

# Detection of Domestic Human Trafficking Indicators and Movement Trends Using Content Available on Open Internet Sources

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## Abstract

*This study applies network analysis to domestic human trafficking activity in online environments to identify trafficking circuits. Numerous websites host online classifieds, discussion forums, review sites, and social media related to sex trafficking. Trafficked persons are systematically moved to various locations throughout the U.S. based on demand, and traffickers use online classified sites to advertise their victims. The goals of this study were to identify indicators of sex trafficking in online advertisements posted on open Internet sources and to derive movement patterns. Online classified ads for adult services in Hawai'i were collected over a six-week time frame and assessed for indicators of human trafficking. Data captured in the analysis was used to detect movement trends of potential trafficked persons and mapped to visualize domestic circuits. A key element in observing movement was the advertised phone number, as it is linked to the individual through online advertisements and customer reviews.*

## 1 Introduction

Human trafficking is a form of modern day slavery, which entails illegal trade in persons for forced labor or sexual exploitation. Although slavery is illegal, it persists today with numbers twice as high as the trans-Atlantic slave trade [1]. Human trafficking is the second most profitable organized crime in the world with an estimated annual global profit of \$31.6 billion [2]. Nearly half of all profits are generated in industrialized countries such as the United States. The U.S. is the second leading destination country for the sexual exploitation of trafficked women and children [3]. In recent years, there has been an increase in attention from the media, government, and law enforcement on international human trafficking issues [4]. However, less attention has been given to domestic human trafficking. The Trafficking Victims Protection Act of 2000 (TVPA) is the first U.S. federal law to

address this problem. The TVPA [5] defines sex trafficking as “the recruitment, harboring, transportation, provision, or obtaining of a person for the purpose of a commercial sex act” and defines severe forms of trafficking as “sex trafficking in which a commercial sex act is induced by force, fraud, or coercion, or in which the person induced to perform such act has not attained 18 years.”

The influx of information and communication technologies (ICTs) has contributed to this growing issue. Technology has been cited as a significant factor facilitating human trafficking [6, 7, 8, 9]. The Internet and the use of online classifieds have changed the environment of sex trafficking. Activities have shifted from a predominantly physical environment to an increasingly virtual environment, with trafficked persons often being advertised online as well as on the street. Virtual red light districts provide a low risk environment for buyers to connect with sellers [1, 4, 6, 7]. Trafficking activity has been documented in chat rooms, social network sites, online classifieds, and social media sites allowing traffickers to exploit a greater number of victims [7].

Mobile phones serve as the conduit between the virtual and physical environments connecting clients to the product for coordination of services. Phones are typically prepaid mobiles, so they cannot be linked to a specific individual through a service contract [10]. However, they can be used to provide other clues to this activity. The majority of ads include a phone number to contact the poster and schedule services. Coordination of scheduling may be done through a central line, with phones linked to the provider via the trafficker or a decentralized manner, with providers maintaining individual numbers [1]. Customer reviews are often linked to phone numbers, indicating the importance of maintaining individual phone numbers for reputation development. Research on the use of ICTs in facilitating trafficking is emerging, but significant gaps exist [7].

This is an exploratory study to better understand and develop methods for tracking domestic sex trafficking activity online. Trafficked persons are a subset of commercial sex workers. The focus of this study was to identify indicators of domestic sex trafficking in online advertising for commercial sex in order to identify potential victims and detect movement trends. Network analysis was used to analyze content available on open Internet sources to gain insight on this covert network. Sparrow [11] argued for the use of social network analysis (SNA) as an effective method to exploit criminal data, citing its ability to highlight network vulnerabilities and transform raw data into intelligence. SNA techniques can be used to process large volumes of data to detect hidden structures and patterns of criminal networks. Klerks [12] pointed out that SNA has primarily focused on positive networks and avoided dark networks. It was not until the early 1990s that academics began to apply these skills to studying covert networks. Using SNA methods to exploit criminal data has the potential to make covert activity more visible. The primary research question is whether content available on open Internet sources can be used to detect trends in movement of potential traffickers or victims (i.e. hubs, circuits, etc).

## 2 Domestic Sex Trafficking

Research has predominantly focused on transnational issues of trafficking, while limited research has focused on domestic trafficking of U.S. citizens. According to current estimates, although many trafficked persons are foreign nationals, a much larger number are U.S. citizens being trafficked within the country [13]. Each year an estimated 100,000 – 300,000 American children under the age of 18 are at risk of being victims of sexual exploitation, suggesting that the most prominent group of trafficked victims within the country are U.S. minors [14]. By targeting and recruiting children (under the age of 18), traffickers fuel the supply chain as victims are introduced and groomed into this lifestyle at an early age. Hanna [15] found “an estimated eighty percent of adult prostitutes started working as children. Research indicates that most adult women who work in the commercial sex industry started working between the ages of 14 and 18 - a time when they were far too young to make an informed decision.”

### 2.1 Definitions of Terms

This criminal network uses various terms to describe roles and activity. Three main roles of this trade involve the trafficker (third party seller), the product (person being sold), and the client. A *pimp* or

*madam* is the term used for the potential trafficker. The product (person) being sold is referred to as the *provider*. The group of providers controlled by a pimp is called a *stable*. The clients of this trade are known as *Johns*. The John community is referred to as *Hobbyists*, *Punters*, or *Mongers*. This activity occurs in various locations. The physical location the provider walks is known as the *track*. *Hubs* are areas known for high volumes of trafficking activity. The series of cities a provider is sold in is called a *circuit*. In this paper we use the term *victims* to refer to involuntary or coerced providers.

### 2.2 Movement along Circuits

Movement is a critical element of trafficking. It does not define trafficking, but it is a key indicator of potential trafficking activity. Providers are shuffled across the nation to various cities based on demand. Movement typically follows a pattern, with providers being moved from city to city on a circuit. A circuit is the systematic movement of providers between cities, which could encompass entire regions [16]. This systematic movement of providers to various cities across the nation for the purposes of commercial sex activity (profit) alludes to a more sophisticated, organized criminal activity taking place. A well-known circuit is the Western Circuit, which includes Seattle, Washington; Portland, Oregon; San Francisco, Los Angeles, and San Diego, California; Hawai‘i; Phoenix, Arizona; Denver, Colorado; and Salt Lake City, Utah. This data is derived from national crime statistics based on counts of arrests in locations [17].

The movement of victims by traffickers is driven by multiple factors. Traffickers remain in a location for a limited time and move frequently in an attempt to avoid detection from law enforcement [17]. Frequent movement is also a control mechanism used by traffickers to keep victims isolated. The continuous movement and short durations of stay prevent victims from establishing social support systems and limits familiarity with a location [1]. A significant factor driving movement is market demand. Movement trends are profit driven. Rotating providers in and out of different cities keeps the supply stream fresh. Providers are advertised as being ‘new’ or ‘available for a limited time only’ enticing the demand side of the market. Due to the illicit nature of this activity and limited research conducted on domestic sex trafficking of U.S. citizens, the exact number of victims in the U.S. is unknown. However, human trafficking cases have been reported in all fifty states [18].

## 2.3 Significance of Phone Number

The advertised phone number is a significant element in observing movement for a number of reasons. The phone number is the link to the provider enabling the John to make contact and schedule services. The area code provides information on the origin of the phone, which may indicate where the provider or trafficker is from [1]. Phone numbers are embedded in the online classifieds as providers are advertised along circuits. These ads can be accessed using a phone number search, which will indicate other advertised locations. Advertised phone numbers are also linked to providers' reputations and product branding through customer reviews. Provider review sites use phone numbers as a search term to access provider history, reviews, current location, etc. In advertisements, providers often refer to their phone number as a search term to be used to access their reviews and indicate if their number has recently changed.

## 2.4 Online Activity

The affordances of technology are changing the sex trafficking industry, with many of the activities and practices surrounding sex trafficking moving to the virtual environment [6]. There are numerous websites dedicated to this community, such as Myredbook.com, TheEroticReview.com, CityVibe.com, and NaughtyReviews.com. Lee and Lee [19] state, "communities no longer exist only in the physical world but also in the virtual world that operates through the Internet." There is a spectrum of behavior in the virtual environment based on the purpose of a site and community needs. According to Lee and Lee [19], users participate in virtual communities to "garner mutual benefits between group members, for example, strengthening social ties, circulating information, archiving experiences and exchanging opinions." Although the behavior of this community may be deemed deviant, their online activities are consistent with other communities in terms of virtual community development and participation.

Criminal network data is deceptive; information may be intentionally misleading, inaccurate, out-of-date, and incomplete [11, 12, 20]. This makes studying covert networks challenging. However, as human trafficking activity increasingly shifts to the virtual environment it becomes more visible [6]. The Internet provides users with a sense of anonymity, which makes participation in this illicit activity feel more discreet online than offline. This false sense of security creates a space for this activity to flourish. The community uses the Internet as a communication channel

providing access to the product and to other members of the community. They participate in information seeking and sharing activities with other community members in open forums. Using the Internet as their communication platform creates an archive of information exchange. The key is to identify which sites and information are useful in detecting sex trafficking and how that information can be used to disrupt this activity.

On the supply side, traffickers provide a product via the Internet. They use online classifieds to advertise the sale of women and/or children for the purposes of sexual exploitation. Traffickers are no longer bound by geographic limitations. They are able to expand their scope of activity through the use of the Internet. Online classifieds provide an optimal means of advertising that is capable of reaching a large audience regardless of geographic location. As this trend develops, cases of sex trafficking have been observed far beyond major city locales and are reaching into remote locations [1]. Ads are often placed in locations prior to arrival for pre-scheduling of appointments to ensure travel is profitable.

On the demand side, Johns use the Internet to search for providers, share information about providers, compare experiences, and provide warnings about potential law enforcement [8, 9]. The Internet provides a virtual catalog of women with access to an abundance of advertisements and reviews to assist in the purchasing of a provider that fits the client's preference. Johns are able to browse through provider profiles in order to gain information about performance ratings and services provided. This grants Johns anonymous access to a far greater number of providers than possible offline. boyd et al. [6] report searching online allows Johns to "remain invisible to law enforcement who have not yet developed sophisticated digital operations."

## 3 Methods

### 3.1 Study Overview

The intent of the study was to examine online adult service advertisements in order to observe the types of data available in these ads and to identify ways to transform this data into meaningful information that can be used to disrupt potential criminal activity. Online advertisements for adult services from Backpage Hawai'i were collected from January 09, 2013 through February 12, 2013. Due to ad volume, ads were collected in one-week increments every other week during the six-week study period, capturing three weeks of data. The methodology used in the analysis involved a three-step process. First, an

audit of Hawai'i Backpage escort ads was conducted and analyzed for indicators of trafficking. Next, phone numbers were extracted from the ads and used to track movement based on area code origin and other advertised locations. Lastly, data obtained from step two was analyzed using social network analysis methods in order to create a visualization of potential circuits.

Backpage is an online classified site that hosts advertisements for a wide range of products, including adult services, which can be found under the 'Escort' section. Backpage was selected for analysis because at this writing it is the leading U.S. site for advertising prostitution [21]. "Other websites also offer adult classifieds, but Backpage not only has the highest frequency of posts but also greater website traffic (user hits) than most alternative choices, generating an estimated \$1.95 million in revenue in June of 2011 alone" [1]. The cost of escort ads average \$3 to \$15 per posting and \$7 to \$20 for reposting [21]. Also, because Backpage is a mainstream online classified site, less stigma is attached to visiting this site than a John site.

Online classifieds in Hawai'i were selected because Hawai'i is a destination location for trafficking. McClain and Garrity [22] define destination cities as areas with the greatest demand, typically locations near military bases, truck stops, conventions, and tourist areas. The multiple military bases, large international conferences, and prime tourist destinations make Hawai'i a thriving location for sex trafficking. Another reason Hawai'i was selected was due to its geographic location. A significant element of this study was to detect likely trafficking activity and map movement. Movement to Hawai'i entails a higher risk due to the security measures associated with air travel, cost of air travel, and the inability to earn profits enroute. On the continental U.S., providers are moved along major roadways and sold at truck stops along the way, allowing traffickers to continue operations during travel [1]. Yet in spite of the costs and risks, Hawai'i being a destination location with a thriving market ensures that travel is profitable.

### 3.2 Content Analysis

An audit of Hawai'i Backpage escort advertisements was conducted during the study period and analyzed for indicators of online human trafficking. Ads were analyzed for the presence of online trafficking indicators using an index developed by the author after an initial study of Backpage advertisements (Table 1). The indicators used in the index were derived from a larger list of sex trafficking and domestic minor sex trafficking indicators produced

by the United Nations Office on Drugs and Crime [23] and the Polaris Project [24]. The indicators were selected based on observability in online advertisements. The raw data was extracted and converted into research results based on these indicators.

**Table 1. Online Human Trafficking Indicators**

<i>Indicator</i>	<i>Explanation</i>
Different Ages Used (Inconsistencies in story)	Discrepancies in age within or across ads
Different Aliases Used (Inconsistencies in story)	Discrepancies in aliases within or across ads
Movement (Frequent movement to work)	Transient language, out of state area code, ad posting in different locations
Shared Management (Travel in groups)	Ads reference multiple providers, shared phone
Ad posted by third party	Third person language used in ad
Advertised Ethnicity/Nationality	Ad includes references to ethnicity or nationality
Potential Restricted Movement	Incalls only –provider may be restricted to hotel room, massage parlor, etc.

Important fields of data include advertised location, advertised age, advertised name, phone number, area code origin, transitory language, and miscellaneous observations (i.e. explicit language/photos). Similar methods were used in previous Backpage studies conducted by Operation Broken Silence [1, 25]. These studies were concerned with identifying the existence of sex trafficking in Backpage adult services ads. The current study expands on previous studies by examining the movement trends associated with potential trafficking activity linked to online advertisements. Advertised location indicates where the provider is operating. Advertised age is the listed age of the poster (typically inaccurate with many ads using ages older or younger than true age). Advertised name serves as an identifier to distinguish unique posts and providers. Both advertised age and name fields provide information relevant to indicators of trafficking if inconsistencies are observed. Phone numbers were used to distinguish unique posts and provide data on movement. Area code origin can indicate movement if the origin is different

from the advertised location. Area codes may also present clues to the source location of providers [1]. Transitory language is any form of language that would indicate movement or travel (i.e. new in town, limited time only, just visiting, etc.). A field for miscellaneous observations was collected for any information that did not fall into the identified data fields or indicator index.

### 3.3 Phone Number Analysis

All unique phone numbers occurring in our data were analyzed to detect and map movement trends, except that phone numbers belonging to fixed locations were excluded (escort services and massage parlors). Movement was determined based on area code origin and other advertised locations. The area code provides information on the origin of the phone. Area code origin served as an indicator of movement if the location of origin was different from the current advertised location (i.e. if the phone number is an out-of-state number it was in at least two locations, the source location and currently advertised in Hawai'i – data source). Movement was further analyzed using a phone number analysis across multiple John sites to identify other advertised locations. John sites allow clients to validate provider authenticity by reviewing advertisement history. These sites include information on the various cities providers have been advertised in, and different ages, aliases, reviews, and photos used in the ads. These sites serve the community's needs by providing a single source of consolidated information on a provider, allowing Johns to verify information by cross-analyzing multiple ads for consistency. This process serves two purposes: it allows Johns to avoid false advertisement (bait and switch), and avoid potential law enforcement operations. The various locations each phone number was advertised in were documented allowing movement patterns to be observed.

### 3.4 Movement Analysis

Provider location data was analyzed using network analysis methods to detect and map circuits with GIS data. A provider by location bipartite network was constructed to analyze movement trends. The phone number served as a proxy for the provider or trafficker. Location data was entered using area code origin and other advertised locations based on the data captured in the phone number search. Circuits were calculated based on aggregate data using a monopartite projection of the network, and visualized. Specifically, the network was folded to create a location-to-location network. Locations sharing telephone numbers were

linked, with the link weighted by number of phone numbers shared between locations. Then, thresholds were established to filter data by edge weight during visualization in order to identify high volume travel routes. GIS data was incorporated in order to overlay circuits on a map. The resulting visualization of high volumen associations between locations was used to identify prominent hubs and circuits. Analysis was performed using the \*ORA software suite [26]. \*ORA is developed by the Center for Computational Analysis of Social and Organizational Systems (CASOS) at Carnegie Mellon to assess and analyze dynamic meta-networks.

## 4 Results

During the study period 1881 escort ads were collected and audited, which is an average of 90 ads per day over a 21-day sample period. After excluding daily duplicate ads 1436 ads were analyzed. The advertised location of each ad was documented to identify an intra-state circuit. The advertised locations within the state were spread over four of the islands (O'ahu, Hawai'i, Maui, and Kaua'i). Total ads by location include: 1255 (78%) in O'ahu, 210 (13%) in Maui, 81 (5%) Hawai'i Island, and 58 (4%) in Kaua'i. Multiple ads (56) listed all four islands as the service location. Based on the advertised location of the sample, findings suggested the presence of a micro-circuit through several of the Hawaiian Islands, indicating that demand exists and air travel to such locations is profitable (Figure 1). The observance of this micro-circuit illustrates the ability for traffickers to extend their reach beyond prominent cities to remote locations via online advertisements.

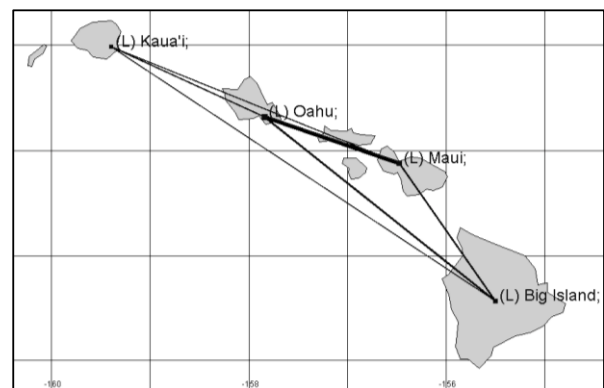


Figure 1. Hawai'i Micro-circuit

## 4.1 Indicator Results

The indicator analysis measured the number of indicators present in an advertisement and the frequency of an indicator across the sample. Of the 1436 advertisements analyzed, 82% of the ads contained one or more indicators and 26% of the ads contained three or more indicators. The number of indicators observed per ad is presented in Table 2. The distribution of ads by indicator was: 685 (48%) Advertised Ethnicity/Nationality, 553 (39%) Potential Restricted Movement, 473 (33%) Movement along Circuit, 426 (30%) Multiple Providers, 261 (18%) Third Party Post, 33 (2%) Different Ages, and 8 (1%) Different Aliases. The presence of sex trafficking indicators does not prove trafficking is occurring, but it raises flags to potential activity that requires further investigation. This information could be used to identify high-risk advertisements, narrowing down the pool of ads warranting law enforcement attention.

**Table 2. Total indicators present per ad**

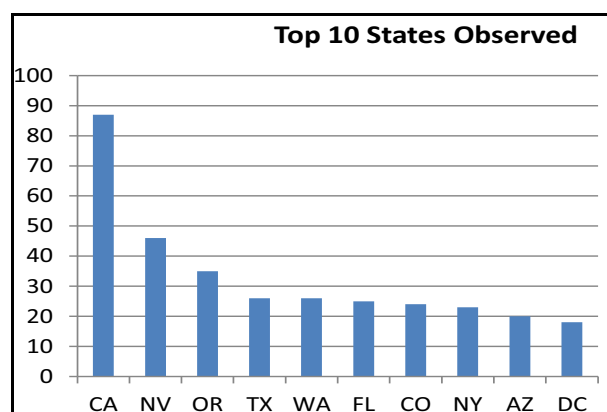
Indicators per Ad	Total ads	% Ads
6	26	2%
5	104	7%
4	86	6%
3	155	11%
2	365	25%
1	448	31%
0	252	18%

## 4.2 Movement Results

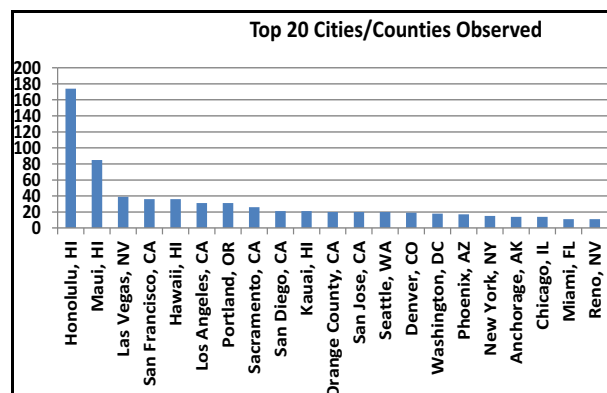
A total of 234 unique phone numbers were recorded during the study period. After excluding fixed locations (i.e. massage parlors or escort services), 208 phone numbers were analyzed. Of those, 165 phone numbers indicated movement. The number of advertised locations ranged from two to 44 cities with an average of six. A total of 44% of the phone number area codes were from Hawai'i and the remaining 66% were dispersed throughout 23 states. The top five area code origins outside of Hawai'i included California, Nevada, Oregon, New York, and Washington. This information could be used to identify potential source locations of traffickers or providers. After analyzing other advertised locations (advertisement history) links to all but four states (Delaware, Maine, New Hampshire, and South Dakota) were observed in the sample, suggesting that Hawai'i is a destination hub for this activity. Figure 2 and 3 below provide information on hub locations observed in the sample.

Based on the sample, Portland, Oregon is among the top 10 hub cities with movement trends through

Hawai'i. This is significant in terms of local current events. In May 2013, a 'traveling escort' from Portland, Oregon was found murdered on the island of O'ahu. The media report indicated that she was 'visiting' Hawai'i and she had posted several online advertisements marketing her services in Waikiki over the past year. The last advertisement posted was a joint ad offering services with a traveling companion. The details provided in the report are indicative of human trafficking activity. The article can be found at [http://www.oregonlive.com/pacific-northwest-news/index.ssf/2013/05/portland\\_woman\\_ivy\\_harris\\_foun.html](http://www.oregonlive.com/pacific-northwest-news/index.ssf/2013/05/portland_woman_ivy_harris_foun.html). Using the methods outlined above her ads would be flagged as high-risk.



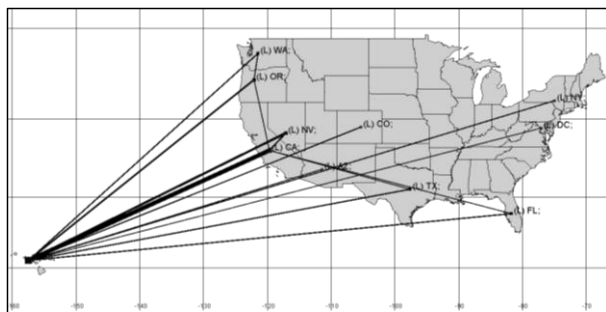
**Figure 2. Frequency Distribution of Advertised Phone Numbers by State**



**Figure 3. Frequency Distribution of Advertised Phone Numbers by City/County**

Circuits were observed at both the state and city/county level to provide insight on inter-state and intra-state movement trends. At the state level, bi-coastal traffic to Hawai'i was observed in the data with data filtered at high-level thresholds (weighted edge of 18 or greater) to detect the most prominent circuits. This included portions of the Western Circuit (WA,

OR, CA, NV, AZ, and CO) as well as links between Hawai'i and New York, DC, Florida, and Texas (Figure 4). Links between the Western Circuit states and East coast states persisted with the removal of Hawai'i (sample source) indicating a high volume of movement between those states (Figure 5). These findings suggest that traffickers are using both ground and airways to extend the reach of their networks. Prevention and deterrent activity has primarily focused on the use of roadways with interventions being established at truck stops [1].



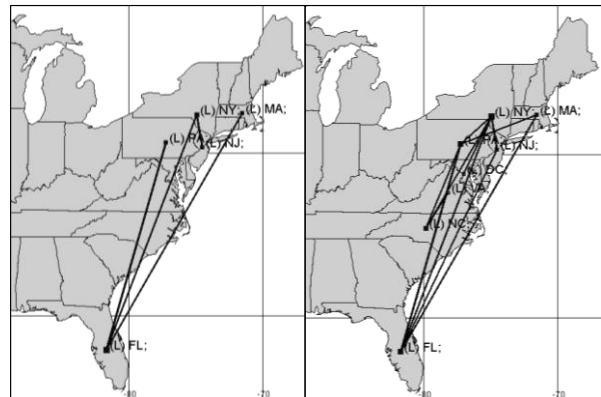
**Figure 4. The Western Circuit and Bi-Coastal Trends including Hawai'i**



**Figure 5. The Western Circuit and Bi-Coastal Trends with Hawai'i Removed**

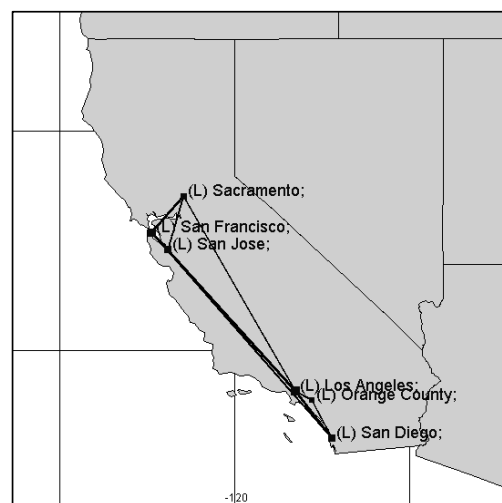
In order to detect regional movement patterns, data was filtered by region and at reduced thresholds to observe an eastern circuit. With data filtered at a weighted edge of at least eight, hub states of Florida, Pennsylvania, New York, New Jersey, and Massachusetts were observed (Figure 6, left hand side). When thresholds were reduced movement patterns between the hub states become apparent, making greater portions of the eastern circuit visible (Figure 6, right hand side). The trends observed were consistent with known trafficking hubs and circuits based on retrospective law enforcement data. In contrast with retrospective data, our method could provide a prospective tool for law enforcement and service

providers to identify trafficking activity in advance and deter this activity.



**Figure 6. Eastern Circuit**

A city-level analysis was conducted to achieve finer granularity. An analysis of the micro-circuits within the top 10 hub states identified above was completed. California's micro-circuit included advertisements in 30 different locations. Filters were applied to identify the most prominent circuit, which included movement between San Francisco, Sacramento, San Jose, Los Angeles, Orange County, and San Diego (Figure 7). Movement trends within Nevada are predominantly between Las Vegas and Reno. Movement patterns within Oregon were spread across eight advertised locations. When filters were applied to reduce noise the persistent circuit included movement trends between Portland, Salem, and Eugene. The observed micro-circuit within Texas encompassed 13 advertised locations with heaviest movement trends between El Paso, Abilene, Waco, Austin, San Antonio, Houston, and Corpus Christi. The micro-circuit in Washington that carried the highest volume of advertisements included movement between



**Figure 7. California Micro-circuit**

Seattle, Yakima, and the Tri-cities. These findings provide insight to the movement trends of potential trafficking activity at the local level.

## 5 Discussion

Trafficking networks are increasingly using technology to facilitate their activity. Research into such uses is increasing, but much work is needed. The intent of this study was to observe the types of data available in online adult service advertisements that offer indicators of trafficking and to identify ways to transform this data into meaningful information that can be used to disrupt potential criminal activity. The primary focus was to obtain data to identify movement trends using network analysis methods. By integrating data from online classifieds and data obtained from phone number analyses, it is possible to detect indicators of sex trafficking and map patterns of movement of potential traffickers or victims. As stated above, the presence of sex trafficking indicators does not prove trafficking is present, but it does identify high-risk ads requiring further investigation. Understanding the ways this community is using the Internet (hub sites, important data fields, and how to use that data) provides researchers with insight on how to automate this process. Also, analysis of online classifieds and the identification of advertisements with potential links to trafficking have policy implications in terms of websites facilitating criminal activity. Most of the ads analyzed contained explicit content obviously advertising prostitution with very few ads attempting to hide the nature of the content. Aside from issues pertaining to human trafficking, websites hosting these types of ads are aiding illegal actions. The Communication Decency Act of 1996 relieves websites from liability of third-party content. This raises concerns about accountability and shared liability of content posted on websites.

Tracking phone numbers proved to be an effective method for detecting movement, as the phone is the means of connecting the purchaser with the product. It is also an integral element of product branding tied to the provider's online reputation through customer reviews. The consistency in findings across a series of studies and the ability to observe known circuits using this methodology illustrates its effectiveness. The ability to observe covert network activity can be exploited to identify vulnerabilities to disrupt the network. Federal efforts to combat human trafficking call for an assessment of trafficking trends within the U.S. The goal is to provide law enforcement and service providers with the information they need to more effectively manage and deploy resources [27]. Currently, law enforcement data on human trafficking

provides retrospective information of criminal activity. Data is based on the number of arrests. The above method outlines a way to capture movement trends of potential trafficked persons prior to criminal action, allowing for a more proactive approach to law enforcement intervention.

Such a method would require further work to develop, but might function as follows. Website "scraping" software would be directed at online classified sites, and natural language processing tools could be used to identify pages bearing potential sex trafficking indicators. These pages might be presented to a human analyst who makes "include/don't include" judgments on a series of candidate pages. Phone numbers and locations would then be extracted from the selected corpus of advertisements, and aggregated into a provider-location network. This network would be automatically folded into a location-location network in a manner constrained by transportation network routes (highways and flights, e.g., travel between Kahului and Lihue generally requires flying through Honolulu). Identification of highly weighted routes could facilitate the allocation of law enforcement resources in general, and the advertisements associated with the end-points of highly weighted routes could be retrieved from the original data to identify time windows for anticipated movement of providers with specific advertised characteristics between specific locations.

The observance of traffickers using both roadways and airways to expand their markets presents clues to potential intervention points via bottlenecks in the supply flow. Traffickers may be harder to detect when traveling along roadways. However, the use of airways is of higher risk for traffickers and providers due to the security measures implemented at airports. Air travel requires identification and high levels of security screening. Training security personnel to screen for indicators of potentially trafficked persons could pose an effective intervention strategy. Similar strategies are in place for the prevention of drug trafficking in order to cut off the supply flow.

## 6 Limitations and Future Directions

Limitations to this study include the manual collection and processing of data, which is quite time intensive and leaves room for error as some ads are deleted or reposted. The methods used suggest potential trafficking activity, but further analysis is needed to definitively state that human trafficking is present. The study observed the movement of an advertised phone number along a circuit, but there is not enough data to identify whom the phone belongs to (trafficker or providers). Also, some numbers were



advertised in multiple cities on the same day, which would require further investigation to identify exact location of trafficker or provider. However, the information obtained is useful in identifying movement trends.

Presently the networks are based on temporal adjacency but not sequence (e.g., a phone number appearing at location A and then location B will generate the same link as B followed by A). In future studies, dynamic network analysis [20] will be applied to analyze trail data (distinguishing sequences of locations) in order to address the following questions: What type of temporal information can be gathered using open Internet sources? Can trends in movement be observed using temporal data (i.e. rotations, average length of stay in location, etc)? Can trafficker and/or provider networks be identified using open Internet sources?

The present study is built on advertisements posted in Hawai'i, so only includes data on persons who appear in Hawai'i, although we detected and analyzed their appearance in other states as well. Data collection will be expanded to include multiple starting points in future studies. Multiple starting points may present different regional trends and provide insight to a larger more complex network. The exploration of alternate data sources examining online human trafficking activity beyond Backpage is also needed. Online recruitment activity is another area needing further exploration. The use of the Internet for recruitment is a growing trend with recruitment activity being reported in mainstream sites such as Facebook and Twitter [7]. Further examination of these sites to gain an understanding of how they are being used and how potential victims are being targeted would provide clues on how to disrupt and/or prevent this activity.

## 7 Acknowledgements

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