcolm Wyeth for his many contributions and in modifying the at-sea data collection protocols to accommodate the complexities of the longline hook data. We appreciate and thank Dana Haggarty for her unwavering support throughout the project. Kathryn Temple and John Holmes provided useful edits.

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Yamanaka, K.L., Lochead, J.K., and Dykstra, C. 2004. Summary of non-halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 27 to August11, 2003. Can. Tech. Rep. Fish. Aquat. Sci. 2535: iv + 53 p.

Yamanaka, K.L., Obradovich, S.G., Cooke, K., Lacko, L.C., and Dykstra, C. 2008. Summary of non-halibut catch from the Standardized Stock Assessment Survey conducted by the International Pacific Halibut Commission in British Columbia from May 19 to July 22, 2006. Can. Tech. Rep. Fish. Aquat. Sci. 2796: vii + 58 p.

Appendix A. Skate and Hook Numbering in Longline Hook Surveys

Throughout Appendix A, 'START' and 'END' haul positions in the data field FE_BLOCK_DESIGNATION in FISHING_EVENT are equivalent to what is now 'BEGINNING" and "END" HAUL_POSITION_CODE in FISHING_EVENT.

Skate and Hook NUMBERING for the HBLL IN and OUT surveys - when gear is PICKED UP at the START position:

I. HBLL IN

Between years 2003 and 2016, all HBLL surveys and for all MAJOR_LEVEL_IDs (Sets), SUB_LEVEL_ID is '1' and MINOR_LEVEL_IDs run sequentially from '1' to the number of the last hook retrieved. *Hook number '1' is the first hook deployed and the first hook retrieved.*

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	MinOfFE_MINOR_LEVEL_ID	MaxOfFE_MINOR_LEVEL_ID
79290	1	1	1	231
79290	2	1	1	223
79290	3	1	1	233
79290	4	1	1	231
79290	5	1	1	230
79290	6	1	1	229
79290	7	1	1	230
79290	8	1	1	227
79290	9	1	1	227
79290	10	1	1	225

II. HBLL OUT

Between years 2006 and 2016, all PHMA surveys and for all MAJOR_LEVEL_IDs (Sets), SUB_LEVEL_ID is '1' and MINOR_LEVEL_IDs run consecutively from 1' to the number of the last hook retrieved. *Hook number '1' is the first hook deployed and the first hook retrieved.*

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	MinOfFE_MINOR_LEVEL_ID	MaxOfFE_MINOR_LEVEL_ID
80331	1	1	1	420
80331	2	1	1	442
80331	3	1	1	480
80331	4	1	1	460
80331	5	1	1	453
80331	6	1	1	444
80331	7	1	1	435
80331	8	1	1	435
80331	9	1	1	465
80331	10	1	1	450

Skate and Hook NUMBERING for the HBLL IN and OUT surveys - when gear is PICKED UP at the END position:

I. HBLL IN and OUT

For the HBLL IN and OUT surveys and when gear is hauled from the END – *hook number '1' is the first hook retrieved (but was actually the last hook deployed)*. If hauled from the END and if using these data for geospatial analysis, then be aware that the start and end latitude and longitude of the geospatial polylines values must be **reversed** in GIS as to reflect where hook number '1' in GFBio should start.

Users need to be savvy -- **confirm hauling direction i.e. START or END!**

Screen capture 1 (below) lists a hook by hook tally taken in the field from a line that was hauled from the END position. How it translates to GFBio can be viewed in Screen capture 2 which lists the capture of the first ten hooks on the longline, corresponding to the first 10 hooks status in Screen capture 1.

Vessel Name: ARGYLE NO1 Vessel Code: ARG ASOP File: 280313

Station: 187, Set Number: 003, Skate Number Date: AUG 1/08 Time of First Flag Out of Water: 1643
Hook 001 Position: Set Start ☐ End ☒ Latitude: 5208.05, Longitude: 13100.27, Depth: 44

Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species
001	✓	013	✓	025	✓	037	DL ✓	049	✓	061	✓	073	✓	085	✓	097	✓	109	
002	✓	014	HBD ✓	026	✓	038	✓	050	✓	062	✓	074	✓	086	H-R	098	✓	110	
003	✓	015	✓	027	✓	039	✓	051	✓	063	✓	075	✓	087	✓	099	✓	111	
004	H-R	016	✓	028	✓	040	✓	052	✓	064	✓	076	✓	088	✓	100	✓	112	
005	H-R	017	✓	029	✓	041	✓	053	DS ✓	065	✓	077	✓	089	✓	101		113	
006	✓	018	✓	030	✓	042	✓	054	✓	066	✓	078	✓	090	✓	102		114	
007	✓	019	✓	031	✓	043	✓	055	✓	067	✓	079	✓	091	✓	103		115	
008	✓	020	✓	032	✓	044	✓	056	✓	068	✓	080	✓	092	✓	104		116	
009	✓	021	✓	033	✓	045	✓	057	✓	069	✓	081	✓	093	✓	105		117	
010	✓	022	✓	034	HBSD ✓	046	✓	058	✓	070	✓	082	✓	094	✓	106		118	
011	✓	023	✓	035	✓	047	✓	059	✓	071	✓	083	✓	095	✓	107		119	
012	✓	024	✓	036	✓	048	✓	060	✓	072	✓	084	✓	096	✓	108		120	

Comments:

Station:_____, Set Number:_____, Skate Number _____

Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species
001	✓	013	✓	025	✓	037	✓	049	✓	061	✓	073	✓	085	✓	097	✓	109	
002	✓	014	✓	026	Q ✓	038	✓	050	✓	062	Q ✓	074	✓	086	✓	098	✓	110	
003	✓	015	✓	027	RAT ✓	039	✓	051	✓	063	✓	075	✓	087	✓	099	✓	111	
004	✓	016	Q ✓	028	✓	040	✓	052	✓	064	Q ✓	076	✓	088	✓	100	✓	112	
005	✓	017	Q ✓	029	✓	041	✓	053	✓	065	✓	077	✓	089	✓	101		113	
006	✓	018	✓	030	✓	042	✓	054	✓	066	YE ✓	078	✓	090	✓	102		114	
007	✓	019	✓	031	✓	043	✓	055	✓	067	✓	079	✓	091	✓	103		115	
008	✓	020	✓	032	✓	044	✓	056	✓	068	✓	080	✓	092	✓	104		116	
009	STAR ✓	021	✓	033	✓	045	✓	057	✓	069	✓	081	✓	093	✓	105		117	
010	✓	022	✓	034	✓	046	✓	058	✓	070	✓	082	✓	094	✓	106		118	
011	✓	023	✓	035	✓	047	✓	059	✓	071	✓	083	✓	095	✓	107		119	
012	✓	024	✓	036	LNS ✓	048	✓	060	✓	072	✓	084	✓	096	✓	108		120	

Screen capture 1.

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
66587	3	1	1	EMPTY
66587	3	1	2	EMPTY
66587	3	1	3	BAIT ONLY (NO CATCH)
66587	3	1	4	ANIMAL - FISH OR INVERTEBRATE
66587	3	1	5	ANIMAL - FISH OR INVERTEBRATE
66587	3	1	6	EMPTY
66587	3	1	7	BAIT ONLY (NO CATCH)
66587	3	1	8	BAIT ONLY (NO CATCH)
66587	3	1	9	BAIT ONLY (NO CATCH)
66587	3	1	10	BAIT ONLY (NO CATCH)

Screen capture 2.

Skate and Hook NUMBERING for the IPHC surveys:

Five to 8 skates have been deployed on the IPHC surveys since 2003. It is important to know the number of skates deployed, as this impacts hook numbering particularly when gear is hauled from the END position.

I. Between years 2007 and 2016

The following table illustrates the numbering of consecutive skate and hooks in GFBio when gear is hauled from either the START or END position. For trip number 67357; sets 1 to 5 are shown, each with five skates numbered1 to 5, each with ~ 100 hooks, numbered from 1 to the number of the last hook retrieved per skate.

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	MinOfFE_MINOR_LEVEL_ID	MaxOfFE_MINOR_LEVEL_ID
67357	1	1	1	97
67357	1	2	1	98
67357	1	3	1	101
67357	1	4	1	98
67357	1	5	1	99
67357	2	1	1	99
67357	2	2	1	100
67357	2	3	1	101
67357	2	4	1	101
67357	2	5	1	100
67357	3	1	1	101
67357	3	2	1	98
67357	3	3	1	101
67357	3	4	1	98
67357	3	5	1	101
67357	4	1	1	101
67357	4	2	1	101
67357	4	3	1	99
67357	4	4	1	101
67357	4	5	1	102
67357	5	1	1	97
67357	5	2	1	100
67357	5	3	1	99
67357	5	4	1	102
67357	5	5	1	98

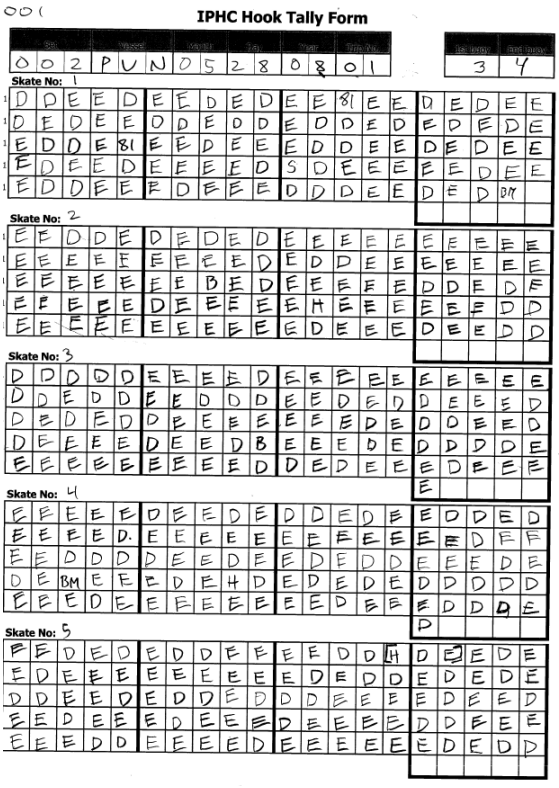
For this trip, Set 1 was hauled from the END position and Sets 2 to 5 were hauled from the START:

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_DIRECTION_OF_SET
67357	1	End
67357	2	Start
67357	3	Start
67357	4	Start
67357	5	Start

When hauled from the **START** position:

Using Set 2 as an example - when the set is hauled from the START position, hook number 1 on skate number 1 is the **first** hook retrieved and the **first** hook deployed. The **last** hook retrieved and the **last** deployed is on skate number 5 and hook number 100.

The screen capture below shows the hook by hook tally taken in the field (on the left) and how it translates to GFBio (on the right). The image on the right lists the capture of the first five hooks for each skate on the longline.



TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
67357	2	1	1	ANIMAL - FISH OR INVERTEBRATE
67357	2	1	2	ANIMAL - FISH OR INVERTEBRATE
67357	2	1	3	EMPTY
67357	2	1	4	EMPTY
67357	2	1	5	ANIMAL - FISH OR INVERTEBRATE
67357	2	2	1	EMPTY
67357	2	2	2	EMPTY
67357	2	2	3	ANIMAL - FISH OR INVERTEBRATE
67357	2	2	4	ANIMAL - FISH OR INVERTEBRATE
67357	2	2	5	EMPTY
67357	2	3	1	ANIMAL - FISH OR INVERTEBRATE
67357	2	3	2	ANIMAL - FISH OR INVERTEBRATE
67357	2	3	3	ANIMAL - FISH OR INVERTEBRATE
67357	2	3	4	ANIMAL - FISH OR INVERTEBRATE
67357	2	3	5	ANIMAL - FISH OR INVERTEBRATE
67357	2	4	1	EMPTY
67357	2	4	2	EMPTY
67357	2	4	3	EMPTY
67357	2	4	4	EMPTY
67357	2	4	5	EMPTY
67357	2	5	1	EMPTY
67357	2	5	2	EMPTY
67357	2	5	3	ANIMAL - FISH OR INVERTEBRATE
67357	2	5	4	EMPTY
67357	2	5	5	ANIMAL - FISH OR INVERTEBRATE

When using these data geo-spatially, hook numbers need to be numbered consecutively for the entire set, from the first hook on the first skate, to the last hook on

the last skate - i.e. numbers 1-501 for set number 2 on trip 67357. In SQL Server, two steps are taken to re-number hook numbers:

1. Run an update query where ((CurrentSkateNum -1) *100 + CurrentHookNum)): this assigns ‘new’ hook numbers to each skate.
2. Run a cursor/loop in the ordered table to reassign hooks to consecutive ‘best’ hook numbers (per skate).

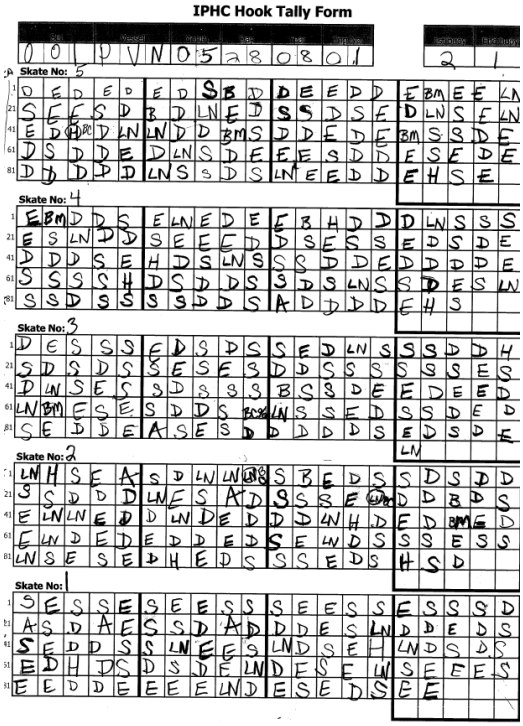
The cursor/loop script is described in greater detail later in this appendix.

When hauled from the **END** position

<u>When hauling from the END position, the IPHC records skates in reverse order and hooks are numbered sequentially from ‘1’ for each skate</u>.

Using Set 1 as an example – when the set is hauled from the END position, hook number 1 on skate number 5 is the **first** hook retrieved and the **last** hook deployed. The **last** hook retrieved and the **first** deployed is on skate number 1 and hook number 97.

The screen capture below shows the hook by hook tally taken in the field (on the left) and how it translates to GFBio (on the right). The image on the right lists the capture of the first five hooks for each skate on the longline.

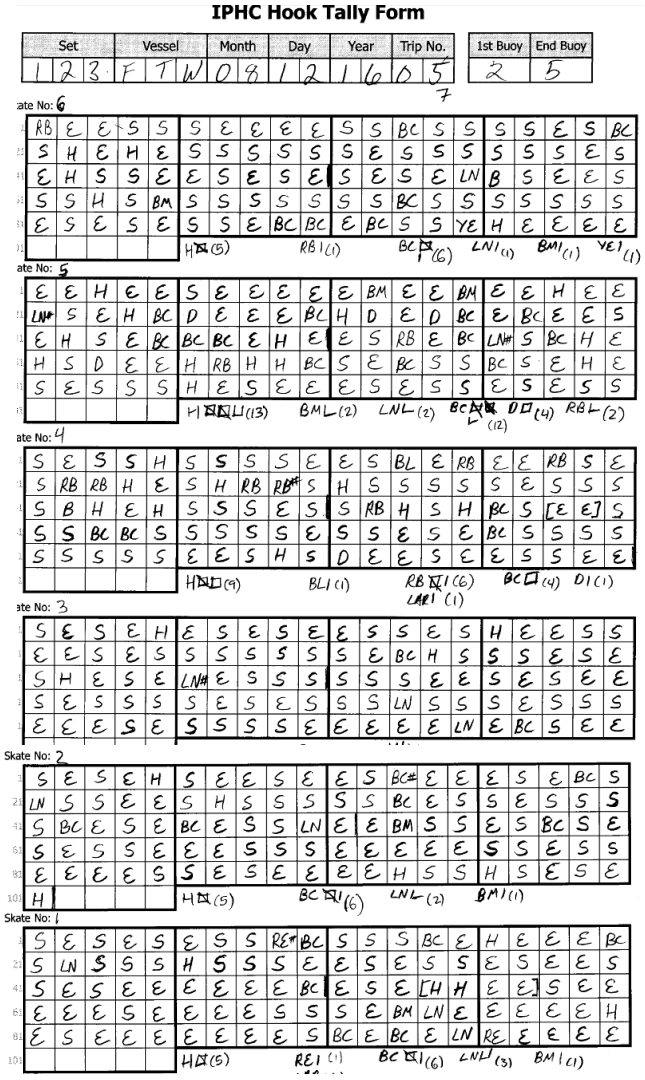


TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
67357	1	1	1	BAIT SKIN
67357	1	1	2	EMPTY
67357	1	1	3	BAIT SKIN
67357	1	1	4	BAIT SKIN
67357	1	1	5	EMPTY
67357	1	2	1	ANIMAL - FISH OR INVERTEBRATE
67357	1	2	2	ANIMAL - FISH OR INVERTEBRATE
67357	1	2	3	BAIT SKIN
67357	1	2	4	EMPTY
67357	1	2	5	ANIMAL - FISH OR INVERTEBRATE
67357	1	3	1	ANIMAL - FISH OR INVERTEBRATE
67357	1	3	2	EMPTY
67357	1	3	3	BAIT SKIN
67357	1	3	4	BAIT SKIN
67357	1	3	5	BAIT SKIN
67357	1	4	1	EMPTY
67357	1	4	2	EMPTY
67357	1	4	3	ANIMAL - FISH OR INVERTEBRATE
67357	1	4	4	ANIMAL - FISH OR INVERTEBRATE
67357	1	4	5	BAIT SKIN
67357	1	5	1	ANIMAL - FISH OR INVERTEBRATE
67357	1	5	2	EMPTY
67357	1	5	3	ANIMAL - FISH OR INVERTEBRATE
67357	1	5	4	EMPTY
67357	1	5	5	ANIMAL - FISH OR INVERTEBRATE

If hauled from the END and if using these data for geospatial analysis, then be aware that the start and end latitude and longitude of the geospatial polylines values must be **reversed** in GIS as to reflect where hook number ‘1’ in GFBio should start.

A detailed description is given next, using a new data set as the example.

UNDERSTANDING IPHC Data Collection when Gear is Hauled from the END position:



Data are collected following protocols agreed to by DFO and the IPHC – *Observe retrieval of the first flag and buoy. Label the top block of squares on the Hook Tally Form with the appropriate skate number depending on which direction the set is being hauled. When the gear is hauled backwards, still begin the hook tally at the top block or square, but use the skate number of the last skate set.*

TRIP_ID	SET_NUM	SKATE_NUM	MIN_HOOK_NUM	MAX_HOOK_NUM
80453	123	1	1	100
80453	123	2	1	101
80453	123	3	1	100
80453	123	4	1	100
80453	123	5	1	100
80453	123	6	1	100

When used geospatially it is important to understand the method in which the hook by hook data are captured. When hauling from the END position, skates are recorded in reverse order and hooks are numbered sequentially from ‘1’ for each skate.

This means that EACH skates hook numbering MUST be reversed because the last hook retrieved (for each skate) was the first hook deployed (on that skate).

In SQL Server, two steps are taken to re-order hook numbers:

1. Run an update query where (MaxSkateNum – CurrentSkateNum) *100 + CurrentHookNum to assign ‘new’ hook numbers to each skate.

2. Run a cursor/loop in the ordered table to reassign hooks to consecutive ‘best’ hook numbers (per skate). An example of the Transect SQL code used for an ordered table with the following fields is:

	year	TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	Direction	Max_skate	Hook_addition	Hook_cumulative
698	2007	64846	19	4	96	END	5	196	197
699	2007	64846	19	4	97	END	5	197	198
700	2007	64846	19	4	98	END	5	198	199
701	2007	64846	19	3	1	END	5	201	200
702	2007	64846	19	3	2	END	5	202	201
703	2007	64846	19	3	3	END	5	203	202
704	2007	64846	19	3	4	END	5	204	203

```
--loop thru the IPHC_Hook_Renumber_END table and put in the consecutive hook numbers
--in order to match those set lines and hook numbers created in a GIS
DECLARE @trip_id int, @major_fe int ,@hook int
DECLARE @i INT = 1
Declare @trip_storage int, @set_storage int

DECLARE hookcursor CURSOR
FOR select trip_id,FE_MAJOR_LEVEL_ID,
Hook_cumulative
      from IPHC_Hook_Renumber_END
for update of Hook_cumulative;
open hookcursor;
FETCH NEXT FROM hookcursor into @trip_id, @major_fe ,@hook
WHILE @@FETCH_STATUS = 0
BEGIN
SET NOCOUNT ON;
        if @trip_storage=@trip_id and  @set_storage=@major_fe
        UPDATE IPHC_Hook_Renumber_END
        set Hook_cumulative = @i,  @i=@i + 1
        where current of hookcursor
        else
            set @i=1
        set @trip_storage=@trip_id
        set @set_storage=@major_fe
        FETCH NEXT FROM hookcursor INTO @trip_id, @major_fe,@hook

end
close hookcursor;
deallocate hookcursor;
--renumber the 0's to 1
update IPHC_Hook_Renumber_END
set Hook_cumulative = 1 where Hook_cumulative=0
```

Performing Step 1 on the Hook Tally Form above, where 6 is the MaxSkateNum, the following ‘NEW’ hook numbers are created: take note of the two ‘501’ hook numbers.

SkateNum	MIN hook num	Max hook num	NEW MIN hook num	NEW MAX hook num
1	1	100	501	600
2	1	101	401	501
3	1	100	301	400
4	1	100	201	300
5	1	100	101	200
6	1	100	1	100

Performing Step 2, which accounts for MAX hook numbers that are less than or greater than 100 per skate, loops the *ordered* ‘new’ hook numbers to consecutive ‘BEST’ hook numbers (per skate).

SkateNum	MIN hook num	MAX hook num	NEW MIN hook num	NEW MAX hook num	BEST MIN hook num	BEST MAX hook num
1	1	100	501	600	502	601
2	1	101	401	501	401	501
3	1	100	301	400	301	400
4	1	100	201	300	201	300
5	1	100	101	200	101	200
6	1	100	1	100	1	100

II. Between years 2003 and 2006

The following table illustrates the numbering of consecutive skates and hooks in GFBio when gear is hauled from either the START or END position. For trip number 52040, sets 5 to 7 are shown, each with eight skates numbered 1 to 8, each skate with ~100 hooks, with hook numbers running consecutively from 1 to the end of each set.

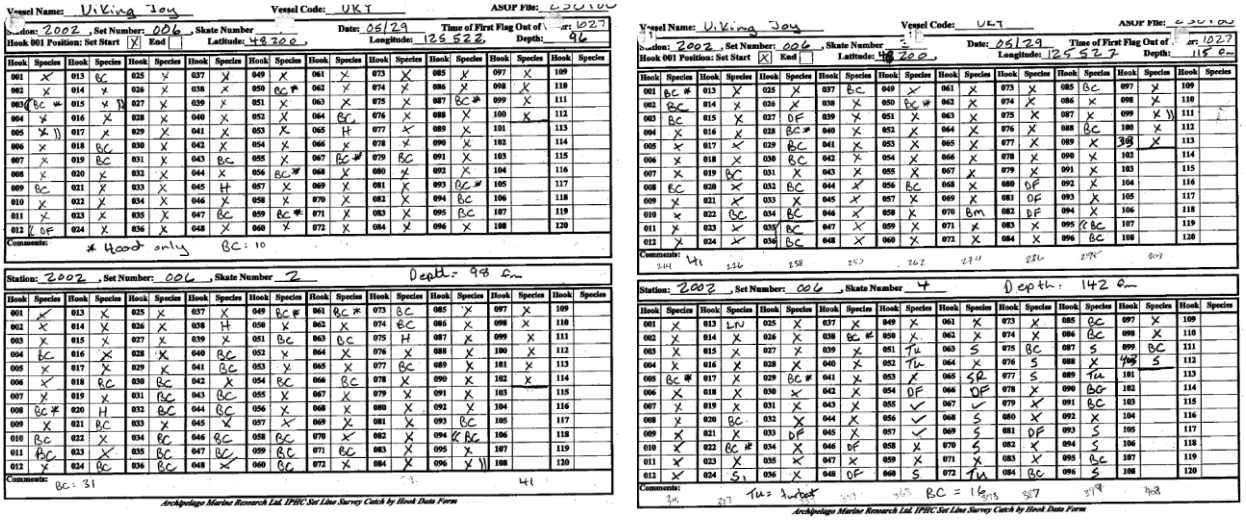
TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	MinOfFE_MINOR_LEVEL_ID	MaxOfFE_MINOR_LEVEL_ID
52040	5	1	1	99
52040	5	2	100	201
52040	5	3	202	300
52040	5	4	301	400
52040	5	5	401	501
52040	5	6	502	602
52040	5	7	603	700
52040	5	8	701	800
52040	6	1	1	100
52040	6	2	101	202
52040	6	3	203	303
52040	6	4	304	403
52040	6	5	404	500
52040	6	6	501	600
52040	6	7	601	700
52040	6	8	701	798
52040	7	1	1	103
52040	7	2	104	202
52040	7	3	203	303
52040	7	4	304	402
52040	7	5	403	503
52040	7	6	504	603
52040	7	7	604	703
52040	7	8	704	802

For this trip, Set 5 was hauled from the END position and Sets 6 and 7 were hauled from the START:

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_DIRECTION_OF_SET
52040	5	END
52040	6	START
52040	7	START

Using Set 6 as an example - when the set is hauled from the START position, hook number 1 on skate number 1 is the **first** hook retrieved and the **first** hook deployed. The **last** hook retrieved and the last deployed is on skate number 8 and hook number 798.

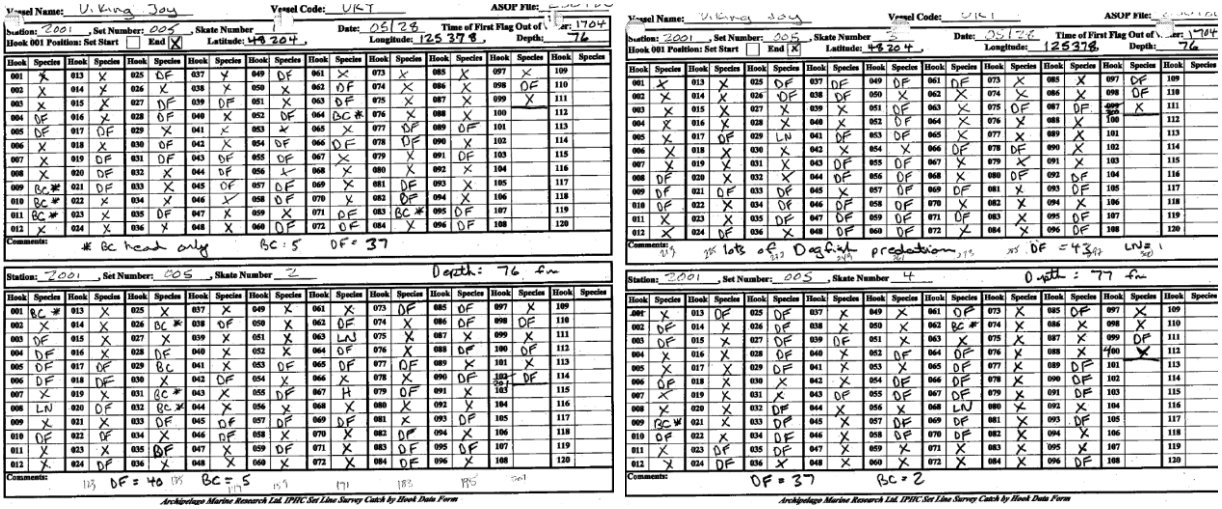
The screen capture below shows the hook by hook tally taken in the field for the first four skates and how it translates to GFBio. The bottom image demonstrates the capture of the first five hooks for the first four skates on the longline.



TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
52040	6	1	1	EMPTY
52040	6	1	2	EMPTY
52040	6	1	3	FISH HEAD ONLY (BODY REMOVED BY PREDATOR)
52040	6	1	4	EMPTY
52040	6	1	5	EMPTY
52040	6	2	101	EMPTY
52040	6	2	102	EMPTY
52040	6	2	103	EMPTY
52040	6	2	104	ANIMAL - FISH OR INVERTEBRATE
52040	6	2	105	EMPTY
52040	6	3	203	FISH HEAD ONLY (BODY REMOVED BY PREDATOR)
52040	6	3	204	ANIMAL - FISH OR INVERTEBRATE
52040	6	3	205	ANIMAL - FISH OR INVERTEBRATE
52040	6	3	206	EMPTY
52040	6	3	207	EMPTY
52040	6	4	304	EMPTY
52040	6	4	305	EMPTY
52040	6	4	306	EMPTY
52040	6	4	307	EMPTY
52040	6	4	308	FISH HEAD ONLY (BODY REMOVED BY PREDATOR)

When gear is hauled from the END as in Set 5 and as shown on the images below – hook number 1 on skate number 1 is the **first** hook retrieved AND is the last hook deployed. If hauled from the END and if using these data for geospatial analysis, then be aware that the start and end latitude and longitude of the geospatial polylines values must be **reversed** in GIS as to reflect where hook number '1' in GFBio should start.

Users need to be savvy -- **confirm hauling direction i.e. START or END!**



TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
52040	5	1	1	EMPTY
52040	5	1	2	EMPTY
52040	5	1	3	EMPTY
52040	5	1	4	ANIMAL - FISH OR INVERTEBRATE
52040	5	1	5	ANIMAL - FISH OR INVERTEBRATE
52040	5	2	100	FISH HEAD ONLY (BODY REMOVED BY PREDATOR)
52040	5	2	101	EMPTY
52040	5	2	102	ANIMAL - FISH OR INVERTEBRATE
52040	5	2	103	ANIMAL - FISH OR INVERTEBRATE
52040	5	2	104	ANIMAL - FISH OR INVERTEBRATE
52040	5	3	202	EMPTY
52040	5	3	203	EMPTY
52040	5	3	204	EMPTY
52040	5	3	205	EMPTY
52040	5	3	206	EMPTY
52040	5	4	301	EMPTY
52040	5	4	302	ANIMAL - FISH OR INVERTEBRATE
52040	5	4	303	ANIMAL - FISH OR INVERTEBRATE
52040	5	4	304	EMPTY
52040	5	4	305	EMPTY

Hook and Skate NUMBERING when GEAR has PARTED:

Between years 2003 and 2016, all longline surveys (HBLL IN, HBLL OUT, and IPHC) had collected data when the gear had parted in a similar fashion – in summary, when the gear parted, the vessel travelled to the other end of the string and the remaining hooks were recorded in reverse order starting with the hook number associated with the last hook deployed.

I. For the HBLL IN surveys, GEAR_PARTED had occurred once since capturing the hook_by_hook data electronically (up to 2016). In this case, after the gear parted, the vessel travelled to the other end of the string to retrieve the gear, and the recorder manually recorded (using pencil and paper) the status of each hook as it came on board, in sequential order. Once the gear was on board and the set was complete, the recorder entered the remaining hooks (those on paper) into the electronic database in reverse order. After 2016, GFBiofield was updated to be able to record when the gear has parted and to re-order the hooks accordingly.

II. For the HBLL OUT surveys (at the time of writing), GEAR_PARTED had occurred twice – both on lines that were hauled from the END position. The vessel travelled to the other end of the string and the remaining hooks were recorded in reverse order, starting with the last cell in the last column of the recording sheet

The screen capture below shows the hook by hook tally recorded in the field – the double slash line (highlighted) in cell 015means that the gear parted after Hook #14 was retrieved. The remaining hooks were recorded on paper, in reverse order (starting at cell 120) and ending at cell 064). The double slash (highlighted) in cell 063, was recorded after the final hook of the set was retrieved. In this situation, when data is uploaded to the GFBio database, hooks are numbered based on the order that they are brought onboard the vessel. The data for the hook recovered after the gear parted is housed in cell 120 on the tally sheet. Thus, when uploaded to GFBio, data from cell 120 on the tally sheet is linked to hook #15 (the next hook after the gear parted at hook #14). This is shown in the screen capture of GFBio below.

Vessel Name: RANGER II Vessel Code: BNK ASOP File: 320402

Station: 132, Set Number: 016, Skate Number — Date: AUG 24/12 Time of First Flag Out of Water: 1042

Hook 001 Position: Set Start ☐ End ☒ Latitude: 54°07'9, Longitude: 133°15'2, Depth: 49 fm

Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species	Hook	Species
001	X	013	X	025		037		049		061		073	YEY	085	X	097	CAN	109	B
002	X	014	X	026		038		050		062		074	X	086	SIL	098	CAN	110	B
003	X	015	//	027		039		051		063	//	075	SIL	087	SIL	099	B	111	B
004	X	016		028		040		052		064	HR	076	CAN	088	X	100	B	112	B
005	X	017		029		041		053		065	B	077	X	089	X	101	X	113	B
006	X	018		030		042		054		066	X	078	YT	090	CAN	102	B	114	SIL
007	B	019		031		043		055		067	B	079	CAN	091	SIL	103	B	115	YEY
008	X	020		032		044		056		068	X	080	CAN	092	YEY	104	B	116	X
009	X	021		033		045		057		069	B	081	CAN	093	X	105	X	117	B
010	B	022		034		046		058		070	YEY	082	B	094	CAN	106	B	118	X
011	X	023		035		047		059		071	YEY	083	B	095	YEY	107	B	119	X
012	X	024		036		048		060		072	SIL	084	CAN	096	YEY	108	B	120	B

TRIP_ID	FE_MAJOR_LEVEL_ID	FE_SUB_LEVEL_ID	FE_MINOR_LEVEL_ID	HOOK_YIELD_DESC
73351	16	1	1	EMPTY
73351	16	1	2	EMPTY
73351	16	1	3	EMPTY
73351	16	1	4	EMPTY
73351	16	1	5	EMPTY
73351	16	1	6	EMPTY
73351	16	1	7	BAIT ONLY (NO CATCH)
73351	16	1	8	EMPTY
73351	16	1	9	EMPTY
73351	16	1	10	BAIT ONLY (NO CATCH)
73351	16	1	11	EMPTY
73351	16	1	12	EMPTY
73351	16	1	13	EMPTY
73351	16	1	14	EMPTY
73351	16	1	15	ANIMAL - FISH OR INVERTEBRATE
73351	16	1	16	BAIT ONLY (NO CATCH)
73351	16	1	17	EMPTY
73351	16	1	18	BAIT ONLY (NO CATCH)
73351	16	1	19	EMPTY
73351	16	1	20	BAIT ONLY (NO CATCH)
73351	16	1	21	ANIMAL - FISH OR INVERTEBRATE

III. After review, 5% of all IPHC sets between 2007 and 2016, where gear had parted during retrieval, are irreconcilable. These data are usable for biomass calculations but not for geospatial analysis. In early 2017, the IPHC updated their data collection protocol manual to better explain how the hook by hook recording should be collected when gear parts. They placed special focus on this procedure during observer training, and are fully aware of the need to catch these errors in the future.

Appendix B. Hook by Hook Data ADMIN Documentation

Hook by Hook Data ADMIN Documentation

Prepared by Lisa Lacko, DFO

http://dfbcv9twvasp001/sql/PacHarvHL_files/HookByHookData.html

Longline Survey Geospatial Data

Groundfish longline survey data is stored in the Department of Fisheries and Oceans (DFO) Pacific Region's Groundfish Biological relational database (GFBio), including species by hook. An historic overview of the structure of the longline hook data in GFBio is documented in this report. Translation of hook by hook data to a geospatial format is supported by transect SQL scripts housed in the Microsoft© SQL Server database engine DFBCV9TWVASP001. These scripts vary according to survey data collection protocols, but they follow 3 main steps:

1. Translate survey set lines to a geography spatial data type based on the recorded start and end location of the longline,
2. Generate spatial data points (hooks) according to the documented number of hooks deployed, pick up location and calculated line length,
3. Extract species by hook and assign each species-hook to the corresponding spatial data points created in step 2.

For database administrators, the T-SQL scripts for the Hard Bottom Longline Outside surveys, the International Pacific Halibut Commission (IPHC) Fishery-Independent Setline surveys, and the Hard Bottom Longline Inside surveys are stored under the hook and line database, PacHarvHL in the procedures *PHMA_Build_Hooks* code, *IPHC_Build_Hooks* code and IRLL_Build_Hooks code, respectively.

International Pacific Halibut Commission (IPHC) Fishery-Independent Setline Surveys (FISS)

The IPHC FISS surveys have been conducted since1963 (excluding 1987-1992) and they encompass nearshore and offshore waters from southern California to the northern Bering Sea. Species by hook data for the Canadian portion of the IPHC survey are available since 2003 (excluding 2013). Each year, between five and eight skates are deployed with ~100 hooks on each skate.

Hard Bottom Longline Outside North and South Surveys

The Hard Bottom Longline Outside North and South surveys provide fishery independent catch rates of all species and biological samples of inshore rockfish from the outside coastal waters of BC for stock assessments. This survey alternates annually between the northern (2007, 2009, 2011, 2014, 2016) and southern (2006, 2008, 2010, 2012, 2015, 2017) portions of British Columbia (BC). Two skates are deployed during the survey sets, with ~225 hooks per skate.

Hard Bottom Longline Inside North and South Surveys

The Hard Bottom Longline Inside North and South surveys provide an abundance index for inshore rockfish in the inside waters (Strait of Georgia). This survey has been conducted in 2003-2004, 2007-2008, 2010, 2012, 2014 and 2016 in the northern portion of the inside waters, DFO statistical areas (SA) 12 and 13. During the years 2005, 2009, 2011, 2013 and 2015, the survey covered the southern portion of the inside waters, SA 14 through 20, 28 and 29. Each year, one skate was deployed during a set with ~225 hooks.

Step 1: Geospatial Survey Set Lines

A geospatial survey set line is represented in the SQL Server environment as a LineString. A LineString is defined as a one-dimensional object representing a sequence of points and the line segments connecting them. The T-SQL command used to derive LineString instances (segmentspatialdata) from the longline start and end locations and corresponding spatial results is shown in Figure 1.

Figure 1: LineString method code used to create instances of longline survey sets and example of SQL Server Management studio spatial results window.

The geospatial survey set line table is composed of fields computed or obtained from GFBio. Table 1 lists the columns that have either been extracted or derived from the GFBio tables *TRIP, FISHING_EVENT, LONGLINE_SPECS* and *USABILITY*. The plot indicator field (Plot_ind) contains a value of 0 if the latitude or longitude values are too close to each other (< 0.001 km) or the direction of set field (FE_DIRECTION_OF_SET) is unknown. In 2018, the FE_DIRECTION_OF_SET field has been replaced by the HAUL_POSITION_CODE. The Distance field of the LineString is calculated with the STLength() method that returns the total length of the elements in a geography instance. The HookDistance field represents the distance between hooks with the addition of 2 hooks that serve as the buoys at each end of the longline. HookDistance is derived from the total length of the survey set divided by the number of hooks deployed.
PacHarvHL houses three geospatial set line tables in this format named *PHMA_Set_GIS_Lines*, *IPHC_Set_GIS_Lines* and *IRLL_Set_GIS_Lines*.

Table 1: List of table columns, corresponding GFBio table names and descriptions for the geospatial survey set lines tables.

Table Column	GFBio Table Name	Description
Year(TRIP_START_DATE)	TRIP	Survey year
TRIP_ID	TRIP	Unique survey trip identifier
CFV_NUM	TRIP	Survey vessel registration number or VRN
FE_MAJOR_LEVEL_ID	FISHING_EVENT	Fishing set number
FE_START_LATTITUDE_DEGREE, FE_START_LATTITUDE_MINUTE	FISHING_EVENT	Start latitude coordinates of longline at deployment
FE_START_LONGITUDE_DEGREE, FE_START_LONGITUDE_MINUTE	FISHING_EVENT	Start longitude coordinates of longline at deployment
FE_END_LATTITUDE_DEGREE, FE_END_LATTITUDE_MINUTE	FISHING_EVENT	End latitude coordinates of longline at deployment
FE_END_LONGITUDE_DEGREE, FE_END_LONGITUDE_MINUTE	FISHING_EVENT	End longitude coordinates of longline at deployment
Plot_ind	(derived)	Plot indicator of 1 if latitude and longitude values are valid and direction of set is known
Distance	(derived)	Distance calculated with STLength() method
FE_DIRECTION_OF_SET	FISHING_EVENT	Direction of set when picked up
HAUL_POSITION_CODE	FISHING_EVENT	2018 update: Direction of set 1=hauled from beginning position, 2=hauled from end position
Max(FE_MINOR_LEVEL_ID)	FISHING_EVENT	Total number of hooks deployed on the longline
HookDistance	(derived)	Calculated based on length and hook count, in kilometers
BLOCK_DESIGNATION	FISHING_EVENT	Survey station identification number
USABILITY_CODE	LONGLINE_SPECS	Determination of a successful set, usable for geospatial analysis
segmentspatialdata	(derived)	Geography LineString data type

Step 2: Geospatial Hook Data Points

The geospatial survey set line table is used as header data to accompany a new row of coordinates for each hook deployed, including the fishing markers at either end. In the example below, Figure 2 shows a survey set that deployed 28 hooks, including hook numbers 0 and 999 to represent the buoys. Currently, PacHarvHL houses two geospatial hook data points tables titled *PHMA_Hook_by_Hook*, *IPHC_Hook_by_Hook* and *IRLL_Hook_by_Hook*. The spatial data points (Table 2) for each hook are generated by moving a point along each LineString path, given a start point, a bearing, and a hook distance. The bearing of the survey set line from the start point to the end point is calculated using the SQL Server built-in math function ATN2. Then, using the bearing and the start point, the next destination point is created using the built-in math function ASIN (arcsine) until the maximum hook value is reached. Specific T-SQL code tasked to create each hook point is found in the *func_MoveAlongPath* code link and *func_MoveTowardsPoint* code link functions in PacHarvHL.

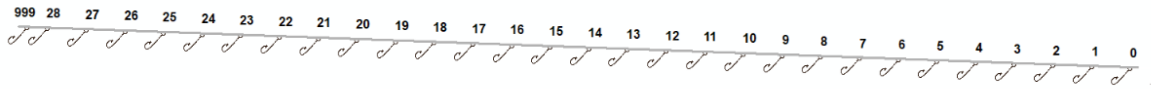


Figure 2: Example image of a lineString with 28 hook data points including 0 and 999 that represent buoys at either end.

Table 2: List of table columns, corresponding table names and descriptions for the geospatial survey hook points tables.

Table Column	Table Name	Description
Year, Trip_ID,Set_ID, VRN,hook, total,Usability_cde	Geospatial survey set lines table	Header data for each set
hook	(derived)	Hook number as generated in a loop for an individual LineString
GIS_coord	(derived)	Spatial data points generated in functions: func_MoveAlongPath and funcMoveTowardsPoint
HookDistance	(derived)	Cumulative hook distance of an individual LineString
pointspatialdata	(derived)	Converted GIS coordinates (GIS_coord) to a geometry data type point
x	(derived)	Extracted GPS x value of the point
y	(derived)	Extracted GPS y value of the point

Step 3: Geospatial Species by Hook Data Points

The geospatial species by hook data tables includes: derived fields or those extracted from GFBio tables TRIP, FISHING_EVENT, LONGLINE_SPECS and CATCH (Table 3). The Hook_id_new field was created to reorganize hook numbers, as survey protocols for recording hook numbers differ. For example, starting in 2007, the IPHC Fishery-Independent Setline Surveys recorded skate numbers in reverse when they were picked up at the END coordinate position, and the hooks were numbered from 1 to ~100 on each skate (described in a previous section of this report). In order to reorganize the hook numbers in consecutive order, a counter was used to populate the Hook_id_new field. PacHarvHL currently houses geospatial species by hook tables in this format named *PHMA_Hook_by_Hook_Species*, *IPHC_Hook_by_Hook_Species* and *IRLL_Hook_by_Hook_Species*. An example of species by hook in a Geographic Information System (GIS) is shown in Figure 3.

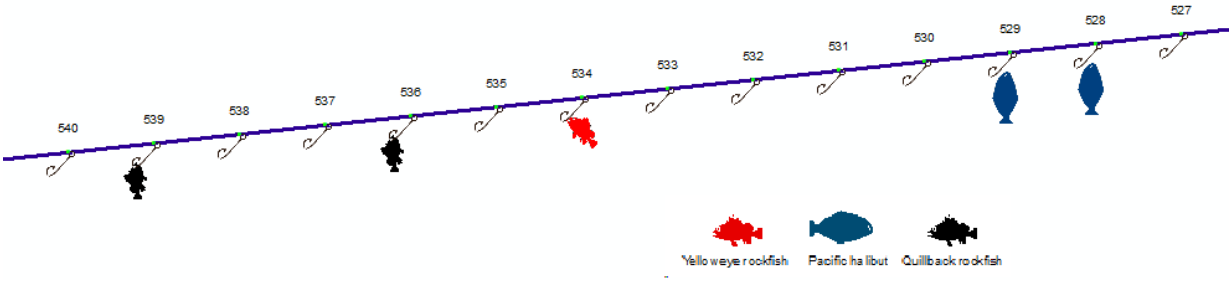


Figure 3: Image of species by hook on a longline survey set.

Table 3: List of table columns, corresponding table names and descriptions for the geospatial survey hook species points tables.

Table Column	GFBio Table Name	Description
TRIP_ID	TRIP	Unique survey trip identifier
CFV_NUM	TRIP	Survey vessel registration number or VRN
FE_MAJOR_LEVEL_ID	FISHING_EVENT	Fishing set number
FE_SUB_LEVEL_ID	FISHING_EVENT	Longline skate number
FE_MINOR_LEVEL_ID	FISHING_EVENT	Hook number
Hook_id_new	(derived)	Assigned hook number
CATCH_ID	CATCH	Unique ID given to identify catch
SPECIES_CODE	CATCH	Species identification code
Rockfish_ind	(derived)	Rockfish species identification of 1

Appendix C. IPHC Effective Skate Calculation

$$E = 1.52S\left(1 - e^{-0.006D}\right)\frac{H}{100}A.$$

where E= number of effective skates;
S= number of skates hauled;
D= hook spacing in feet;
H= number of hooks
A= adjustment value for differences among hook types (equals 1 for circle hooks)