An observational ontology for the salmon research community

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Afternoon talk

- The OBOE model
- More detailed look at the salmon ontology
- Drawing from other semantic efforts
- OBOE Semantic Annotations
- Challenges in modeling concepts

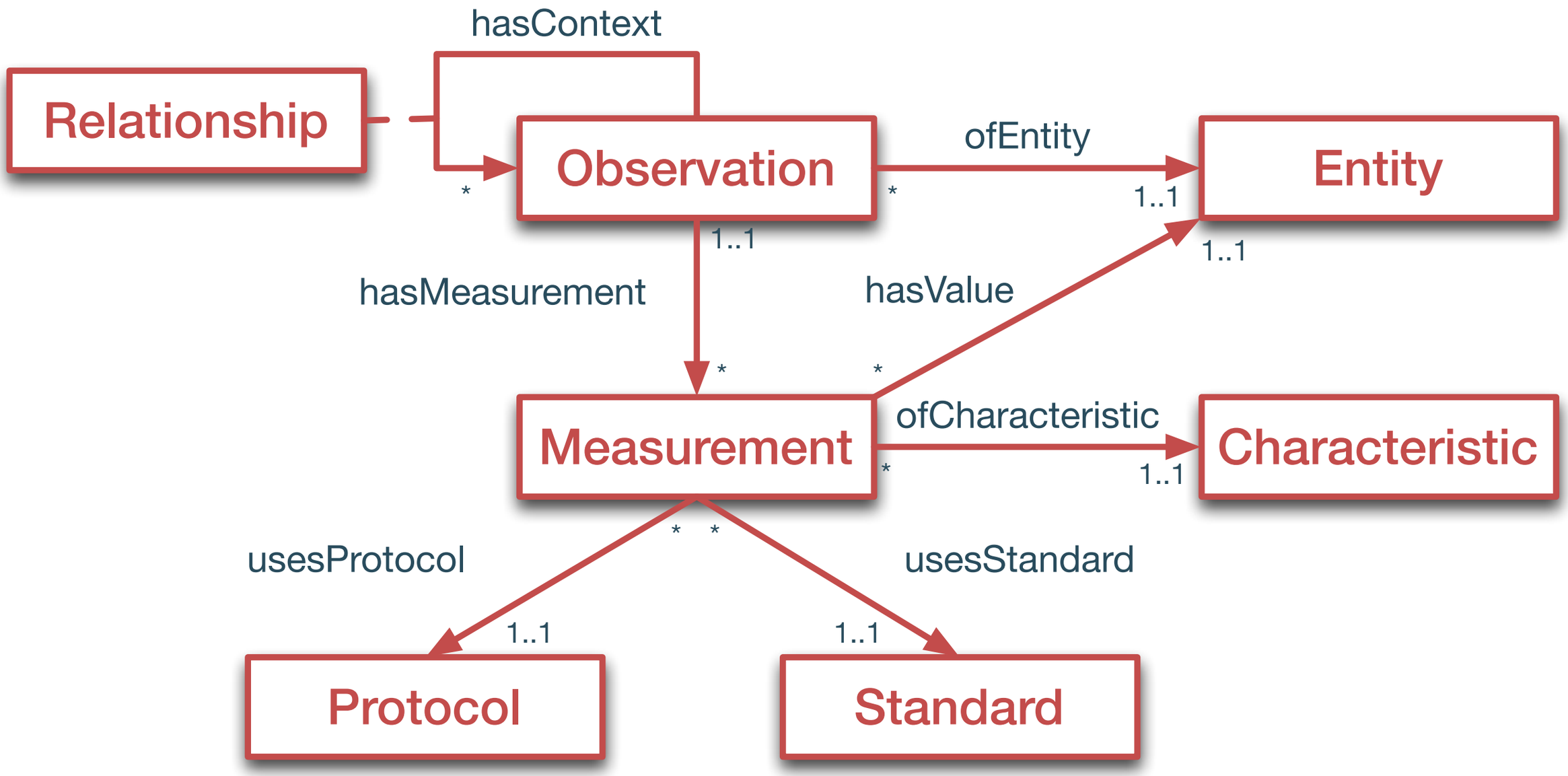
Extensible Observation Ontology

- Known as "OBOE"
- Madin, J., Bowers, S., Schildhauer, M., Krivov, S., Pennington, D., & Villa, F. (2007). **An ontology for describing and synthesizing ecological observation data**. Ecological Informatics, 2(3), 279-296. ELSEVIER SCIENCE BV. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/S1574954107000362

OBOE Scientific Observations

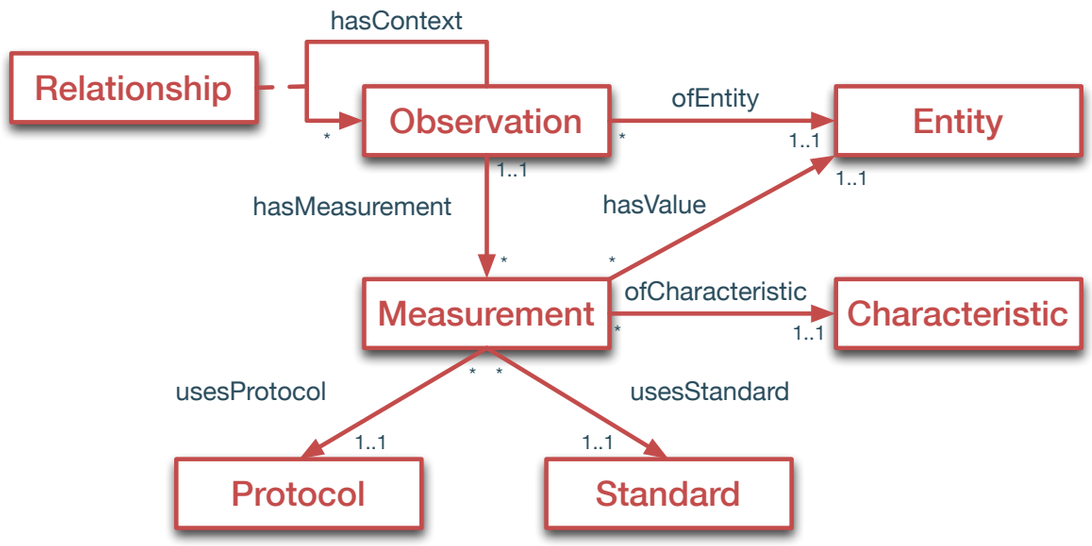
- A scientific **Observation** is the
  - **Measurement** of the **Value**
  - of a **Characteristic**
  - of some **Entity**
  - in a particular **Context**

Core OBOE model



Example

	A	B	C	D	I	J	K	L	M	N	O	P
1												
2			Tucannon Smolt									
3			Pulled									
4			Debris: L=1, M=2, H=3		Wild Chinook				Hatchery Chinook			
5	start	start	end	end	Wild				Hatchery			
6	date	time	Date	time	Spr.	Mort.	Fall	Mort	Blue VIE	Mort.	Purple VIE	Mort.
7	10/8/07	1015	10/9/07	830	0	0	0	0	0	0	0	0
8	10/9/07	831	10/10/07	830	1	0	0	0	0	0	0	0
9	10/10/07	831	10/11/07	915	0	0	0	0	0	0	0	0
10	10/11/07	916	10/12/07	930	0	0	0	0	0	0	0	0
11	10/12/07	931	10/15/07	1000	2	0	0	0	0	0	0	0
12	10/15/07	1001	10/16/07	1200	0	0	0	0	0	0	0	0
13	10/16/07	1201	10/17/07	930	1	0	0	0	0	0	0	0
14	10/17/07	931	10/18/07	1015	6	0	0	0	0	0	0	0
15	10/18/07	1016	10/19/07	1130	5	0	0	0	0	0	0	0
16	10/19/07	1131	10/20/07	1245	3	1	0	0	0	0	0	0
17	10/20/07	1246	10/21/07	1230	2	0	0	0	0	0	0	0
18	10/21/07	1231	10/22/07	1100	9	0	0	0	0	0	0	0



Core OBOE model

- Uses the Web Ontology Language (OWL-DL)
- In turn is expressed in Resource Description Framework (RDF)
  - collections of relationships (subject, predicate, object)
  - Example:
    - SteelheadPopulationSample is-a PopulationSample

Salmon Ontology in OWL

oboe-salmon.owl — dev

× oboe-salmon.owl

```
<rdf:RDF xmlns="http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl#"
     xml:base="http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl"
     xmlns:dc="http://purl.org/dc/elements/1.1#"
     xmlns:oboe-spatial="http://ecoinformatics.org/oboe/oboe.1.0/oboe-spatial.owl#"
     xmlns:sweet-biosphere="http://sweet.jpl.nasa.gov/ontology/biosphere.owl#"
     xmlns:oboe-anatomy="http://ecoinformatics.org/oboe/oboe.1.0/oboe-anatomy.owl#"
     xmlns:oboe-characteristics="http://ecoinformatics.org/oboe/oboe.1.0/oboe-characteristics.owl#"
     xmlns:oboe-chemistry="http://ecoinformatics.org/oboe/oboe.1.0/oboe-chemistry.owl#"
     xmlns:oboe-standards="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl#"
     xmlns:oboe-biology="http://ecoinformatics.org/oboe/oboe.1.0/oboe-biology.owl#"
     xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
     xmlns:owl2xml="http://www.w3.org/2006/12/owl2-xml#"
     xmlns:oboe-ecology="http://ecoinformatics.org/oboe/oboe.1.0/oboe-ecology.owl#"
     xmlns:oboe-taxa="http://ecoinformatics.org/oboe/oboe.1.0/oboe-taxa.owl#"
     xmlns:oboe-temporal="http://ecoinformatics.org/oboe/oboe.1.0/oboe-temporal.owl#"
     xmlns:oboe-core="http://ecoinformatics.org/oboe/oboe.1.0/oboe-core.owl#"
     xmlns:owl="http://www.w3.org/2002/07/owl#"
     xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
     xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
     xmlns:oboe-environment="http://ecoinformatics.org/oboe/oboe.1.0/oboe-environment.owl#">
    <owl:Ontology rdf:about="http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl">
        <rdfs:label xml:lang="en">OBOE Salmon</rdfs:label>
        <rdfs:comment>
        This ontology contains terms that are common to salmon migration research
        with an initial emphasis on juvenile salmon migration research. It is a
        domain-specific extension of the OBOE ontology.
      </rdfs:comment>
        <owl:versionInfo>Version 1.0 pre-release</owl:versionInfo>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-anatomy.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-biology.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-characteristics.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-chemistry.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-core.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-ecology.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-environment.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-spatial.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-standards.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-taxa.owl"/>
        <owl:imports rdf:resource="http://ecoinformatics.org/oboe/oboe.1.0/oboe-temporal.owl"/>
</owl:Ontology>
```

Line: 540 Column: 112 XML Tab Size: 4

Alive Wild Smolt Steelhead Pop. Sample

- Thing
  - Characteristic
  - CharacteristicQualifier
  - Entity
    - AdministrativeFeature
    - AnatomicalEntity
    - Container
    - EcologicalCommunity
    - EcologicalHabitat
    - Instrument
    - Organism
    - PhysicalFeature
    - Population
    - PrimitiveValue
    - Sample
      - AirSample
      - PopulationSample
        - CherrySalmonPopulationSample
        - ChinookSalmonPopulationSample
        - ChumSalmonPopulationSample
        - CohoSalmonPopulationSample
        - PinkSalmonPopulationSample
        - SockeyeSalmonPopulationSample
        - SteelheadPopulationSample
          - ParrSteelheadPopulationSample
          - SmoltSteelheadPopulationSample
            - AliveSmoltSteelheadPopulationSample
            - DeadSmoltSteelheadPopulationSample
            - HatcherySmoltSteelheadPopulationSample
            - WildSmoltSteelheadPopulationSample
              - AliveWildSmoltSteelheadPopulationSample
              - DeadWildSmoltSteelheadPopulationSample

Alive Wild Smolt Steelhead Pop. Sample

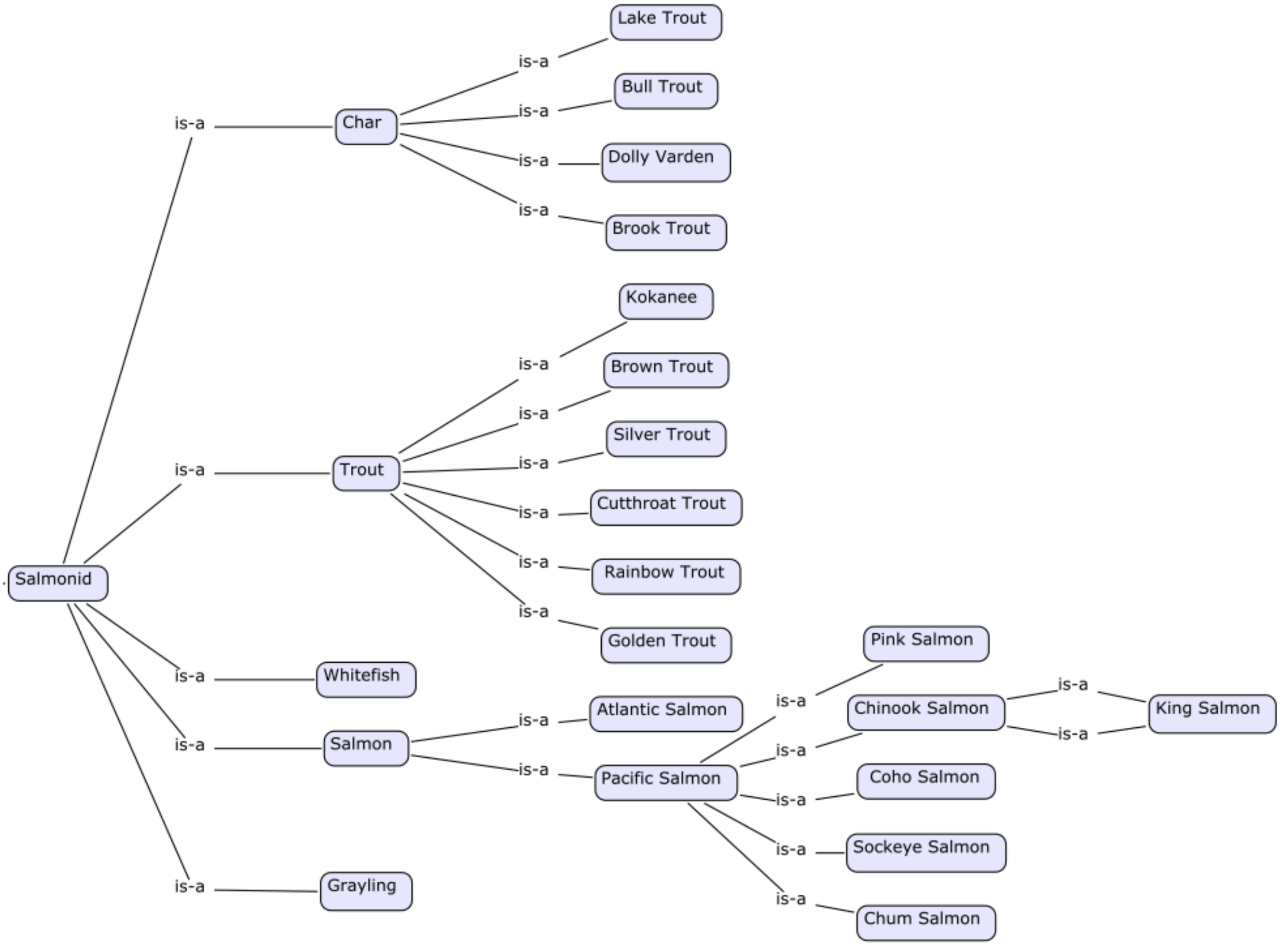
```
<!-- http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl#AliveWildSmoltSteelheadPopulationSample -->

<owl:Class rdf:about="http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl#AliveWildSmoltSteelheadPopulationSample">
    <rdfs:label xml:lang="en">Alive Wild Smolt Steelhead Population Sample</rdfs:label>
    <rdfs:subClassOf rdf:resource="http://ecoinformatics.org/oboe-ext/salmon.1.0/oboe-salmon.owl#WildSmoltSteelheadPopulationSample"/>
    <dc:description xml:lang="en">A sample of a live smolt steelhead population sample of wild origin (non-hatchery raised).</dc:description>
</owl:Class>
```

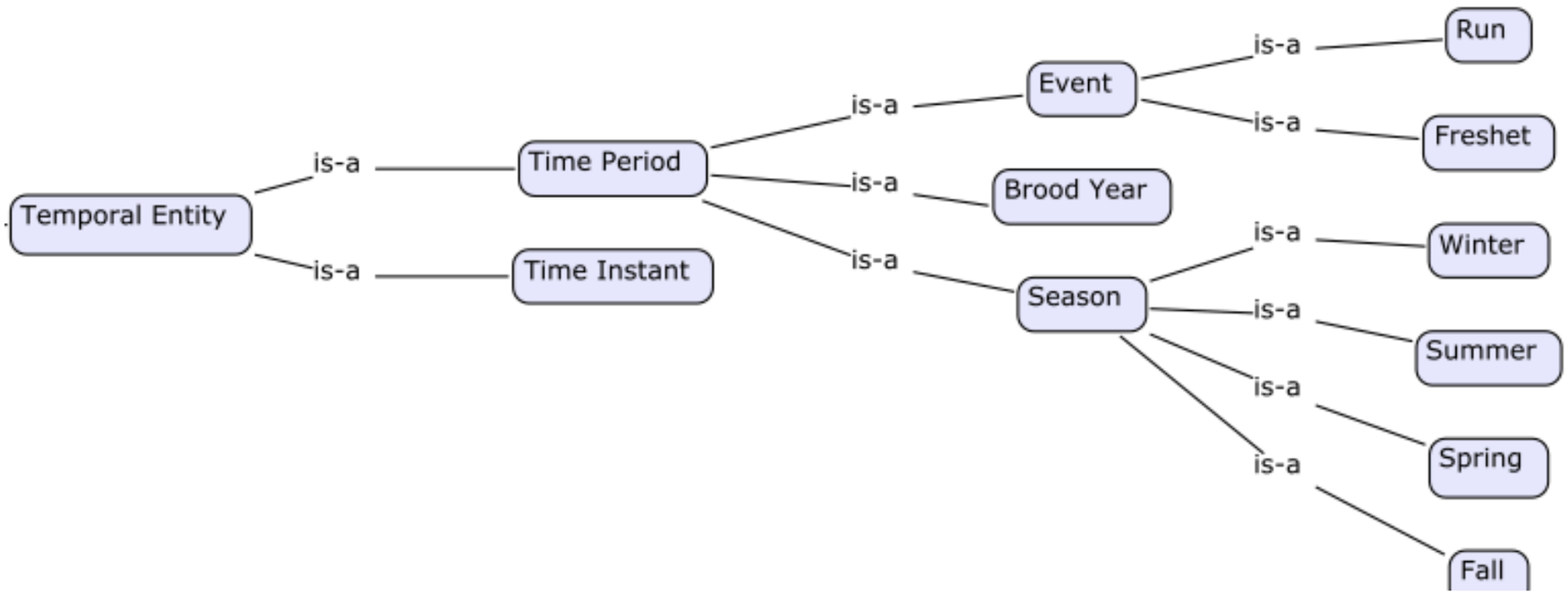
Salmon Ontology Concepts

- Entities being Observed
- Characteristics measured
- Standards And Protocols used

Organism, Sample Entities

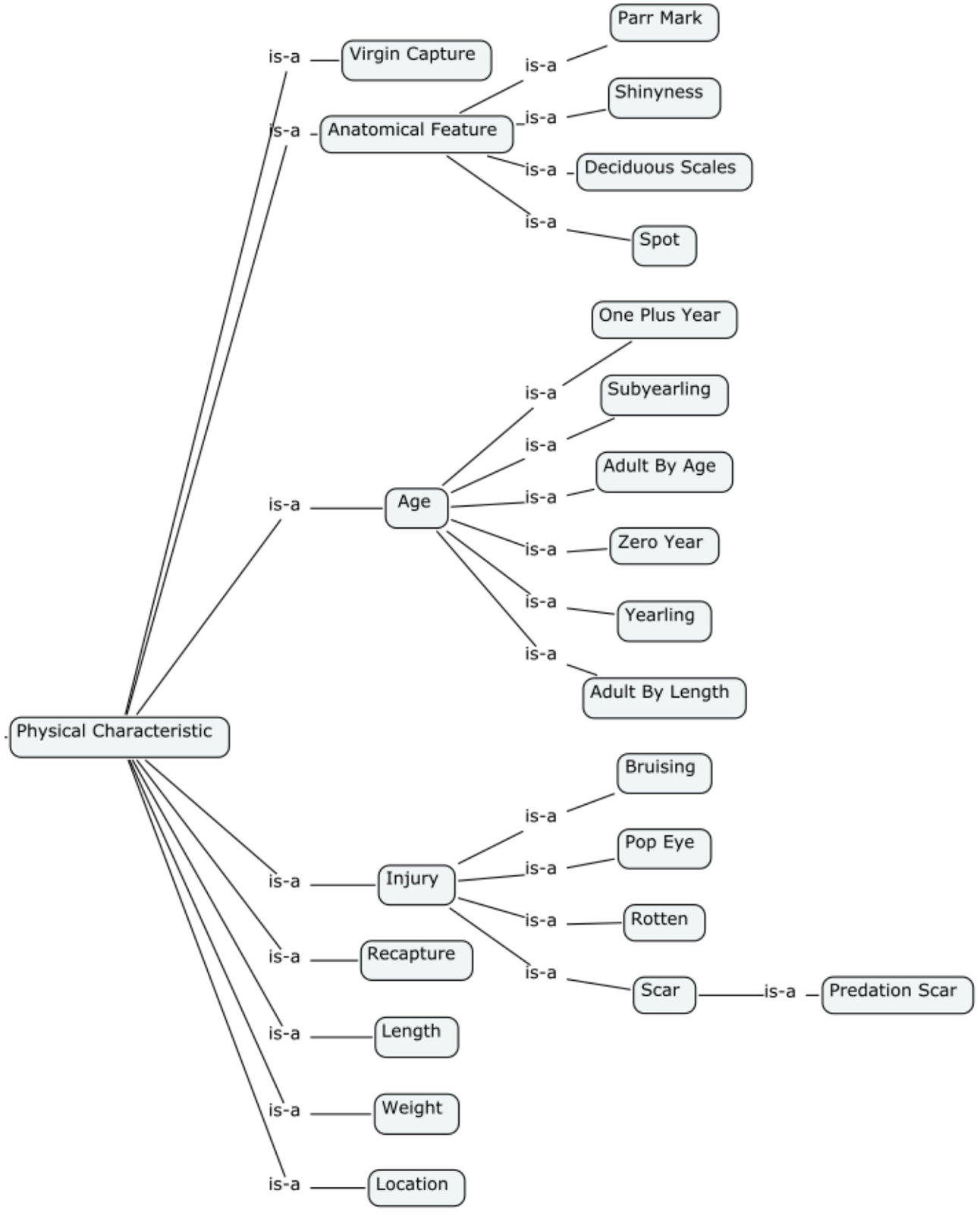


Other Entities: Time, Location

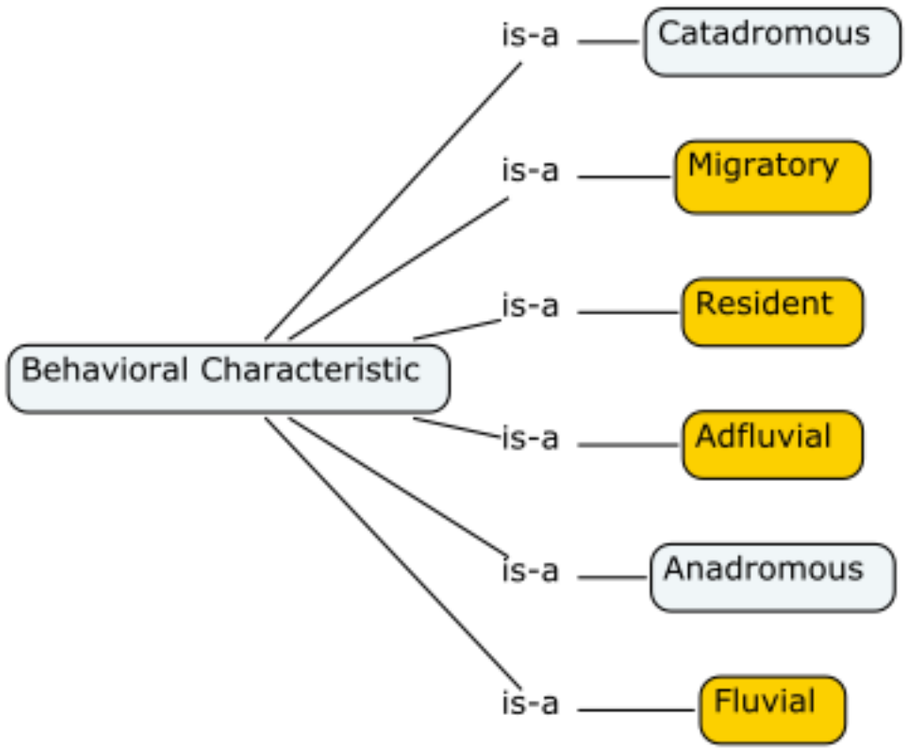


- Adopted concepts from other efforts
- Open Geospatial Consortium
  - Geography Markup Language (GML)
  - NASA SWEET ontologies

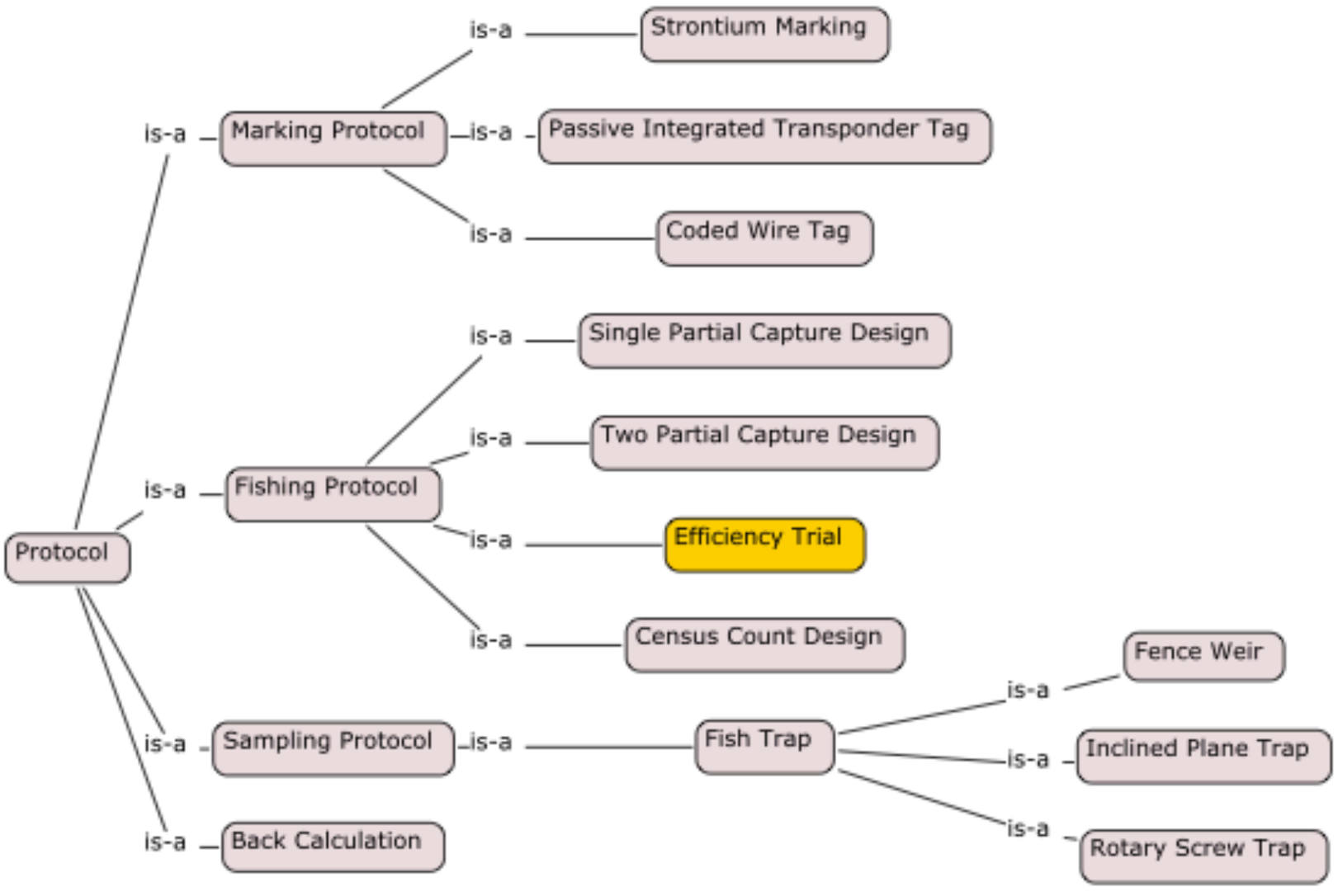
Physical Characteristics



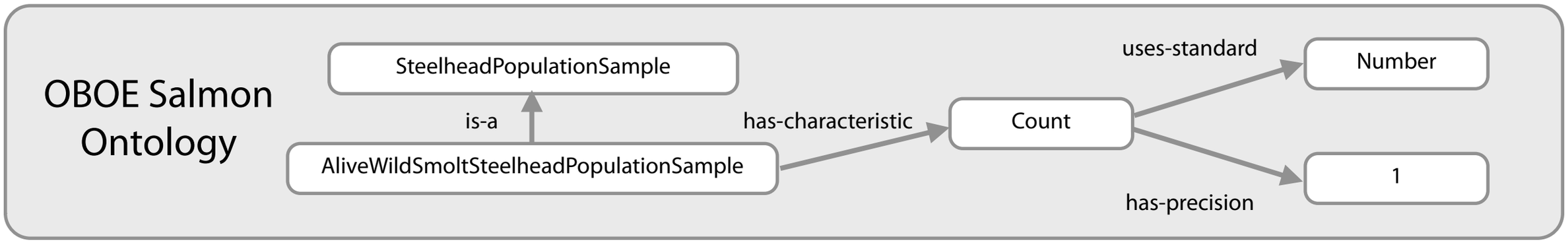
Behavioral Characteristics



Protocols


Protocol
is-a
Marking Protocol
is-a
Strontium Marking
is-a
Passive Integrated Transponder Tag
is-a
Coded Wire Tag
is-a
Fishing Protocol
is-a
Single Partial Capture Design
is-a
Two Partial Capture Design
is-a
Efficiency Trial
is-a
Census Count Design
is-a
Sampling Protocol
is-a
Fish Trap
is-a
Fence Weir
is-a
Inclined Plane Trap
is-a
Rotary Screw Trap
is-a
Back Calculation

Semantic Annotations



Structural Metadata

```
<attribute id="att.4">
  <attributeName>
    live_stlhd_smolt
  </attributeName>
</attribute>
```

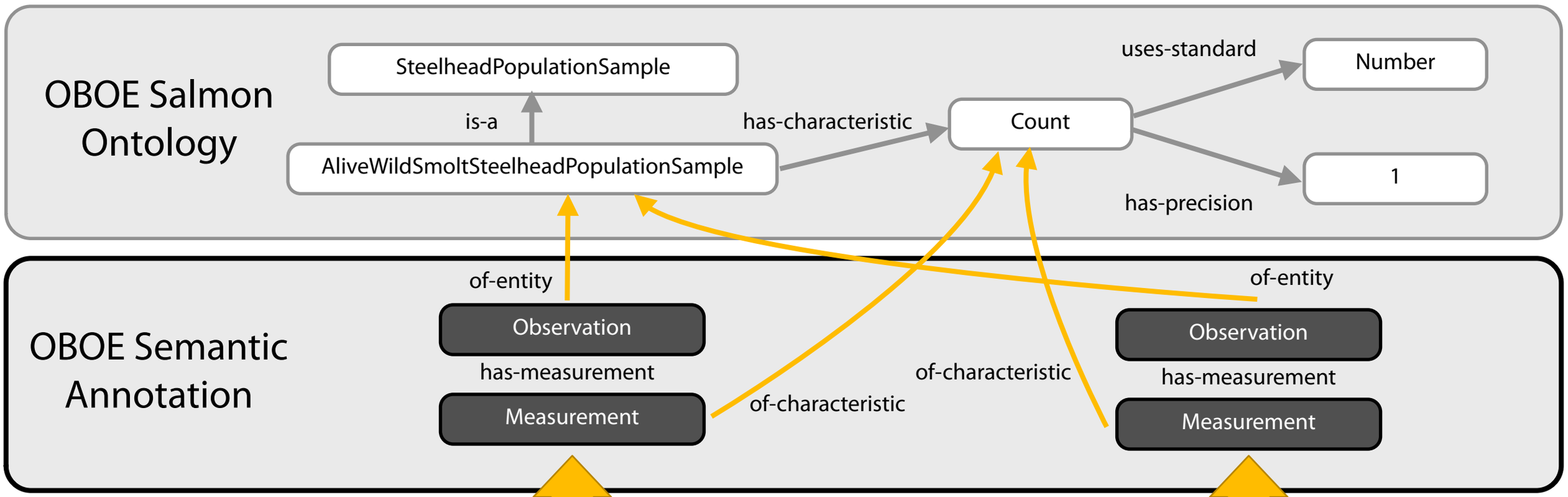
```
<attribute id="att.4">
  <attributeName>
    species
  </attributeName>
</attribute>
```

Data

date	live_stlhd_smolt	dead_stlhd_smolt
2/15/09	27	2
2/16/09	34	0

date	species	live_count	dead_count
2/15/09	STHD	45	0
2/16/09	COHO	23	1

Semantic Annotations



Structural Metadata

```
<attribute id="att.4">
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    live_stlhd_smolt
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</attribute>
```

```
<attribute id="att.4">
  <attributeName>
    species
  </attributeName>
</attribute>
```

Data

date	live_stlhd_smolt	dead_stlhd_smolt
2/15/09	27	2
2/16/09	34	0

date	species	live_count	dead_count
2/15/09	STHD	45	0
2/16/09	COHO	23	1

Population Sample Annotation

untitled

```
1  <?xml version="1.0"?>
2  <sms:annotation id="jmx.60.28" dataPackage="jmx.130.11">
3     <sms:observation label="o15">
4        <sms:entity id="oboe-salmon.owl:AliveWildSmoltSteelheadPopulationSample"/>
5        <sms:measurement label="m15" precision="1.0">
6           <sms:characteristic id="oboe-characteristics.owl:Count"/>
7           <sms:standard id="oboe-standards.owl:Number"/>
8        </sms:measurement>
9     </sms:observation>
10    <sms:map dataObject="0" attribute="live wild stlhd smolts" measurement="m15"/>
11 </sms:annotation>
12
```

Line: 12 Column: 1 XML Tab Size: 4

Temporal Entity Annotation

untitled

```
1  <?xml version="1.0"?>
2  <sms:annotation id="jmx.60.28" dataPackage="jmx.130.11">
3      <sms:observation label="o1">
4          <sms:entity id="oboe-temporal.owl:TimeInstant"/>
5          <sms:measurement label="m1" precision="1.0">
6              <sms:characteristic id="oboe-characteristics.owl:Time"/>
7              <sms:standard id="oboe-standards.owl:Day"/>
8          </sms:measurement>
9      </sms:observation>
10     <sms:map dataObject="0" attribute="trap_set_date" measurement="m1"/>
11 </sms:annotation>
12
```

Line: 2 Column: 17 XML Tab Size: 4

Full Semantic Annotation

untitled

```
<?xml version="1.0"?>
<sms:annotation id="jmx.60.28" dataPackage="jmx.130.11">
    <sms:observation label="o1">
    <sms:observation label="o2">
    <sms:observation label="o3">
    <sms:observation label="o4">
    <sms:observation label="o5">
    <sms:observation label="o6">
    <sms:observation label="o7">
    <sms:observation label="o8">
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    <sms:observation label="o10">
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    <sms:observation label="o16">
    <sms:observation label="o17">
    <sms:observation label="o18">
    <sms:observation label="o19">
    <sms:observation label="o20">
    <sms:observation label="o21">
    <sms:map dataObject="0" attribute="trap_set_date" measurement="m1"/>
    <sms:map dataObject="0" attribute="trap_set_time" measurement="m2"/>
    <sms:map dataObject="0" attribute="trap_check_date" measurement="m3"/>
    <sms:map dataObject="0" attribute="trap_check_time" measurement="m4"/>
    <sms:map dataObject="0" attribute="staff_gauge" measurement="m5"/>
    <sms:map dataObject="0" attribute="live_wild_spring_chinook_smolts" measurement="m6"/>
    <sms:map dataObject="0" attribute="dead_wild_spring_chinook_smolts" measurement="m7"/>
    <sms:map dataObject="0" attribute="live_wild_fall_chinook_smolts" measurement="m8"/>
    <sms:map dataObject="0" attribute="live_hatchery_chinook_smolt_blue_vie" measurement="m9"/>
    <sms:map dataObject="0" attribute="dead_hatchery_chinook_smolt_blue_vie" measurement="m10"/>
    <sms:map dataObject="0" attribute="live_hatchery_chinook_smolt_purple_vie" measurement="m11"/>
    <sms:map dataObject="0" attribute="dead_hatchery_chinook_smolt_purple_vie" measurement="m12"/>
    <sms:map dataObject="0" attribute="live_hatchery_chinook_smolt_captive_brood" measurement="m13"/>
    <sms:map dataObject="0" attribute="dead_hatchery_chinook_smolt_captive_brood" measurement="m14"/>
    <sms:map dataObject="0" attribute="live_wild_stlhd_smolts" measurement="m15"/>
    <sms:map dataObject="0" attribute="dead_wild_stlhd_smolts" measurement="m16"/>
    <sms:map dataObject="0" attribute="live_wild_stlhd_parr" measurement="m17"/>
    <sms:map dataObject="0" attribute="dead_wild_stlhd_parr" measurement="m18"/>
    <sms:map dataObject="0" attribute="live_hatchery_stlhd_cwt" measurement="m19"/>
    <sms:map dataObject="0" attribute="live_hatchery_stlhd_left_green_vie" measurement="m20"/>
    <sms:map dataObject="0" attribute="dead_hatchery_stlhd_left_green_vie" measurement="m21"/>
</sms:annotation>
```

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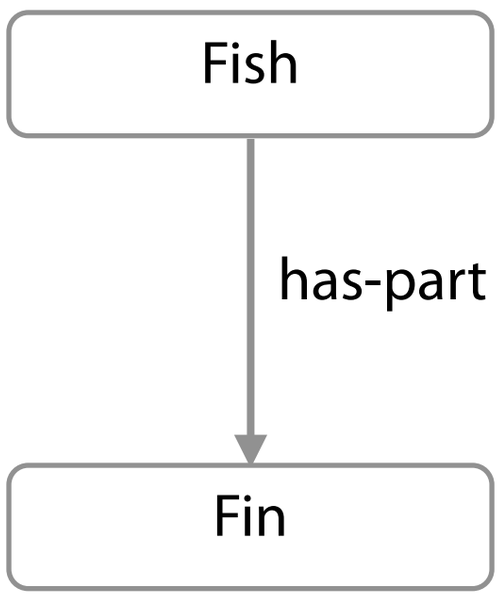
Challenges in modeling concepts

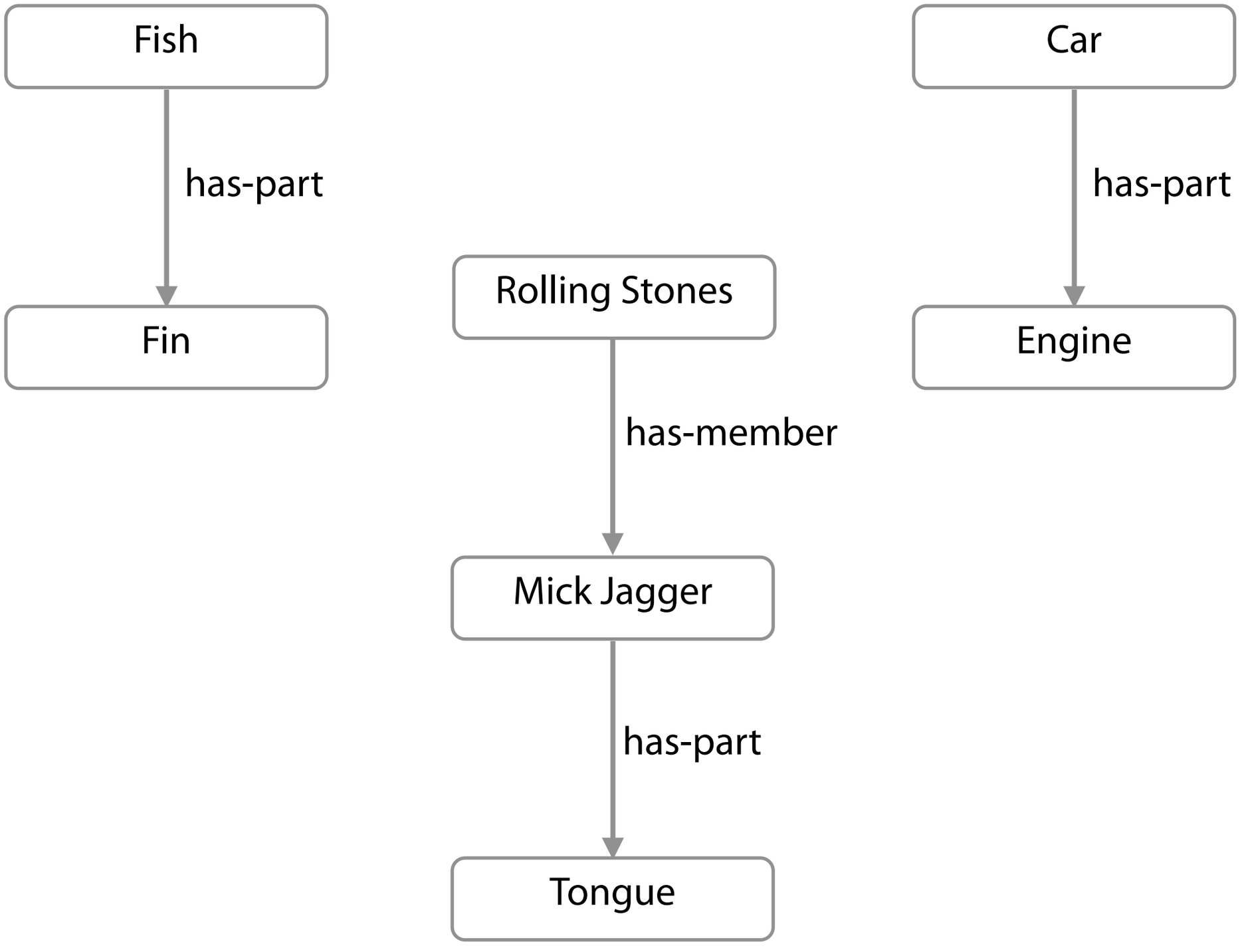
- Entities as collections of characteristics
- Modeling part-whole relationships

Part-Whole Relationships



Part-Whole Relationships

Part-Whole Relationships



Challenges in modeling concepts

- Entities as collections of characteristics
- Modeling part-whole relationships
- Knowing the detail depth to model
  - equalivalent, disjoint, transitive
- Getting a large group on the same semantic page